THE EFFECT OF COLLABORATIVE COMPUTER AIDED LEARNING ON PROBLEM SOLVING SKILLS IN ALGEBRA AMONG POLYTHECNICS STUDENTS

MOHD SAZALI KHALID

MAIZAM ALIAS

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Mohd Sazali Khalid
Universiti Tun Hussein Onn Malaysia
hjsazali@uthm.edu.my

Maizam Alias
Universiti Tun Hussein Onn Malaysia
maizam@uthm.edu.my

Abstract

Algebra is the foundation of many analytical-mathematical problem solving tool in technical oriented discipline. Algebra however, is not well understood by many technical students especially those who are at the foundation level of engineering programme. The purpose of this study was to determine if collaborative computer aided learning can improve problem solving skills in algebra among engineering students in polytechnic certificate programmes. A quasi-experimental design with four intact groups of students was used in the study. Scores obtained on algebra problems after using either one of the following method were compared, the collaborative computer aided learning method (CDiCL method), the collaborative learning (CL) method, the computer aided learning method (CD method) and the conventional method. The Student Team Assessment Division method of collaborative learning was used by the collaborative learning group and the CDiCL group. A specifically designed algebra courseware developed using Hermann Brain Dominance principles were used by the CD and the CDiCL group. Interactions during teaching and learning were also observed. Analysis of variance was used to test equality of means obtained on the algebra test. The descriptive statistical analysis results show that the CDiCL group obtained the highest gain score ($\bar{x}$ =6.40),followed by the CD group ($\bar{x}$ =6.08), the conventional group $\bar{x}$ =3.71) and the CL group ($\bar{x}$ =1.91). Results of the analysis using Welch test indicate that the differences between means is statistically significant (F=4.551, $df1$=3, $df2$=58.06, p=0.01). A post hoc test indicates that the mean score of the CDiCL group is statistically significantly different from the CL group only. The CDiCL group also perceived themselves to be more effective ($\bar{x}$ =2.94, s=0.54), more participative ($\bar{x}$ =4.03, s=1.4) and more prepared ($\bar{x}$ =4.14, s=1.54) compared to the other groups. In conclusion, the CDiCL group although no better than the conventional group in terms of inducing algebra learning appears to be providing a more conducive learning experience indicated by students' perception of their learning experience.

Introduction

Algebra is the foundation of many analytical-mathematical problem solving tool in technical oriented discipline. Algebra however, is not well understood by many technical students especially those who are at the foundation level of engineering programs.

Polytechnics under the Ministry of Higher Education (MoHE) are technical educations institution that is responsible for producing semi skilled professionals for many engineering disciplines. However, the average polytechnic engineering students whose achievements in mathematics have been mediocre at the Sijil Pelajaran Malaysia (GCE "O" levels) find that engineering mathematics very challenging. Current approach like intensive remediation that are commonly practiced in many parts of the world Zhang et.al (2008) is time consuming. The practice of allowing new inexperienced engineering graduates to teach mathematics is also not helping the situations. Mohd. Salleh (1990) discovered that fresh students in UTM, Malaysia were both weak in understanding the structure of algebra and their difficulties were due to ability like language comprehension. Mohd Salleh (1990) showed there is a strong evidence between understanding mathematics and teaching methods. Efforts have been constantly made to identify new methods ensuring the mathematics standards of polytechnic engineering students are of adequate level and they could complete their engineering programs (certificate and diploma) within specified time.

The use of technology to improve learning effectiveness has been widely studied. The outcome of these studies has been mixed depending on levels of education, type of students and the context of learning. For example Mays (2001) in her diagnostic error analysis in mathematics discovered significant differences in the classroom instructions which is dependent on the technology used. The use of collaborative learning method has also been tried in some instances to improve mathematics learning Felder and Brent (2004). The aim of this study is to determine the effect of technology supported by collaborative learning on the learning of algebraic concepts among polytechnic engineering students under the MoHE.

Objectives

Aspects of mathematics that are of critical importance to engineering education is algebra and problem solving. Algebra is the gate to calculus . Problem solving helps to bridge the knowledge the students have with the application that is warranted (Levine, 1990). The objectives of this paper are to determine:

(i) the effect of technology supported collaborations on learning by learners of different ability
(ii) which ability-levels of student in different methods perform much better as opposed to item tested in pre and post tests?
(iii) the effect of using technology supported collaborative learning on achievement in algebra problems solving
(iv) the effect of the learning processes - the peer interactions between student to student, student to teacher in the technology supported group that promotes learning

The independent variables are the traditional teaching method (control), Collaborative learning only (CL), technology only (CD) and technology-supported collaborative learning (CDiCL). The dependent variables are the gain score. The mediating variables are the level of perceptions of member effectiveness and participations and preparedness among group members. Controlled variables are teacher qualities, lecture notes, and classroom time of interaction.

Related Works

In mathematics education, researchers like Linchevski and Herscovics (1996) tried to overcome the cognitive gap where many students are not able to spontaneously operate with unknowns. Difficulties in simplifying algebraic expressions where students finish off algebraic equations such as $2x+3$ as $5x$ or 5 were met by Tirosh *et al.* (1998). This is because literal symbols is found to be the main cause of their difficulties in mathematics Christou *et al.* (2007). However a body of research found that teaching culture where students are mostly been spoon fed by teachers in Schifter & Fosnot (1993) did play important role in shaping the understanding concepts in algebra. Telling methods in mathematics teaching created confidence in handling mathematical content and this support is lacking in teaching mathematics with computers (Zain, *et al.* 2006).

Group dialogue used by students while solving problems generates linkages between mathematical symbols and formal language (Morell *et al.*, 2001). But group work depends on motivation thus influencing effectiveness, preparedness and commitment levels among members.

Computer Based Learning CBL through drilling and practice in mathematics packages helps students to acquire more skills and understanding. A cognitive theory by Hermann (1995) wrote: the human left brain specialized on facts while the right brain dwells better on visual images. Styne (2004) adapted Hermann model for mathematics work and concepts in South Africa. Styne found that human's retention rate which differs from one individual to another based on different learning styles and attitude upbringing can be improved through collaborative learning. But designing computer software with multimedia technology is a big challenge when Mayer et al (2001) claimed most instructional designers talked about human memory overloading. But in the computer laboratories, one screen per idea may not be the most effective method for group. Thus a merging point between group learning and CBL individualized learning has to be explored. CDiCL is proposed here to address the above issues.

Methodology

The target population of the study is polytechnic engineering students in 20 polytechnics in Malaysia. The samples were four intact classes of certificate engineering students from Kota Bharu Polytechnic (KBP), a total of 139 students. They were expected to be representative of the whole populations of polytechnic engineering students in Malaysia as institutions are under one governing body.

Research Tools and Materials

Five research tools were used in this study, a courseware (CD-interactive), lecture notes, peer evaluation form, a pre-test, and a post test. The CD-interactive was written in English developed using the ADDIE

instructional model. Its content was limited to Pre-Algebra, Factorization and Simplification only. This was determined from SPM (GCSE equivalence) item analysis. There are three modules in the CD called Revision, Test and Links. Exercises were provided at the end of each topic in the Revision module. The CD Test module (MCQ format) contained three levels. The students will need more than 50% correctness in order to proceed from one level to another. The Links provided as an enrichment strategy. The layout, content and interface design of this cd was developed based on the Hermann Whole Brain Theory model. The CD design also incorporates the education philosophy called psychomotor, cognitive and affective.

A pilot test on the usability gave a) learning ability 87%; b) effectiveness 76%; c) screen arrangement 76%; d) graphics 77%; e) user satisfaction – 79%; f) overall performance 88%. A more than 70% depict acceptable and strong level as Sung (1997) suggested. Content validity was assured by a subject matter expert in KBP, mathematics graduate teachers from a Kelantan secondary school, two senior mathematics lecturers in UTHM who checked the accuracy of the marking schemes and 23 math lecturers in KBP participating in an effective math teaching method course. The English difficulty level was tried to 10 Form Two (aged 14+) secondary school students in SM Meranti, Kelantan and cross-examined by a senior English language lecturer from KBP. Thirty questions (both in English and Malaysian language) were designed to facilitate collaborative learning in CL module but four questions were tried per week focusing on solving word problem solving (WPS) for group discussion. A short test was prepared to monitor their mathematics' understanding 10 minutes before the end of each computer laboratory interactions in each week thus creating team commitment and accountability.

Lecture notes based on the B1001 module was taken from the DPCCE MoHE. The content of these lecture notes were piloted to 50 DIT Diploma Students 2005/2006 KUiTTHO/UTHM. Peer Evaluation Form was administered to all participants in group work. Each member was graded on the scale of 2 to 10 in terms of group interaction. The forms were adapted from Murdoch University. SPSS Version 12.0 was used to process the findings. Collaborative learning used STAD format with five important roles i.e. group leader, assistant leader, time keeper, runner and reporter. Any team leader lasted for two weeks. An observation sheet was used to check the learning processes in all teams using CL only and CDiCL methods. External motivation (like CADBURY) is given for the team that showed the most learning processes taking their respective roles.

The Pre Test and Post Test instruments consisted of 10 questions in each test. It covered factorization, simplification, equations, number computations, and fractions. The questions in Pre and Post Tests were checked by KBP math lecturers and 40 marked scripts were cross-checked by two independent lecturers from KUiTTHO/UTHM to ensure consistency with the marking scheme. Audio-video recording and semi-structured interviews were done to triangulate the results from the quantitative analysis results done. Qualitative analysis was done with Atlas/ti Version 5.

Research Procedure

The study uses a quasi-experimental design approach with pre and post test using equivalent groups. To control any confounding variables like differences in teachers' impact, the researcher taught all the four different classes in the morning sessions within the eight week period covering early pre-algebra topics as contained in polytechnic teaching and learning syllabus B1001. Participant observation was also used to extract information related to the objectives. Basic design of study is shown in Figure 1.

Group 1: Pre Test → treatment 1 → Post Test
Group 2: Pre Test → treatment 2 → Post Test
Group 3: Pre Test → treatment 3 → Post Test
Group 4: Pre Test → treatment 4 → Post Test

Figure 1. Summary of the research design and procedure

In Treatment 1, students were given no CD-interactive and no CL (Control Group). In Treatment 2, students were given CL only while in Treatment 3, students were given CD only. Finally in Treatment 4, students were given both CD-interactive and CL. STAD (student teams' achievement division) and not TGT (team game tournament) was applied in CL method in Group 2 and Group 4. Five students work in a group taking specific roles. CL participants tried to solve 4 word type problem solving questions per session. Everyone

has to help each other to solve the questions. The roles in CL changed after every 2 weeks. Peer Evaluation Forms were completed at the end of each CL session to enforce accountability and commitment levels. Common to all groups is a hard copy of lecture notes. CDiCL Dictionaries were given to all groups to familiarize math terms.

Each group has four different levels of students based on their mathematics grade at SPM. The levels are high (scoring 1A,2A), average(3B,4B), weak(5C,6C) and very weak (7D,8E). The group leader in CL was chosen from the high achieving students. Each student's work were compared at Pre Test and Post Test. Their learning gain/lose was recorded based on tested items like arithmetic, symbol manipulations and word problems.

Duration of treatment was 8 weeks (but 2 weeks were used to train CL and CD skills). Each week the treatment was administered in the first hour of a B1003 Computer Application subject. Interviews and video recording done to triangulate findings. Interview was done during late evenings for 3 months consecutively in F-Block, KBP to avoid administrative problems with the students.

Results

This section has two parts – learning gains and learning processes. The immediate section produced the learning gain components of this research.

Effect of technology supported collaborative learning on learners of different ability

Forty marked scripts that was done by the researcher and cross examined by another senior mathematics lecturer were used to gather the data below. Comparison between marks at the pre-test and post test between each level of students from all the four different groups were analyzed and the learning gain is recorded.

Figure 2 shows the distribution of learning according to group and ability (lowest, low, middle and highest). From Figure 2 (a) all group types contain losers (<= 0 gain score). However the highest numbers of losers are in Group 1 (Control Group). Figure 2(b) Group 3 and Group 4 contained more gainers (6 – 15 marks). Figure 2(c) depicted more gainers in Group 4 (6 – 20 marks). While in Figure 2(d) more gainers in Group 2 and Group 3 only. This indicate that only low to middle achievers in mathematics in CDiCL and CD groups had benefited from technology while low achievers in CL only group gained the most from elaborated explanation by peers and lecturers.

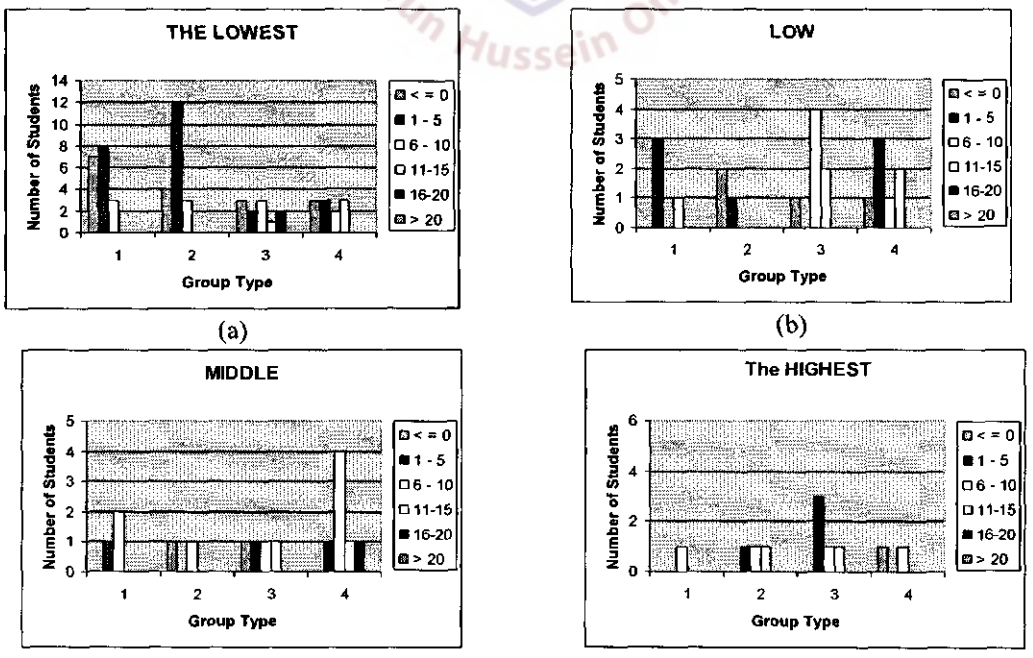

Figure 2. *The trend in gain score among different level of achievers in each group type*
Legend: Group Type 1= Conventional; Type 2= Collaborative Learning; Type 3= CD only; Type 4=CDiCL

Which ability-levels of student in different methods perform much better as opposed to item tested in pre and post tests?

Comparison between marks at the pre-test and post test between each level of students from all the four different groups were analyzed and the learning gain is put in Table 1.

Table 1: Descriptive statistics of groups and different levels of learners

Group	ability	Mean	Std. Deviation	n
Conventional	high	5.50	.	1
	average	7.37	2.75	4
	poor	3.80	5.77	5
	extremely poor	2.66	3.26	16
	Total	3.71	3.95	26
CL only	high	7.67	5.03	3
	average	1.33	5.13	3
	poor	-1.67	4.51	3
	extremely poor	1.66	3.54	19
	Total	1.91	4.35	28
CD only	high	4.00	6.20	6
	average	5.38	5.15	4
	poor	8.70	5.62	10
	extremely poor	5.00	7.50	10
	Total	6.08	6.35	30
CDiCL	high	7.00	.	1
	average	8.93	4.71	7
	poor	6.64	5.72	7
	extremely poor	4.59	7.03	11
	Total	6.40	6.02	26
Total	high	5.41	5.22	11
	average	6.53	4.96	18
	poor	5.90	6.23	25
	extremely poor	3.12	5.20	56
	Total	4.54	5.54	110
Dependent Variable: Gain_Score				

Table 1 above shows that CDiCL group Level (average) and level (extremely weak) obtained the highest gain score (8.9 and 4.6) comparatively to their equal counterparts in other methods. The CD only group scored the highest gain score among level (poor students) as compared to their respective counterparts in other methods. In the CL only group the level (brightest) scored the highest gain score as compared to other counterparts in the other teaching methods. Mean while in the conventional group, the average ability students

obtained the highest mean gain. However, the impact between ability level against method is not statistically significant (p=0.324) as shown in Table 2 below.

Table 2: Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	777.71(a)	15	51.85	1.90	.033
Intercept	1353.90	1	1353.90	49.51	.000
Group	167.90	3	55.97	2.05	.113
ability	89.12	3	29.71	1.09	.359
Group * ability	287.75	9	31.97	1.17	.324
Error	2570.64	94	27.35		
Total	5612.00	110			
Corrected Total	3348.36	109			
a R Squared = .232 (Adjusted R Squared = .110)					
Dependent Variable: Gain_Score					

Effect of technology supported collaborative learning on algebra achievements: analysis of quantitative data

Twenty nine students failed to come for the Post Test. Thus only data from 110 students were used in the analysis (Table 3). The Welch *F* method was used to compare the means as suggested by Fields (2000) because one of the two important assumptions of ANOVA i.e. equality of variance cannot be met (Table 4). The result of the Welch Test in Table 5 shows that there is statistically significant difference between at least two means ($p<.05$). A post hoc test (Table 6) were carried out to compare the means using the Tamhane's test as suggested by Fields (2000). Table 3 shows that the mean scores of each group are different from the other with the lowest score achieved by Group 2 and the highest score by group 4. The *Welch test* in Table 4 indicates that at least two means are statistically significantly different ($p<.05$). A post hoc test (Table 6) indicates that the mean of Group 4 is statistically significantly different at the 5% level of significance from Group 2 and mean of Group 3 is also statistically significantly different from Group 2. Thus CDiCL treatment produced greater learning of algebraic concepts and procedures compared to collaborative learning only.

Table 3 *Descriptive Statistics of Gain Score in each group*

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	26	3.7115	3.95265	.77518	2.1150	5.3080	-1.50	13.50
2	28	1.9107	4.34625	.82136	.2254	3.5960	-6.00	13.00
3	30	6.0833	6.35051	1.15944	3.7120	8.4547	-5.50	18.00
4	26	6.4038	6.01668	1.17997	3.9737	8.8340	-9.00	17.00
Total	110	4.5364	5.54246	.52845	3.4890	5.5837	-9.00	18.00

Table 4 *Levene Statistic – Homogeneity of Variances*

Test of Homogeneity of Variances

Gain_Score

Levene Statistic	df1	df2	Sig.
3.083	3	106	.031

Table 5 *Welch Method – as an alternative to ANOVA*

Robust Tests of Equality of Means

Gain_Score

	Statistic[a]	df1	df2	Sig.
Welch	4.551	3	58.056	.006

a. Asymptotically F distributed.

Table 6 *Cross difference between groups using Post-Hoc alternative*

Dependent Variable: Gain_Score

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tamhane	1	2	1.80082	1.12940	.526	-1.2880	4.8897
		3	-2.37179	1.39471	.452	-6.1945	1.4509
		4	-2.69231	1.41182	.324	-6.5848	1.2001
	2	1	-1.80082	1.12940	.526	-4.8897	1.2880
		3	-4.17262*	1.42089	.029	-8.0602	-.2850
		4	-4.49313*	1.43769	.018	-8.4483	-.5380
	3	1	2.37179	1.39471	.452	-1.4509	6.1945
		2	4.17262*	1.42089	.029	.2850	8.0602
		4	-.32051	1.65427	1.000	-4.8397	4.1987
	4	1	2.69231	1.41182	.324	-1.2001	6.5848
		2	4.49313*	1.43769	.018	.5380	8.4483
		3	.32051	1.65427	1.000	-4.1987	4.8397

*. The mean difference is significant at the .05 level.

Why is this so? Perhaps there is some differences between the learning processes in each of the teaching method. Now the next part shows the result from the learning processes. This is done when the participants are required to fill in the Peer Assessment forms and some video and audio recordings were made.

Peer Evaluation Forms asked opinions on: a) how effective was your group, b) how many members participated in your work group and c) how many participants were really prepared. Table 7 showed that CDiCL group has the highest ratings for all three and therefore was the most effective. It was concluded that if a student perceived his peers to be effective then there will be more positive attitude, motivation and participation in the working group. Table 7 below produced mean and standard deviation on factors for successful learning.

The effect of the learning processes - the peer interactions between student to student, student to teacher in the technology supported group that promotes learning

Table 7 *Mean and standard deviation*

Item	Group / Level Description	I		II		III		IV		Likert Scale used
		$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	
1	Effective	2.4	0.67	2.5	0.62	2.5	0.72	2.9	0.54	4
2	Participation	2.3	0.55	3.6	1.15	2.8	1.17	4.1	1.54	6
3	Fully preparedness	2.5	0.63	3.8	1.15	3.1	1.23	4.0	1.36	6

Other than peer assessment forms, each team member was asked to assess their peers in their team based on a standard rubrics. The score is 10 for perfect collaborative work and 2 for minimum collaborative work. Since each team has 5 members then each team's maximum point is 40. Table 8 below can help to explain the above data when team totals peer weekly ratings are scored. The CDiCL and CL only groups contained 5 member per team.

Table 8 Total Marks from each team in Group CL only

Week Number \ Team's Name	W1	W2	W3	W4	W5	W6	W7	W8
PROTON	40	35	35	30	30	30	25	25
TNB	40	30	30	25	30	25	30	25
WIRA	40	35	35	20	20	20	20	20
MAWAR	40	40	25	20	20	20	20	20

From Table 8 in the CL only group, the girl team called MAWAR scored the lowest total as compared to the boys' team like PROTON, TNB and WIRA. Collecting their peer assessment forms is very time consuming.

Table 9 Total Marks from each team in Group CDiCL

Week Number \ Team's Name	W1	W2	W3	W4	W5	W6	W7	W8
PERWIRA	40	35	35	30	30	30	30	30
MOTO	40	30	30	25	30	30	25	25
GIRLS	40	35	35	20	20	20	20	20
REMPIT	40	40	25	20	25	25	25	25
ASTRO	40	40	25	30	30	20	20	20

The trend as in Table 8 in the CL group shows the girls evaluated each other lower than the boy's team was also observed in CDiCL group as shown in Table 9. Even though from the observation of the researcher and technicians regarding the students' work where they having difficulty with the word problem solving, the boys seemed to award high evaluation points to each other as compared to the girls' teams MAWAR and GIRLS. This interesting phenomenon will be used as the basis for the interviews later on between the researcher and the students.

Differences in the learning processes i.e., learning interaction between groups

All groups played the standard learning process such as teaching, learning and assessment. The conventional group replicated the comfortable teach and learn method like their former schools. CL only group played out the 5 different roles STAD as needed while solving word problem. The solution sheet given out was used to guide their understanding in mathematics. They are required to sit for short test 10 minutes before the session ended. This produced some team commitments and accountability. The CD only group tried dyad method while using the cd and they could hear other pairs discussing and talking aloud at other terminals. Once they completed the sub-modules from the CD after the 20th minute they were given handouts to discuss WPS. Finally the CDiCL used the cd for 20 minutes and the next 20 minutes they played out the STAD roles as required by CL method. They got the solution sheet in guiding their understanding and they sat for short 10 minute test similar to CL group.

The differences are the amount of group interaction between CDiCL, CL methods and CD only method. Other differences are quality of discussion would be different between teams of size 5 compared to team of size 2. The quality of interaction and discussion would be more intense if all team members were putting serious effort in WPS. But sometimes it was noticed that team of similar ability could function better (completing the sub modules from the CD faster and accurate) compared to pairs of different level of ability. Team that has mixed gender looks more vibrant in their interaction as compared to teams of similar gender. Another important observation was not all high achievers (leader) can lead their team well. Few average ability peers can function as effective leaders because they were born leaders with social skills like persuasion and good personality. CD and conventional groups were exposed to short and directed question by the researcher while CL and CDiCL were given some experience in handling cognitive and meta cognitive thinking questions. i.e., 'why' questions.

Discussion

The findings are the group that uses CDiCL has similar mean score on algebra test to group using CD and conventional. Group using CDiCL have more interactions compared to other groups. Group using CDiCL has higher mean score on algebra problems compared to group using CL method. There are few explanations to this. Firstly, the students are still new in using the technology CDiCL and they got different kind of learning experience. Secondly, they are weak in English and since CDiCL is put in English the learning gains was quite low. Thirdly, the students are new to each other thus the intensity of interactions in collaborative learning groups could not be optimized and next, it was found that some students are surface learners and not deep learners through their experience with the CDiCL. Finally the word problem solving exercises proved strongly that many students did not have much experience doing this kind of work during their previous secondary schools. They preferred to do number problems compared to word problem solving. Simplifying mathematics

problems by the researcher did not help the students in the long run. Students who improved concurs to Morell *et al.* (2001) where technology improves learning by encouraging groups to function actively in the classroom. Participant observation methodology found that the teacher's voice and questioning techniques played important roles as parallel to Felders (1991) since the voice played an important part in constructing mathematical understanding. It was found that if problem solving was not properly guided many students would be off-task. This demand a lot of energy to implement (Slavin, 1995). Some group work failed to produce important impact due to the lack of motivation, interest and commitments level among team members especially by introducing WPS. WPS demanded three levels of skills – comprehension, mathematical model and finally solving the model. This is hard because some low achieving learners took time to learn new skills like writing mathematical symbols. Thus there is a possibility that peer assessment forms are filled up with some feeling of handicaps of WPS. Some misconceptions between arithmetic and algebra could be solved if the researcher was trained on correct mathematics questioning techniques that were considered vital for cognitive development and maturity parallel to Moursund (2006) propagated. This maturity didn't happen in CDiCL which run for two months only.

From the short transcript of this mathematics work in KBP there is some signs of significant influence between group interactions and the courseware in building the understanding of algebra. This multimedia courseware by adapting Hermann Whole Brain model plus effective interactions between lecturers, students and peers did motivate students to learn from interviews. The findings in this project were consistent with Mayer (2003) where text, animations and personalization are very important elements in technology learning. However, some students avoided text by claiming '*..the pictures and animations are more than enough to understand the material..focus on numbers and literals ..not the language..* '. The contribution made by this research is the use of the Hermann Brain Model i.e., four-quadrant screen model which helped the students to monitor their progress as contained in the lesson objectives. They have more control with the courseware when they know in advance how much more quadrants in each screen to cover in order to achieve any lesson objective. By feeling s/he is in control of their learning could be a plus factor among low achieving students to learn more. This is different to Mayer et al (2001) model where their using of text and visual screens helped students to learn rain and lightning concepts in the science laboratory. Biological sciences need the students to see and believe instantly while CDiCL four quadrant model proposed that the students must be trained to think deeply from text materials in the first place (Healy, 1998) followed by some discussion between peers in reaching common understanding before they were given the visual or animated diagrams as a summary of a concept. In short the students in CDiCL were trained to think first , to understand second and to achieve full agreement third with their peers. This has to be done to produce some thinkers in mathematics education (Healy, 1998). It is difficult to achieve the most learning impact from CDiCL which was in English. However, nothing is lost when from interview sessions they admitted to appreciate when texts were removed prior to animation and pictures. This allowed focusing to happen among CD and CDiCL users. Thinking aloud protocols were vividly displayed at most terminals, encouraging peer interactions, elaborations and mere discussion among team members. Poor questioning techniques by the researcher that fail to make discussion work more motivating has so much to be desired. It seems that from properly extended elaboration between peers and researcher, low and middle achievers gained the extra benefit as consistent with Felder (1991). In KBP we found that the success of collaborative learning depended on good leadership and peer modeling of extended elaboration. These qualities are not easy to obtain from low performing students. The two other missing factors among the students were they hesitate to lead and take challenging roles in their learning processes. This is against the belief that most constructivists and cognitivists agree that learning can happen from active participation. The low and poorest group of students failed to attend interview sessions because of anxiety that was not yet removed from the 8 week work in KBP. Their withdrawing from taking effective leader's role in any CL exercise regardless of persuasion by the researcher caused a surprising result which is not parallel to Slavin(1995) CL work. However, teaching by better peers to weaker peers not only resulted in the low achieving students to benefit (see Figure 1) but also the high achieving students themselves gain from structuring and restructuring their understanding all along the episodes. The different total team scores as in Table 8 and Table 9 explained that few members were not giving their best effort to achieve team success in CL activities especially their weekly quizzes. This is because as the weeks moved on towards the end of the eighth week, everybody sensed that each one of them is falling behind in playing their respective roles like leader and reporter of the team. The hard questions in WPS added more weight explaining this behavior. This kind of team behaviour explain some how the differences

between effectiveness, preparedness and perception of each student in any CL teams as parallel to Slavin (1995). In short, the benefits in KBP were limited because time constraint (1 hour laboratory per week) and difficulties encountered in English CD contents and interpreting WPS into mathematical structure. The study contributed a bit for Malaysia in deciding whether mathematics should be taught in English in all institutions Future research could try to extend the use of CDiCL (malay language) in checking the most learning effect using technology.

Conclusion

The study set out to identify whether there is an impact of interaction between three important components of teaching and learning, namely lecturers, students, peers while using CDiCL courseware. The learning outcomes resulting from using technology supported collaborative learning was that using CDiCL leads to more students' interactions as compared to the conventional method and using CDiCL also produces superior problem solving performance when compared to the CL method but not the other two methods. The average and weak students from both CDiCL and CD was found to learn mathematics using technology. The contribution made by CDiCL towards mathematics education using Mayer's cognitive loading principles was also explained.

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