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The Influence of Teamwork Using a Multimedia Interactive Courseware in Learning Pre-Algebra

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Abstract

A strong grasp of mathematics is a key factor in ensuring success in engineering education. This paper reports on a study that attempts to investigate the contribution of teamwork and interactive multimedia courseware (CDiCL) towards learning of pre-algebra among engineering students. The quasi-experimental design method with pre and post test were used which involved four intact groups of students namely, the Control group, Collaborative Learning (CL) only group, Courseware (CD) only group and CDiCL group. Interviews and participant observations were also used for gathering qualitative data. Results of the quantitative data analysis showed that two groups that used the CD outperformed the two other groups who did not. The qualitative data analysis results revealed that teamwork among the CD users were more effective when team size is small (3 to 4).

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1. Introduction

Semi skilled technical professionals such as technicians and engineering assistants need to possess a certain level of mathematical skills as mathematics often forms the basis of analytical-mathematical problem solving tool in their line of work (Smith et al., 1996). Achievements in mathematics among engineering students who are future semi technical professionals throughout many countries is quite worrying (Zhang et al., 2008). New approach in teaching method need to be identified to ensure these students acquires the understanding of mathematics. Some educators suggest technology to supplement learning while others promote team learning in learning mathematics (Waycaster, 2001; Clark, 1998; Idris, 1999). Maxwell (2008) suggested teamwork not only in learning but encompassing many other endeavours since teamwork divides the effort and multiplies the effect. Efforts of getting any job done and the effect multiplies itself into motivation and improvement in trust, attitude and commitment could suit the working culture of these technicians. However, the outcomes of these studies have been mixed depending on the levels of students and context of learning. For example, in (Waycaster, 2001; Mays, 2001; Salwa, 2003) discovered significant differences in classroom instruction by the technology used and Clark (1998) assessed student’s

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satisfaction in learning, and staff time. Learning from the internet is gaining momentum on the world wide basis. One aspect of mathematics that is of particular concern is algebra as this is the gate to calculus (Mays, 2001). There is a strong link between these algebra and calculus in engineering studies. Research by (Idris, 1999) analyzed linguistic aspects in learning mathematics among secondary students. Overall they concluded there is some misunderstanding of the difference in basic concepts in mathematics and algebra through the languages used in classrooms among the teachers and the students. Current teaching methods in schools and polytechnics (MOHE) have not been that successful where remediation has been dominating the prescription of early mathematics skills like algebra in general.

The purpose of the study is to analyze (a) whether the team work in collaborative learning principles by using an interactive multimedia courseware called CDICL can produce significant impact in learning algebra among members in collaborative learning groups and (b) what factors do contribute to important team work in order to produce success in understanding algebra and calculus using computers and internet.

The assumptions and limitations of this study are all engineering polytechnic students are academically equivalent as processed by TED, MoHE. Academic program runs on 15 week semester. This project took strictly the KBP (Kota Bharu Polytechnic) time-table set-up.

2. Related Issues

In mathematics education, students are spoon fed by teachers who are comfortable with using the “telling method” in teaching (Dillenbourg, 1999). The telling method is much favoured as it creates high confidence among teachers in handling mathematical content often limiting the types of questions that that students can pose to them. Due to this fact, teachers dislike introducing new things into their teaching. For example, the confidence that teachers demonstrate in the telling mode is lacking when the teacher is asked to integrate computer technology into their teaching (Zain et al., 2006). Past bad experience in teaching and learning mathematics resulted in many cases of anxiety among teachers (and students alike) especially when they need to handle the computers at the same time. The teachers did not have enough time to check the contents from courseware thus this affected their confidence in delivering effective lessons (Zain et al., 2006).

In today’s working world, team-working is essential and in Malaysia where multiculturalism is the norm, the ability to work together becomes more important. Therefore, it is important to provide a curriculum that encourages collaborations among the diverse communities of people. Furthermore, team-working is already favoured by many students as according to Atkinson (1999) and Dillenbourg (1999), students like to learn with team mates of similar interests. Currently students are trying hard to learn mathematics not only in the classroom but also in laboratories using their own street language and this form of behaviour could be vital during their formative years as students (Essein, 2006). During this learning processes the teachers must pin point two things i.e., students’ accountability and commitment (Felder, 1991) in team work. Factors such as motivation that influence effectiveness, preparedness and commitment levels among the students doing problem solving needs teacher’s control (Steers, 1991; Woodhouse, 1986) because without control it is hard to quantify the outcome of any kind of learning. Nik Aziz (1995) stressed that in Malaysia many teachers are finding it difficult to explain to the class about the finer points behind problem solving. There are two main reasons to this. Firstly the teaching institutions are not able to recruit applicants from the high achieving group who wanted to be teachers while the second factor is many teachers have limited time to cover the syllabus for the public examination. Good teachers are needed in teaching about thinking of cognition as it involves doing whereas meta-cognition involves mental activities in choosing and planning what to do and monitoring what is being done (Garafalo and Lester, 1985). However, good topics to complete the syllabus fast are mundane number, formulae manipulation that excluding problem solving such as word problem solving (WPS). Gone were the days where the teachers allowed their students to explore things and find some excitement along the way. Therefore, without problem solving less emphasis is on cognition and meta-cognition in Malaysian schools and polytechnics thus the students suffer silently when WPS is a must when studying in the higher institutions. There are less questions that are purely facts. What they are going to get is mostly an episode where they have to manipulate variables into equations and produce solution. If the teachers cannot provide exploration therefore computers and internet can give that as an alternative. But the success of any exploration in classroom is guided by probing questions by the teachers (Felder, 1991).
Computer Based Learning CBL suits individualized learning (Webb, 1991). This is because CBL provides opportunities for drill and practice which suit the development of basic mathematical skills and concepts of an individual. However, most schools are not equipped to individualized learning thus at present the schools has to merge the strengths of team learning in CL and individualized learning in CBL.

CBL has to be designed to cater to the different learning predisposition. However, to design computer mathematics software with multimedia technology is a challenge when the principles in instructional design, dual coding theories and generative theory of multimedia learning (Atkinson, 2001; Stemler, 1997; Aris et al., 2002) had to be adhered so that learning happens in CBL. Other considerations include memory overloading which is a critical factor to be dealt with by instructional designers (Chin, 2005). Past studies on retention rate indicate that human’s retention rate differs according to teaching methods, 50% by discussion group, 75% by doing and 80% by teaching others need some consideration (Linda, 2004). Moreover, in the computer laboratories one screen per idea may not be the most practical method for teamwork when different ability learners are put together. A cognitive theory by Hermann (1995) has been sued to develop learning courseware that caters to the different functions of the brain - human left brain specialized on facts while the right brain dwells better on visual images. The theory has been adapted by Styne (2004) on his works on learning model for mathematical concepts.

Currently, computer supported collaborative learning (CSCL) is picking up in its popularity since it helps students to do self learning and with the availability of internet facilities in many schools students also acquire social skills at the same time. The new technology also enables a teacher to monitor the progress of many students from many classes in different blocks of any institution. Thus this work called CDiCL is proposed to address the above issues.

3. Method

3.1 Population

The population consists of polytechnic engineering students in Malaysia.

3.2 Sample

The samples were made up of four intact classes of certificate engineering students from Kota Bharu Polytechnic (KBP) totalling up to 137 students. The sample can be assumed to be representative samples for the whole populations of polytechnic engineering students in Malaysia based on the fact that all polytechnics are governed by one central agency and are subject to similar quality checks and regulations.

3.3 CL principles

In the CL method, each team member is require to play a specific role such as a team leader, assistant team leader, reporter, manager and time keeper. The roles are rotated every fortnightly. The team members are selected by the teachers based on SPM Math grade only. The team leader has the highest grade.

3.4 Variables

The independent variable was the method of learning CDiCL, CD and CL and traditional teaching, while the dependent variables are the gain score after the post test, level of perceptions of member effectiveness, participation and fully preparedness among group members.

3.5 Research Tools

a. Pre-algebra courseware

The courseware was specifically developed for the study to be used by two groups and written in English. A pilot test was conducted to gauge its usability and the results are shown to be acceptable as illustrated in Table 1.
Table 1. The usability of CD-interactive

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>learning ability</td>
<td>87</td>
</tr>
<tr>
<td>effectiveness</td>
<td>76</td>
</tr>
<tr>
<td>screen arrangement</td>
<td>76</td>
</tr>
<tr>
<td>graphics</td>
<td>77</td>
</tr>
<tr>
<td>user satisfaction</td>
<td>79</td>
</tr>
<tr>
<td>overall performance</td>
<td>88</td>
</tr>
</tbody>
</table>

A score of greater than 70% indicate a courseware that is in the category of “strong acceptable” level (Sung, 1999). Content validity was assessed by a subject matter expert in KBP, graduate mathematics teachers from a Kelantan secondary school, two mathematics’ IT lecturers in UTHM and 23 mathematics lecturers in KBP who were participating in a teaching method course. The English difficulty level of the CD was tested on 10 secondary school students in SM Meranti, 50 DIT students from UTHM and cross-examined by a senior English language lecturer from KBP. The Courseware development was developed using the ADDIE instructional model. Its content was limited to Pre-Algebra, Factorization and Simplification only. The CD’s content 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 has three tests. The student needs password and to score at least 50% in each test to proceed further tests. The Links called purplemath is for enrichment purposes. The layout, content and interface design of this CD was developed based on the Hermann Whole Brain Theory model. The CD design incorporates psychomotor, cognitive and affective elements as required by education guru. Moreover the strength of this courseware is it dissolves the facts and formulae from the left quadrants of the computer screen first before animations and pictures appeared on the right quadrants. By doing so it relieves overloading in the students memory. Besides it can be useful among its users that in differentiation, at times, they have to differentiate things in two parts like the product and quotient rules. This requires the students to look at things in two different blocks at the same time.

b. Lecture notes
Lecture notes B1001 modules were taken from TED (MoHE). The notes used daily in all the four participating classes. To eliminate confounding variable the first author is the only one teaching the four classes. Peer Evaluation Form. Each member graded their peers on the scale of 0 (none) to 10 (the highest) in terms of group interaction at the end of each week. This is to inculcate commitments, accountability among team members.

c. Pre Test and Post Test.
There were 12 questions in each test. It covered number computation, substitution, factorization, simplification, linear equations, sign number, fractions and word problems. 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 UTHM to ensure consistency in marking.

d. Peer evaluation form, interview protocols, audio recordings
Peer Evaluation form, Audio-video recording and semi-structured interviews were done to triangulate the results from the quantitative analysis results done by SPSS version 12.0. ATLAS/ti version 5.0 was used to analyze dialogue.

e. Collaborative learning instrument
The Collaborative Learning (CL) has 30 questions. Four questions were tried weekly to focus solving word problem thus encouraging group discussion in CL mode. The questions were mostly about daily transaction between a merchant and his customers where they need foreign exchange. Others are in engineering context where engineering technician needs to convert things correctly in order to take out the correct amount of paint in order to mark the road surfaces correctly and clearly.
3.6 Research Procedure

The study uses a quasi-experimental design approach with pre and post test using non-equivalent groups. Participant observation was also used to extract important points 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 |
Treatment 1: students were given no CD-interactive and no CL. Control Group
Treatment 2: students were given CL only with wps. Strategy is using STAD (Student Team Assessment Method) i.e., each student has a unique role
Treatment 3: students were given CD only.
Treatment 4: students were given both CD-interactive and CL, doing WPS.
Common to all groups are a hard copy of lecture notes and Dictionary CDiCL.
Duration of treatment was 8 weeks. Each week the treatment was administered in the first period of a B1003 Computer Application subject. Peer Feedback forms, interviews and video recording done to triangulate findings. Internet service was available.

Figure 1: Research Procedure in CDiCL Project

Below is the picture of the groups undergoing the different learning processes within 60 minutes per week.

<table>
<thead>
<tr>
<th>Group</th>
<th>Conventional</th>
<th>CD Only</th>
<th>CL Only</th>
<th>CDiCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Process</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Where, × represents researcher (lecturer) in charge and ○ represents student.

We would like to highlight from Figure 2 the CL only group works in team while solving word problem with the help of their teachers. Meanwhile, CDiCL group did the learning from the CD in the first 20 minutes before they moved into teamwork in the last 40 minutes. CD only group were learning using the CD and solving problems in twos or threes per team at a computer. The conventional group sat behind a bench with 5 of them together.

4. Results and Discussion

This study produced more dominant quantitative results as compared to qualitative results. But in this paper, we dwell more on the latter since it portrays many interesting things behind the numbers and graphs.
4.1 Quantitative Results

It was found using ANCOVA where score from Pre Test is used as covariate and Post Test score as dependent variable that Group 3 scored the highest gain score followed by Group 4, Group 1 and surprisingly Group 2 performed the least. Gain score is the difference in marks between the Post Test and Pre Test. Below is the Table 2 on the Descriptive Statistics for each of the participating group using SPSS Version 12.0 only.

Table 2: Descriptive Statistics of each of the Participating Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre Test</th>
<th>Post Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Conventional</td>
<td>5.89</td>
<td>4.4</td>
</tr>
<tr>
<td>CL Only</td>
<td>6.45</td>
<td>5.8</td>
</tr>
<tr>
<td>CD Only</td>
<td>8.47</td>
<td>4.6</td>
</tr>
<tr>
<td>CDiCL</td>
<td>6.00</td>
<td>5.6</td>
</tr>
</tbody>
</table>

It was also found that there was a statistically significant difference between Group Type and Post Test at a $F$-value of 4.032 at 0.009 significant level (Khalid, 2010).

4.2 Qualitative Results

Peer Evaluation Forms are used as a basis for future interviews. The forms asked opinions on the four methods. The opinions covered: a) how effective was your group, b) how many members participated in your work group and c) how many participants were really prepared. A Spearmann correlation values was generated using SPSS and it was concluded there are moderate correlation with values 0.3 to 0.6 between firstly – member participations and effectiveness; and secondly – fully prepared and effectiveness.

4.3 Participant Observation

This study called a few series of interviews between the main author and KBP mathematics lecturers, the main author and the students. One of the transcripts is shown in Figure 3 below.

Question 1: Subtract $\frac{t^4}{2} + \frac{t^2}{3}$ from $(\frac{t^2}{2} + \frac{4}{5})$

Question 2: Subtract 10 cent from RM1

R: researcher     S1: student 1     S2: student 2

Pre Use of CD

Answers:
Question 1. $(\frac{t^4}{2} + \frac{t^2}{3}) – (\frac{t^2}{2} + \frac{4}{5})$
Question 2. RM1.00 - 10 cent = 90 cent

After using CDiCL

Answers:
Question 1. $(\frac{t^2}{2} + \frac{4}{5}) – (\frac{t^4}{2} + \frac{t^2}{3})$
Question 2. 100 – 10 = 90 cent

R: Why you put $t^4 - t^2$ in the Pre Test?
Why like that?

S1: It is easy to subtract bigger 4 to smaller 2. I can get 2.
S2: It looks more logic to me. t^4 minus t^2. You get Tt^2.
S1: if t^2 minus t^4 .. it will look funny .. t negative 2

R: But you see the word ‘subtract from’. Did you see that a lot examples from the CD?
S1: Yes… a lot .. but .. this time .. not logic if I put 2 then 4

R: How about the Ringgit and the sen problem?
S1: So simple this time. Common sense. We are used to buy and sell.
S2: If the question like this ..so easy .. too easy (laugh)
S2: the numbers ringgit and sen easier to understand than that one. Using t^4 and t^2
R: so you are saying .. if the students are used to one thing ..in their life ..that will be easier for them in mathematics in the classroom?
S2: Yes. Much more practical. In the market, shops like that.. then using algebra t’s and x’s.

From Figure 3, it shows there is some confusion between two things. First, the students are more number influenced than algebra. Secondly there was confusion over the language ‘subtract ... from’ and index power where the students thought it illogical to subtract smaller from a bigger number. Some students in Group 2 and Group 4 found it difficult to solve word problem solving. The influence from the team leader is highly needed in solving the problem within 20 to 30 minutes group work. Group 3 was aided by the courseware all the time since the CD came with simpler facts, diagrams and animations. Team work fluidity did not come as vivid as it should be since few members in a team came late. Interviews discovered that late attendance is a result of poor attitude in mathematics among participants and this is very hard to remove within eight weeks even though from video camera recording they were happy to learn among them. The final discovery was team size of 5 in Group 2 and Group 4 created some confusion since too many ideas did not lead to any solution in problem solving unless the teacher interrupted. Group 3 which has 2 members only per computer terminal has less problem since the team size is smaller and looked more focused.

4.4 Discussion

The CL only group performed worst and this is not consistent to Felder (1991). The factors like motivation, attitude from the levels of preparedness, participation among team members was not so encouraging and this was contributed more with the difficulty in solving problems WPS. The CD only and CDiCL benefited from the use of multimedia interactive courseware due to the contents such as math facts and good animations did simplify their understanding and this help them in doing problem solving. The findings are consistent with (Morell et al., 2001; Zhang et al., 2008). It accepted that technology improves learning by taking teamwork to function actively in the classroom and this impact is felt differently in each group. Figure 3 proved some form of learning algebra was slowly developing by the use of CDiCL method. Participant observation methodology found that the team leader and teacher played a strong influence in any discussion including word problem solving in the learning process (Felder, 1991). Some team work failed to produce big impact due to the lack of motivation, interest and commitments level among team members since the biggest hurdle they found was solving word problems using their limited ability in mathematics and experience. This is quite prevalent among low achievers since from history they brought with them bitter experience in mathematics learning. Low achievers are little motivated and this attitude could somehow affect his other team mates as well. It was difficult to control in KBP since this low achieving students form a big number in newer applications for engineering education not only in Malaysia but also elsewhere (Zhang et al., 2008). Students who perceived their group as effective feel that their group members are more prepared and participated actively (Khalid et al., 2006). Team building must be properly organized because teamwork takes more time to click efficiently and the time frame of eight consecutive weeks may not be enough to push itself under the umbrella of collaborative learning. The other result is the group with less human interaction as found in smaller team work performed much better in the gain score because it deals with less problem in its team
such as non preparedness and participations thus they can focus more on the CD. If they understand the courseware in English they could do more problem solving. The contribution of this work is that team size of 2 was found to have fewer problems than a bigger team thus it is recommended the courseware is used in smaller team. Another contribution is even though students confessed to remember things longer obtained from the CD by taking Hermann Brain Dominance Model which might be useful as a start in solving word problem solving; more enhancements can be done if team members are trained in questioning skills as well. Cognitive and meta-cognitive skills resulted from good questioning technique could come along the way. This leads to a possible implementation of a Computer Supported Collaborative Learning environment in polytechnics (MoHE) in Malaysia in future.

5. Conclusion

The study set out to identify whether teamwork using an interactive multimedia CD in learning algebra has an impact on learning. The application of the Hermann Whole Brain Dominance model appears to be effective in producing good interactions between the team members and the teachers. The level of interactions however appears to moderated by the size of a team where fewer than 5 members per team have more positive interactions with the courseware thus producing better learning in mathematics. Future research could expand on the issues of how CDiCL can be used in teamwork leading to more fruitful CSCL since most polytechnics in urban cities in Malaysia have internet facilities.

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