Technology Enhanced Collaborative Learning for Learning of Calculus

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Abstract: - Conceptually and pedagogically, Computer-Supported Collaborative Learning (CSCL) has provided positive impact on mathematical learning. Much evidence have been documented on roles of CSCL approach in facilitating various types of learning and enabling new kind of learning experiences. In addition CSCL enable integration of technology in learning activities thus allowing for a “smooth learning flow”. Technology or computer-support learning allows more students to be actively thinking about information, making choices, and executing skills than is typical in teacher-centred learning. Moreover, when technology is used as a tool to support students in performing authentic tasks, the students are in the position of defining their goals, making design decisions, and evaluating their progress. The teacher's role changes as well. As students work on their technology-supported products, the teacher moves around the room, looking over shoulders, asking about the reasons for various design choices, and suggesting resources that might be used.

This study aimed to investigate the motivational and cognitive factors enhanced with the integration of an interactive software Autograph in comparison to the conventional way for teaching Calculus at the secondary level. The Autograph has 2D and 3D graphing capabilities for topics such as functions, transformations, conic sections, vectors, slopes and derivatives. A quasi-experimental research design was used for this study with three phases implemented: 1) Introductory lesson on use of Autograph, 2) Integrated collaborative learning in using Autograph software, 3) Assessment using motivation questionnaire, achievement test and the Paas Mental Effort Rating Scale. Teaching and learning utilizing the Autograph software was found to be more superior significantly, t (77) = 2.58, p < .05 compared to the conventional learning mode. However, conventional strategy learners incurs low mental effort compared to used of Autograph. These findings also suggested that in utilizing any technological tools, a comprehensive measures addressing issues of instructional efficiency is crucial especially when involving large scale and formal implementation of technology integration in teaching and learning.

Key-Words: - Technology-assisted learning, Computer-Supported Collaborative Learning, mental load, instructional efficiency index, Autograph software.

1 Introduction
The rapid progress of technology has influenced the teaching and learning of mathematics. Many efforts are being made to enhance the learning experiences of students in mathematics. In the traditional teaching of mathematics, students are passive recipients when teacher passes complete information to them. Hoppe [10] referred to technology as information and communication technologies in a broad sense including not only computers and networks of different types, but also new electronic devices and digital media in general. Use of technology as a tool or a support for learning with others allows learners to play an active rather than a passive role of recipient of information transmitted by a teacher, textbook, or broadcast. The student is actively making choices about how to generate, obtain, manipulate, or display information. Technology use allows more students to be actively thinking about information, making choices, and executing skills than is typical in teacher-led lessons. Moreover, when technology is used as a tool to support students in performing authentic tasks, the students are in the position of defining their goals, making design decisions, and evaluating their progress. Meanwhile, with the integration of technology such as computers software, students are encouraged to get deeper understanding of concepts [3. Furthermore, use of technology can also enhance understanding of abstract mathematical concepts by enhancing their visualization or graphic representation where it shows the relationships between objects and their properties. Deeper understanding of concepts will increase the ability of the students when working with mathematics (Oldknow, 2008). Findings from Tarmizi, Ayub, Abu Bakar, and Md.Yunus [22] also confirmed that students who undergone integration of technology in the learning of mathematics were found to be more enthused and were enjoying their lessons more than students who had undergone the traditional approach. Consistently, students’ perception on computer-
supported learning were found positive Ayub, Tarmizi, Abu Bakar, and Md. Yunus [2]. They found that the mean in students’ level of avoidance was lower for the group that used technology as compared to the traditional group. This indicated that the technology group would not avoid using the software during mathematical learning activity.

The teacher’s role changes as well. The teacher is no longer the centre of attention as the dispenser of information, but rather plays the role of facilitator, setting project goals and providing guidelines and resources, moving from student to student or group to group, providing suggestions and support for student activity. As students work on their technology-supported products, the teacher moves around the room, looking over shoulders, asking about the reasons for various design choices, and suggesting resources that might be used.

Alagic [3] explained that every piece of technology used would reduce teaching time. However, with proper planning of the lesson and its implementation, use of software such as the Autograph or the graphing calculator would not be considered a waste of time. This misconception is common among those who have never used the tools or who have been unsuccessful in their attempts. Learning to use learning software in the context of mathematics can be a very rewarding experience, enhances teaching, and not something that would diverts from the focus of the teaching. However much has to be explored on information communication technology integration or CSCL approach in teaching and learning. Technology indeed has changed the way classrooms operate, integrating multimedia during learning, online accessibility thus making teaching and learning more interactive and participatory [7].

2 CSCL with Autograph Software
Autograph environment has 2D and 3D graphing capabilities for topics such as transformations, conic sections, vectors, slope, and derivatives. In real-time, users can observe how functions, graphs, equations, and calculations. The Autograph software evolved in the mathematics classrooms of Oundle School, in United Kingdom, and this 3rd version has come of age to embrace all the possibilities. Autograph can be used for drawing statistical graph, functions, and vector and for transforming shapes. It also enables users to change and animate graphs, shapes or vectors already plotted to encourage understanding of concept. In mathematics class, the use of Autograph software enables students to visualize and further understand mathematical phenomenon in real life.

The use of Autograph is similar to the use of Geometer’s Sketchpad software (GSP) which allows learners to acquire skills and knowledge in using the computers whilst concurrently exploring the potentials of the software [2], [12] & [22]. Their findings indicated that integration of mathematical softwares in the teaching of mathematics supported with the use of learning module simplified learning and increases students understanding. Specifically, Stacey [19] contended that the use of software in mathematical learning enhanced the understanding of mathematical concepts related to variables and functions as well as provides motivation for the learning of Algebra.

2.1 Mathematics Achievement and Mental Load
Mathematics performance is the product of learning process. It is measured by tests or examinations. Scores, given through methods of calculations and correct answers represents performance shown in percentage. Mathematics performance in this study is based on scores obtained through a posttest given by the teacher after learning sessions for both the experimental and traditional group. Mathematics achievement assessment was also based on students level of procedural knowledge which refers to the rules, algorithms, or procedures students acquire and use to solve mathematical tasks. In addition, mathematics achievement was also based on conceptual knowledge which refers to the mathematical concepts students acquire and use to solve a mathematical problem [5].

Paas and collaborators explained that mental load is the aspect of cognitive load that refers to the amount of cognitive capacity or resources which is actually allocated to accommodate the demands imposed by the task [14], [15], [16], [17], [20], [21], [22] & [23]. Therefore, it can be considered to reflect the actual cognitive load. Mental effort is measured while participants are working on task.

Based on cognitive load theory, cognitive load can arise from three sources during instruction: intrinsic, extraneous and germane cognitive load [4], [14], [15], [16], [17], [20] & [21]. The first source of cognitive load is intrinsic cognitive load which is connected with the nature of the material to be learned. It is related to the integral complexity of an idea or set of concepts, and reflects the difficulty of learning the concept(s). This means that the existence of this cognitive load is due to the mental demands or the complexity of the information itself. For example,
the mental calculation of 2 + 4 has lower intrinsic load than solving a simultaneous linear equation. Thus, intrinsic cognitive load is unchangeable.

The cognitive or mental load are measured based on the assumption that people are able to introspect on their cognitive processes and to report the mental effort expended [6], [11], [15] & [21]. These measures typically use rating scale techniques to report the experienced effort or the capacity expenditure. Paas was the first to demonstrate this finding in the context of cognitive load theory. He developed a 9-point symmetrical category Likert Scale on which subject rates mental effort used to perform a particular learning task. The rating scale was a modified version of Bratfisch, Borg and Dornic’s (1972) scale for measuring perceived task difficulty. The numerical values and labels assigned to the categories ranged from very, very low mental effort (1) to very, very high mental effort (9). The use of rating scale techniques in cognitive load research sometimes appears to be questionable [6], [15] & [21]. However, it has been demonstrated that people are quite capable of giving a numerical indication of their perceived mental burden (for example, Gopher & Braune [8]) [24], [25] & [26].

Quite a number of experiments have proven the added value of the instructional efficiency measure by showing that the differences in effectiveness are not always identical to differences in efficiency (Halabi, Touvinen & Farley [9] and Salden, Paas and Merrienboer [18]. Further, these cases where the instructional efficiency scores were calculated had enriched knowledge about the effect that different instructional formats have on various aspects of the learning process.

Specifically, the objective of this study is to compare the effects of integrating technology in teaching and learning mathematics i.e. Autograph software on various performance variables and perceived efficacy constructs in the learning of Calculus at the secondary school level.

3 Research Methodology
The target population of this study was Form Four students in national secondary schools in Malaysia. The samples selected for this study were Form Four students from a randomly selected school after which permission was granted by the school management to conduct the study. The students were from intact classes and the lessons were conducted over nine weeks and the computer-supported learning was conducted in the school computer laboratory. Due to limited number of computers, the students were assign to group of three thus working collaboratively during the lessons. There were two groups, whereby Group 1 undergone the Autograph learning mode and Group 2 was the conventional learning group. The total number of students in Group 1 was 40 and Group 2 was 39 and the groups were equivalent because they are both from science stream.

The treatment group was first introduced to the use of Autograph software. The students in the Autograph group were provided with one computer installed with Autograph software. In this phase, the students were required to explore and be familiar with the software and its functions. In the second phase, students were introduced to the basic concept of Calculus utilizing several learning resources obtained from the web. This was followed by the ‘teaching and learning using the software’ phase. This phase involves instruction using the constructivist approach where students actively explore and participate in the learning activity guided by a learning module and their mathematics teacher or facilitator. Two modules were developed to enable the students to learn about Calculus at the secondary level. One was Traditional Approach Module and the other, the Autograph Learning Module. The students involved were initially surveyed for their familiarity with the Autograph software. None of them in the group were found to have used Autograph. The modules were developed to enable the students to be familiar with the Autograph. The module introduced the various features in the tools necessary to explore during the learning activity.

During the teaching and learning phase, students were given assessment questions to evaluate extent of short term learning. Teaching and learning phase for Autograph group were same with the control group. Students from the control group were also guided by the same instructional format.

At the end of the learning or treatment session, students were given an achievement test. To assess mental load, students were required to state their mental effort expended or used for each question they answered in assessment and achievement test based on Paas Mental Effort Rating Scale. It has 9-point symmetrical Likert scale measurement on which subject rates their mental effort used in performing a particular learning task. It was introduced by Pass (1992) and Pass and Van Merrenboer (1994). The numerical values and labels assigned into different range from 1: very low mental effort to 9: very high
mental effort.

Research hypotheses of this study are:

i. There is significant difference in mean performance on groups using Autograph technology and the conventional method in learning mathematics.

ii. There is significant difference in measure of mental load on groups using Autograph technology and the conventional method in learning mathematics.

iii. There is significant difference in instructional efficiency index on groups using Autograph technology and the conventional method in learning mathematics.

4 Results and Discussion

The means, standard deviations of the performance variable are provided in Table 1. For all statistical analysis, the 5% level of significant was used throughout the paper. The mean overall test performance for the Autograph group was 54.75 (SD = 17.05) and the mean overall test performance for the conventional group was 45.54 (SD = 14.61). The t-test of independence between groups test showed that there was a significant difference in mean test performance between Autograph group and conventional group, \( t (77) = 2.58, p<0.05 \). Further, planned comparison test showed that mean overall test performance of Autograph group was significantly higher than the conventional group. This finding indicated that the Autograph group had performed better in test phase than the conventional group.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental effort</td>
<td>Autograph</td>
<td>31</td>
<td>24.13</td>
<td>11.55</td>
<td>2.07</td>
</tr>
<tr>
<td>(Test phase)</td>
<td>Control</td>
<td>31</td>
<td>29.97</td>
<td>9.85</td>
<td>1.77</td>
</tr>
</tbody>
</table>

The mean mental effort during test phase for the Autograph group was 24.13 (SD = 11.55) and the mean mental effort during test phase for control group was 29.77 (SD = 9.85). The independent t-test results showed that there was significant difference in mean mental effort during test between Autograph group and conventional group, \( t(77) = -2.071, p<0.05 \). Therefore, mean mental effort during test phase of Autograph group was lower from those of conventional group.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>SE</th>
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</thead>
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<tr>
<td>Mental effort</td>
<td>Autograph</td>
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<td>1.050</td>
<td>.2072</td>
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<tr>
<td>(Test phase)</td>
<td>Control</td>
<td>31</td>
<td>.1024</td>
<td>0.918</td>
<td>.1930</td>
</tr>
</tbody>
</table>

The mean 2-D instructional efficiency index for control group was .1024 (SD=.918) meanwhile the mean 2-D instructional efficiency for Autograph group was .6379 (SD = 1.05). The results also indicated that there was significant difference on mean 2-D instructional efficiency index between the Autograph group and the conventional group, \( t(60) = 2.138, p < .05 \). This suggests that learning mathematics by integrating the use of Autograph was more efficient than using conventional strategy mode of learning.

Table 3: Comparison on instructional efficiency

<table>
<thead>
<tr>
<th>Variables</th>
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<th>N</th>
<th>M</th>
<th>SD</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-D instructional</td>
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<td>1.050</td>
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<tr>
<td>efficiency</td>
<td>Control</td>
<td>31</td>
<td>.1024</td>
<td>0.918</td>
<td>.1930</td>
</tr>
</tbody>
</table>

5 Conclusion

In this study, based on the 2-D instructional efficiency index calculation, utilizing Autograph Learning Module was instructionally more efficient compared to conventional method. Hence use of Autograph has enhanced learning conditions and has reduced extraneous cognitive load which in turn can create optimal learning condition. Therefore, this shows that although dynamic software may provide positive impact upon learners’ thus becoming potential tools in teaching mathematics in Malaysian secondary school level, the use of Autograph software need to be further considered in its utility and feasibility.

It maybe concluded that findings of this study were in favor of the Autograph strategy in teaching Calculus.
However, this conclusion should lead to further investigations. Several factors that may further investigations are time constraints, lack of focus on the students’ part during the teaching and learning activity, teachers’ factor, and improved learning module for the students. These findings also suggested that in utilizing any technological tools, a comprehensive measures addressing issues of instructional efficiency is crucial especially when involving large scale and formal implementation of technology integration in teaching and learning. It maybe concluded that although technology can enhance learning and teaching, however it does not necessarily enhance achievement among learners. Therefore, with systematic planning of instructions and good learning package, learning mathematics using Autograph will give new view in mathematics teaching and learning.

References:


