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Cognitive workload and mathematics instructional design for non-users of mathematical software applications

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Abstract

This study investigated the cognitive load of learners who are non-users of mathematical software applications, including Maple, when they worked on worksheet with printed Maple commands in the learning of Calculus II. For this purpose, 36 students aged 21-22 years were randomly selected to complete the worksheet and the questionnaire after each lesson for four lab lessons consecutively. A total of 136 worksheets and completed questionnaires were collected and analyzed. The results showed that there were no significant differences in the cognitive workload among learners of different ability levels or between both sexes in general. However, when controlling the ability groups, it was also found that the exam score of the female respondents in the medium ability group correlated negatively with the mental effort load, psychological stress load and competency. It was also found that female respondents in the lower and medium ability groups scored significantly higher in the cognitive workloads compared to their male counterparts. The findings also show that respondents who experienced higher cognitive loads performed better in their lab worksheet and final exam. Analysis of students' written remarks revealed that respondents were motivated to learn using such worksheet. The worksheet was believed to empower learners who have limited access to and minimal knowledge of mathematical software applications to use Maple in performing integrations. This method of teaching is successful in negotiating technology into the highly exam-oriented teaching and learning environment, hence the mathematics courses.

1. Introduction

With the advent of the technological age, a variety of mathematics software applications has been developed to enhance the learning of mathematics. Despite the availability of numerous softwares, mathematics educators in general are still slow in adopting the technology. Studies have shown that the lack of teachers with sufficient knowledge and skills in conducting ICT-related activities is the main factor that hinders the extensive use of technology in Malaysian classrooms [8, 17].

In some learning institutions where paper and pencil examination is the major assessment tool, teaching tends to take the center stage in the classrooms while hands-on practices are less favoured. However, most developers of instructional materials, specifically those that incorporate technology generally assume that all learners have full access to technological software as well as technological infrastructure in the classrooms. Zaidatun Tasir and Ong [18] pointed out that most of the printed self-instructional modules for courses in Malaysia that incorporate technology usually include guided programmed exercises that emphasize the technology more than the learning quality. They attributed the long sentence structure as well as the need to search and match texts with window elements as stumbling blocks to learners when working on the assigned exercises.

Learners who are non-users of technology spend most of their time doing mathematics in classrooms with minimal technological support and only got to participate in lab activities on rare occasions. As such these learners are largely under-prepared for technology. In view of this, it will be more helpful if these learners can gain access to self-instructional module that minimizes the extraneous cognitive demand on the technical command but concentrates more on solving the assigned mathematics problems. Since the main concern for teaching learners who are under-prepared for technology is to learn mathematics using technology, they should not be encumbered with unnecessary technical know-how. Compelled by the need to bridge the gap that has just been discussed, this study aims to explore the possibility of allowing students who are non-users and under-prepared for technology to experience doing mathematics with technology supported by a specially designed lab worksheet. Besides that, it also seeks to introduce an alternative teaching method to negotiate technology into the highly exam-oriented teaching and learning environment, hence the mathematics courses.

2. Learning and human cognition

Student-centred approaches such as inquiry-based learning, problem-based learning, experiential learning, and constructivist learning are highly recommended for varying and improving instructional practices. Despite these well established teaching and learning approaches, Kirschner, Sweller and Clark [9] argue that no instructional procedures are effective without reference to the structures of human cognitive architecture. Consequently, no successful learning can occur without proper cognitive load management [12]. By the same token, no successful learning can happen when learners are overloaded with complex learning materials [12].

To further understand the complexity of learning process, Clark and Mayer [1] noted that learners can process only a limited amount of information in working memory at any one time. They believe that our memory system constrains the way we learn and suggest that it is the learner’s mental or cognitive processing that leads to learning. Mayer [11] also observes that learning occurs when learners know how to select relevant information and focus on important training content needed for building new knowledge and skills.

Confronting various theories and beliefs on effective learning, one is often distracted from the fundamental processes needed to devise effective learning procedures. Therefore, it is imperative to go back to the basic definition of learning as a point of departure. Kirschner et al. [9] define learning as a change in long-term memory. This definition is crucial in Cognitive load theory (CLT) which concerns with the instructional implications of working memory limitations, and together they can provide coherent explanations for effective instructional practice [16]. CLT is an instructional theory that deals with learners’ cognitive process and instructional design [2, 16]. The theory revolves around three forms of cognitive load: intrinsic, extraneous and germane load. Central to this theory is the reduction of extraneous cognitive load and allowance of more working memory to be devoted to the intrinsic and germane cognitive loads to enhance learning [16]. Kalyuga [5] pointed out that extraneous cognitive load is caused by cognitive processes that are not necessary for learning. He stated that for effective and efficient instructional design CLT is pertinent in generating learning conditions that require the learners to keep their working memory within its capacity limits.

In spite of the importance of keeping a good balance between extraneous cognitive load and working memory, many instructional designs are adopted by mathematics practitioners without any explicit reference to the learner's knowledge level or experience in a particular domain [7]. Kirschner et al. [9] distinguished two types of instructional guidance as the minimal guided discovery learning and the fully guided direct instructional guidance. Hitherto, there are ongoing disputes about which instructional guidance is best for teaching. This study shares the same view with the proponents of direct instructional guidance and believes that during teaching, novice learners should be provided with full information and not be left to discover the concepts and procedures by themselves. As promoted by the CLT, effective instructional procedure should keep learner's working memory load within its capacity limits. It is also known that learners' background and the environmental contexts contribute to the cognitive load (Paas & Van Merriënboer, 1994, cited in [14]). Therefore, in an environment where technology is not actively utilised, the introduction of technology in mathematics should neither harm learners by overloading their learning capacities nor provoke the underpinning institutional culture.

3. Research Questions

This study investigated the cognitive workload of learners learning integration with Maple within limited time and condition in which technology is not a component of the examination but required by the syllabus. Based on the premise that learners who are under-prepared for technology have limited time and accessibility to technology, this study initiated the use of worksheets with Maple commands printed alongside each question to remove the extraneous load from the learners in remembering the commands of the software. At the same time it proposed to reduce the split-attention situation whereby learners are required to search-and-match in recalling some key elements in the process of learning new knowledge and skills.

The research questions that examine the effect of the specially designed lab worksheets on learners' cognitive load are:

1) Do the worksheet score, the exam score and the cognitive load correlate with each other?
2) Does the cognitive load differ significantly across the sexes and different ability groups?
3) How do learners who are new to Maple software respond to the use of the specially designed worksheet in the learning of integral calculus?

The hypotheses of the study are:

1) H_o: There is no significant correlation between the worksheet score, the exam score and the three components (mental, psychology and competency) of the cognitive load.
   H_1: The worksheet score, the exam score and the three components (mental, psychology and competency) of the cognitive load correlate significantly.
2) H_o: There is no significant difference in the means of the cognitive load between the sexes and between different ability groups.
   H_1: The cognitive load differs significantly between the sexes and between different ability groups.

4. Methodology

The population of this study consisted of all students who took Calculus II at diploma level. Their age ranges from 21 to 22 years old. The first author cum researcher conducted four lab lessons on solving integral calculus with Maple software. At the end of the study a total of 136 sets of data were collected from a random sample of 34 participants from four lab lessons.

In this study, the teaching of Calculus II was based on the programme schedule and the scheme of work set by the Faculty of Mathematical Sciences. The syllabus required the students to attend four hours of classes a week, including lectures and tutorials. In addition a weekly one hour lab practice with Maple software was included for knowledge enhancement but was not to be tested in the exam. The intended task of intervening with specially designed worksheets in this study was to complement and provide additional support for students' normal lab lessons. The contents of the worksheets included: definite and indefinite integration, integration by substitution, integration by parts, and trigonometric substitution. All participants had no knowledge of Maple software and about 60% were lower-achievers with GCPA less than 3.0.

The researcher was aware of the expertise reversal effect [7] which accounts for the phenomenon in which an effective instructional technique for inexperienced learners may not be effective and may even have negative consequences when applied to more experienced learners. In order to minimize the occurrence of the expertise reversal effect, the selected sample was restricted to learners who used Maple for the first time.

i. Cognitive workload

The respondents of the study were considered to be under-privileged for technology since they could only gain access to and have hands-on practice using the Maple software one hour and once a week in the designated lab. There was a concern that if these respondents were to learn mathematics via technology under time constraint, a high cognitive load was very likely to be expected. This speculation is based on the complexity of Calculus and the complicatedness of Maple commands which are specific and exclusive.

Focusing on the role of CLT on learning difficulty, the researcher adapted a seven-item questionnaire developed by Ou Yang, Yin and Wang [8] to measure learners' cognitive load when learning in a technologically enhanced (PDA device) environment. All items were rated on a 9-point Likert scale ranging from 1 (very, very low) to 9 (very, very high). The questionnaire showed a high reliability with Cronbach alpha coefficient of .959. The researcher further divided the seven items to three new components: *mental load*, *psychological load*, and *competency*. The *mental load* and *psychological load* which consisted of three items each were named after the subscales employed in the Subjective Workload Assessment Technique (SWAT) developed by Sheridan and Simpson (cited in [3]) to rate the intensity of respondent's workload of a task. SWAT has been reported to be used widely to detect the workload variations in achieving work goals in real-time assessments. While the third component *competency* has one item "Using MAPLE is ……to me" rated on a 9-point Likert-type response scale ranging from 1 (very, very easy) to 9 (very, very difficult). This single subjective self-rating item was modelled after Kalyuga et al. [6] as well as Pass and Merrienboer's [13] CLT study to investigate the cognitive load. The reliability for both *mental load* and *psychological load* showed Cronbach's alpha coefficients of .931 and .888 respectively. The breakdown of the seven items is displayed in Table 1.

Table 1: Items on three workload subscales

Category	Items
Mental	Completing this worksheet is (**1** very, very **easy**...**9** very, very **difficult**) to me. The thinking required for learning the materials in this worksheet is (**1** very, very **easy**...**9** very, very **difficult**) to me. Answering the questions in the worksheet is (**1** very, very **easy**...**9** very, very **difficult**) to me.
Psychological	Learning the materials in this worksheet is (**1** very, very **fun**...**9** very, very **tiring**) to me. In the process of this learning activity, my frustration is (**1** very, very **small**...**9** very, very **big**). When answering the questions in the worksheet, my stress is (**1** very, very **small**...**9** very, very **big**).
Competency	Using Maple is (**1** very, very **easy**...**9** very, very **difficult**) to me.

After the completion of the learning task in each lab lesson, the respondents were immediately asked to rate the specific tasks with regard to mental effort load, psychological stress load and their competency with Maple. They were also asked to write down their thoughts about the learning of and doing integrations using Maple.

ii. Worksheets

Maple is a licensed software and could only be installed in the desktop computers in the lab. Hence, students get to learn and have hands-on practice on integrations using Maple for only an hour a week. Based on the design of the study the researcher did not put in extra time besides the allocated classroom hours to teach Maple. The competency of using the Maple software depended entirely on the effectiveness of the worksheets.

The researcher employed worksheets adapted from the Maple Labs Calculus II available at http://math.georgiasouthern.edu/math/faculty/MapleLabs/Maple_labs.html. In the worksheet, Maple commands were printed and displayed in red in each question (see figure below). The purpose of using the command was explained briefly after each command. Respondents did not have to memorize the Maple commands when solving problems on integration in the worksheets. They just followed through the commands given in the worksheet. Reinforcement exercises were added at the end of each worksheet to check the respondents' competency to apply the appropriate commands.

Always start by loading the student package (use colon to suppress printout):

```
>with(student):
```

1. Define the function $f(x) = \dfrac{1}{16+x^2}$:

```
>f:=1/(16+x^2);
```

Find the indefinite integral of the function:

```
>int(f,x);
```

1. $\int \cos(3x)e^{4x}dx$

```
>int(cos(3*x)*exp(4*x),x);    #this is the simplest command to get the answer.
```

```
>Int(cos(3*x)*exp(4*x),x); value(%); #if you want to see the integral displays on the screen.
```

Use the second command from number 1 for the rest of the lab unless otherwise stated.

2. $\int_0^{\pi/2} \cos(3x)e^{4x}dx$

```
>Int(cos(3*x)*exp(4*x),x=0..Pi/2); value(%);        # to get the exact value

>Int(cos(3*x)*exp(4*x),x=0..Pi/2); evalf(%);        # to get a numerical value
```

Sample exercise for Improper Integrals:

3. Consider $\int_0^{\infty} \frac{1}{x^2+1}\,dx$

a) Solve by hand without using the computer.

b) Now use Maple to verify your answer from part a). Be sure to write down your output from the computer.

First we need to define the function $f(x) = 1/(x^2+1)$, then we can integrate.

```
>f:=x->1/(x^2+1);

>Int(f(x),x=0..infinity);value(%);
```

Reinforcement exercise for Improper Integrals:

4. Consider $\int_{-\infty}^{\infty} \frac{e^x}{1+e^{2x}}\,dx$ Recall: In Maple e^x = exp(x)

a) Solve by hand without using the computer. (HINT: use substitution)

b) Now use Maple to verify your answer from part a). Write down the commands that you used as well as the output from the computer.

c) List the command used in 4b) which is different to the command used in Question 3b).

Figure1: *examples of the worksheet*

As shown in the figure above, the lab worksheet consisted of a series of Maple commands printed besides each solution step to a given problem. Respondents were required to write down the output without having to memorize the Maple commands in order to solve a given problem. To alleviate the problem of overloading learners' working memory, the exercise questions were organized from basic to more difficult as the lessons progressed. The topics of the lab lessons in the research study were taken from Techniques of Integration and Improper Integrals. A total of four lab lessons were conducted. Each lab lesson took one hour to complete.

Lab 1 started with basic Maple commands for doing integration, Lab 2 concentrated on solving the indefinite and definite integrals, Lab 3 dealt with integrations of trigonometric functions and Lab 4 focused on improper integrals. Each worksheet was supplemented with extra questions without the Maple commands to check respondents' competency in using the software. Respondents were also asked to solve one or two simpler questions in the worksheet by hand to counter check their procedural skills. The worksheets were collected immediately after the class had ended and were scored by the researcher. The organization of the whole series of lab lessons followed closely the weekly scheme of work without disrupting the original classroom time-table and the allocation of classrooms by the time-table committee. The whole process took five weeks to complete. The marks for questions on integration in the final exam were also taken for analysis.

5. Results and Discussion

In the analysis of data, the participants were divided into three ability groups based on their formative test marks in the topic of Techniques of Integration (low: 1-45 marks; medium: 46 -69 marks; high: 70 and above). The results also examined and compared the differences in performance between the sexes. The dependent variables included: the worksheet scores, the three cognitive loads, the final exam marks and respondents' written reflections on learning calculus with Maple software. Table 2 presents the descriptive statistics on the mean of the quantitative data for the five dependent variables between the sexes and different ability groups.

Table 2: Means of quantitative variables between ability groups and genders

Ability Group/ Gender		Mental		Psychological		Competency		Worksheet		Exam	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Low (44)	M (26)	9.71	5.814	9.39	5.947	2.58	1.901	2.74	2.048	28.23	13.533
	F (18)	14.00	5.531	12.44	4.829	3.61	1.754	1.46	0.927	31.72	7.706
Med (50)	M (21)	7.77	4.439	7.59	4.125	1.95	1.647	5.40	2.355	54.27	7.548
	F (29)	12.41	5.294	11.25	5.386	3.45	1.956	4.23	2.314	61.31	5.399
High (42)	M (14)	10.71	4.513	9.86	5.096	2.86	1.791	7.20	2.886	87.85	8.047
	F (28)	10.25	5.872	9.21	5.432	2.86	1.880	6.96	1.196	78.93	6.879

Note: (sample size); Med: medium; M: male; F: female.

The results in Table 2 show that female respondents in low and medium group scored higher in the three cognitive load subscales compared to male respondents, indicating that they experienced more mental effort and psychological stress when dealing with calculus using Maple. However, they perform better in their worksheet and final exam than their male counterparts. These are supported by the results (see Table 3) that female respondents' final exam correlated negatively with mental load (r = -.306, p < .01), psychological load (r = -.307, p < .01) and competency (r = -.244, p < .05). Their final exam was found to correlate significantly and positively with worksheet score (r = .753, p < .01).

Table 3: Correlations between the dependent variables

Exam (gender)	Mental	Psycho	Competency	Worksheet
Exam (male)	n.s.	n.s.	n.s.	.683 (**)
Exam (Female)	-.306(**)	-.307(**)	-.244(*)	.753(**)

*p < .05. ** p < .01., n.s. = not significant

Similarly the final exam and worksheet scores for male respondents were found to be significantly and positively correlated (r = .683, p < .01). The male respondents in the high ability group scored higher than their female counterparts in the cognitive load, worksheet and final exam. Their final exam correlated significantly with the worksheet score (r = .435, p < .01). Although their exam marks correlated negatively with the mental load, psychological load and competence, the correlations were not statistically significant at p < .05.

The overall correlations are shown in Table 4. Mental load correlated positive and significantly with psychological stress (r = .864, p < .01) and competency (r = .834, p < .01). Worksheet scores correlated negatively with psychological stress (r = -.179, p < .05) and positively with exam marks (r = .692, p < .01). Taking all these into consideration, the null hypothesis stating that there is no significant correlation between the worksheet score, the exam score and the three components (mental, psychology and competency) of the cognitive load is rejected.

Table 4: Correlations between the dependent variables

	Mental	Psycho	Competency	Worksheet	Exam
Mental	1	.864(**)	.834(**)	-.155	-.083
Psycho	.864(**)	1	.844(**)	-.179(*)	-.114
Competency	.834(**)	.844(**)	1	-.085	-.057
Worksheet	-.155	-.179(*)	-.085	1	.692(**)
Exam	-.083	-.114	-.057	.692(**)	1

*p < .05. ** p < .01.

Subsequent analysis used independent sample t-tests to test the mean differences in the mental load, psychological load, competency, final exam mark and worksheet score of both sexes. Meanwhile, analysis of variance was conducted to examine the cognitive load between different ability groups. Heavy cognitive workload is indicated in high scores in the mental load, psychological load and competency. By the same token, this is also indicative of the use of less effective worksheets.

From the results, the female respondents displayed much higher mean scores in the three components of cognitive load compared to their male counterparts. However, there was no significant difference in the mental load, psychological load, and competency between male respondents ($\bar{x}_{\text{mental}}$ = 9.26, SD = 5.134; $\bar{x}_{\text{psychological}}$ = 8.85, SD = 5.178; $\bar{x}_{\text{competency}}$ = 2.42, SD =1.798), and female respondents ($\bar{x}_{\text{mental}}$ = 11.99, SD = 5.693; $\bar{x}_{\text{psychological}}$ = 10.77, SD = 5.364; $\bar{x}_{\text{competency}}$ =3.27, SD = 1.884; $p > .05$). Similarly, the ANOVA results showed no significant difference across the means of the three components at $p <.05$ level for the different ability groups ($\bar{x}_{\text{mental}}$ = 3.16, F (2, 137) =.451, p=.638; $\bar{x}_{\text{psychological}}$ = 3.26, F (2, 137) =.272, p=.763; $\bar{x}_{\text{competency}}$ = 2.93, F (2, 137) =1.325, p=.270). Hence, the null hypothesis that there is no significant difference in the means of the cognitive load between the sexes and between different ability groups could not be rejected.

However, results of t-tests in Table 5 show that when controlling the ability groups, male respondents in low ability group were found to score lower in the mental load than the female respondents in the same ability group. Statistical significant difference was observed in the mental load for male ($\bar{x}_{\text{mental}}$ = 9.73, SD = 5.814), and female respondents ($\bar{x}_{\text{mental}}$ =14.00, SD = 5.530; t(137) = -2.442, p = .019). The eta squared for mental load = .042. In other words, although statistically significant, the difference in the means was small according to Cohen [3].

In the medium group, male respondents again scored lower than their female counterparts in mental load, psychological load and competency. All three subscales were statistically significant between male ($\bar{x}_{\text{mental}}$ = 7.77, SD = 4.439; $\bar{x}_{\text{psychological}}$ =7.59, SD = 4.124; $\bar{x}_{\text{competency}}$ =1.95, SD = 1.647) and female respondents ($\bar{x}_{\text{mental}}$ =12.41, SD = 5.294; t (137) = -3.401, p = .001; $\bar{x}_{\text{psychological}}$ = 11.25, SD = 5.386; t (137) = -2.720, p = .009; $\bar{x}_{\text{competency}}$ = 3.45, SD = 1.956; t (137) = -2.956, p = .005). The eta squared for mental load = .08 (medium), eta squared for psychological load = .05 (small) and eta squared for competency = .06 (medium). The differences in the means for mental load and competency were quite substantial according to Cohen [3]. In other words, female respondents in the study experienced higher mental load and showed lower competency than the male respondents. In the high ability group, no statistically significant results were obtained for the three components of the cognitive load.

Results in the worksheet score show that male respondents in the low ability group scored higher ($\bar{x}_{\text{worksheet}}$ = 2.74, SD = 2.048) than female respondents ($\bar{x}_{\text{worksheet}}$ = 1.46, SD = .926; t (137) = 2.793, p = .008; eta squared = .05). Those in the high ability group also scored higher in the exam marks ($\bar{x}_{\text{exam}}$ = 87.85, SD = 8.04) than their female counterparts ($\bar{x}_{\text{exam}}$ = 78.92, SD = 6.87; t (137) = 2.793, p = .008; eta squared = .09). However, in the medium ability group, female respondents scored significantly higher in the exam marks ($\bar{x}_{\text{exam}}$ = 61.31, SD = 5.39) than male ($\bar{x}_{\text{exam}}$ = 54.27, SD = 7.54; t(137) = -3.884, p = .000; eta squared = .1). Table 5 displays the results.

Table 5: t-tests between the sexes

Components	Gender	Low		Medium		High		t	Sig.	Estimated effect size
		Mean	SD	Mean	SD	Mean	SD			
Mental	Male	9.73	5.81	7.77	4.44			-2.442^{L}	.019*	$.042^{L}$
	Female	14.00	5.53	12.41	5.29			-3.401^{M}	.001**	$.079^{M}$
Psycho	Male			7.59	4.12			-2.720	.009**	.052
	Female			11.25	5.38					
Competency	Male			1.95	1.64			-2.956	.005**	.061
	Female			3.45	1.96					

Worksheet	Male	2.73	2.05					2.793	.008**	.05
	Female	1.46	.926							
Exam	Male			54.27	7.54	87.86	8.04	-3.884^{M}	.000**	$.101^{M}$
	Female			61.31	5.39	78.93	6.87	3.747^{H}	.001**	$.09^{H}$

$*p < .05$. $**p < .01$.

Note: Means and SD that are not significant are not printed in the table.

A total of 81 written remarks were obtained from 136 lab worksheets in the four lab lessons. The written reflections were analysed and categorized into groups by matching the key words. Emerging themes from respondents' responses included: affection (e.g. like, interesting, want to), motivations (e.g. add more exercise, give more questions), content and technical difficulty (e.g. confused, difficult) and, learning environment (e.g. time, test). Table 6 shows the classifications of the written remarks.

Table 6:
Example of some written remarks

Category	Some examples	%
Affection	Interesting to learn new skill; interesting and not boring; I want to practice more on the worksheet; I like Maple;	20.9
Motivation	Give more exercises; give more challenging exercise questions; give us take home assignments to practice more on Maple; I want to come to attend the Maple lab lesson every Thursday afternoon; give more tricky questions; use Maple in our quizzes.	33.3
Content and technical difficulty	The question is long and difficult to understand; forget the spacing and symbols; make mistakes when writing the expression.	19.8
Learning environment	Add more time to the lab lesson; computer not functioning; computer slow to load.	26

It was found that 20.9% expressed affection, 33.3% of the remarks were related to motivation, and 19.8% experienced content and technical difficulty. The remaining 26% indicated dissatisfaction with the learning environment.

6. Conclusions

This study investigated the cognitive workload of learners when learning integration using Maple under a tight schedule and restricted accessibility to the technology. The study employed a specially designed lab worksheet which the suitability of its usage was examined from the aspect of the cognitive load for learners who are under-prepared for technology. Using Pearson's correlation, the overall result shows that the worksheet score correlated weakly and negatively with the psychological load and has a positive and moderately strong correlation with the exam score. In other words, respondents enjoyed learning integration with the use of the specially designed worksheet. Interestingly, respondents who fared well in the worksheet also performed equally well in the exam. These observations are reflected in respondents' written remarks in which 20.9% of the respondents expressed positive affection towards the use of the worksheet and 33.3% expressed positive attitude to learn Maple. It was beyond the researcher's expectation that some of the respondents requested for more challenging questions and asked to implement quizzes using Maple. This shows that the lab lessons could have indirectly boost the respondents' confidence in using Maple to learn mathematics despite the presence of hindering factors such as time and infrastructure as well as being novice to the technology.

The results of the study also show that overall there was no significant difference in cognitive load when treated separately between the sexes and learners of different ability groups. The findings show that the mean scores for mental effort load and psychological stress load in the learning of integration using Maple decreased respectively from low, medium to high ability group but the result was not statistically significant.

However, differences in cognitive load started to emerge when both sexes were controlled in different ability groups. It was found that female respondents in medium ability group in the study experienced significantly more mental effort, more psychological stress and were less competent with Maple than their male counterparts in the same ability group. But they scored significantly better than the male respondents in their exam. This could be due to the extraneous load that could have acted as a positive impetus that pushed these female respondents to perform better in their final exam.

Although there are some challenges dealing with the mental load and competency, a relatively lower percentage (19.8%) of respondents expressed in their written remarks that they had experienced some difficulties in understanding the questions and the given instructions in the worksheet . However, this feedback was expected and it also corresponds to Zaidatun Tasir and Ong's [18] findings.

In general, it could be deduced that the specially designed worksheet does not increase excessive cognitive load on learners who are novice of, as well as under-prepared for technology. In other words, displaying guided instructions in the worksheet could help to reduce some psychological stress in the learners when they are required to learn new mathematics skills with new technology within a limited time and accessibility. As such, the specially designed worksheet is believed to be able to empower novice learners to use Maple to perform integration. Evidently this method of teaching is successful in negotiating technology into the highly exam-oriented teaching and learning environment, hence the mathematics courses.

It is interesting to find that the results of this study concur with Shih et al. [14] that there are no significant differences in cognitive load among different ability groups but contradict that of Ou Yang et al. [10] that cognitive load is the key factor affecting students' learning using electronic tutoring system. These observations, however, need further confirmation from a larger sample to rigorously examine the impact of learner's ability on the cognitive load. Future study may also investigate the cognitive load on teachers who are not competent with new technology. Researchers who intend to further investigate this aspect of learning may also include the comparison between the different cognitive loads involved when using different mathematical technology in teaching various topics, or may consider exploring expertise reversal effect [7] among experienced and novice learners.

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