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An Empirical Study on E-Learning versus Traditional Learning among Electronics Engineering Students

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Abstract: In academia, it appears that many lecturers are still contented in using traditional lecturing methods. Cultivating the use of e-learning requires proper understanding of its difference with traditional learning. In this study, the difference between e-learning with traditional learning was descriptively and empirically investigated, with an emphasis on a module in Electronics Engineering known as Fundamentals of Operational Amplifier. This research involved first-year electronics engineering students from the Faculty of Engineering and Technology, Multimedia University Malaysia. Upon completion of the module, they were asked to participate in a survey and quiz. The data collected were analysed using the normality, reliability and Analysis Of Variance (ANOVA) tests. It was found that e-learners had significantly different results compared to traditional learners. They also exhibited better performance and agreeability in the quiz and survey respectively. In concurrence with the findings of previous researchers, this study suggested that graphical lessons can have a substantial effect on the acceptance of e-learning. The findings of this study can be used to not only improve the course design on Fundamentals of Operational Amplifier but also as a platform to develop greater and more effective learning outcomes in Electronics Engineering and other fields. Generally, although more analyses may be required to verify the existing findings in e-learning, this study can still serve as precursory information regarding the flexibility and effectiveness of e-learning in electronics engineering courses.

Keywords: E-Learning, Lecturing, Fundamentals of Operational Amplifier, Traditional Learning, Electronics Engineering

Introduction

In recent years, there has been an increased focus on e-learning. In engineering education, previous studies generally found a positive relationship between traditional learning and e-learning (Rodríguez *et al*., 2013; Soler, 2010; Soler *et al*., 2006; Ubell, 2000). Previous developments on e-learning have involved computer-based assessment platforms for teaching and learning, Artificial Intelligence applications and autocorrect functions in e-learning platforms (Rodríguez *et al*., 2013; Soler, 2010; Soler *et al*., 2006).

However, it appears that these studies on e-learning have yet to examine the impacts of using video demonstrations to prove the derivations of circuit designs and circuit analyses, both of which are topics covered in most electronics engineering subjects. Many lecturers in electronics engineering are reluctant to change their traditional methods in delivering lectures as they refuse to leave their comfort zone of Power Points and slides. In addition, proving derivations of circuit designs and circuit analyses is still done by many lecturers manually (for instance, with marker pen writings on the whiteboard). These lecturers may feel that it is much of a hassle to integrate technology into their lectures. Moreover, the proofs of derivations and analyses are only written and explained once in a traditional classroom. If students were to miss that particular class, they have to either figure out the derivations on their own afterwards or just be left incapable of attempting such derivations or analyses. Consequently, the learning in this case becomes very teacher-centred (or in other words, traditional), where students rely very much on their lecturers and work is done alone with little to no collaborations.

Hence, this study proposes a new e-learning module known as FUNDA OP-AMP specifically for learning the subject Fundamentals of Operational Amplifier in Electronics Engineering. This e-learning module is developed in order to inculcate students and lecturers with 21st century learning. This module demonstrates the processes of derivations in circuit designs and analyses through videos. With this module, the work steps can be played back as many times as the students want. If students were unsure of an important section on derivation in class, they would be able to go through this module to clarify the uncertainty. Their understanding can also be improved by going through the module several times.

This study involved 2 groups of students, namely the e-learning group (exposed to the FUNDA OP-AMP module) and the traditional learning group (exposed to traditional lecture methods). The e-learning group was to be engaged in a more student-centred manner. The FUNDA OP-AMP module was released to the e-learning group prior to the actual lecture class in order for this group of students to do some self-learning at home before they come to class. In the lecture class, this group was allowed to speak out their doubts and uncertainties on the subject face-to-face with the lecturer/instructor both individually and in group discussions.

Literature Review

The definition of e-learning has evolved over the past few decades and continues to change. Although the origin of the term is uncertain, it is believed that its first use was in 1999 when a computer and software company in Atlanta offered and labelled their online courses coupled with live instruction as e-learning (Friesen, 2015). This definition suggested that e-learning was restricted to only virtual learning without face-to-face intervention, a constraint that has become less true with the later development of e-learning.

It is important to make aware of the purpose of e-learning. Apart from improving students' performance and cost effectiveness, e-learning also aims to be highly personalised for each learner. This has been suggested by Thorne (2003) when he described e-learning as the process of engaging the ordeals of customising learning and development to the necessities of students. In order to meet the objectives of e-learning, social interaction in a traditional classroom is equally as important as the utilisation of an individualised online system.

According to Ubell (2000), one of the first approaches in e-learning involves databases knowledge, which is an underlying subject in computer engineering. In 2006, the technical engineering team in computer management and systems in the University of Girona found that the use of e-learning platforms not only increased the students' motivations in studies but also improved their academic results (Soler *et al*., 2006). The most relevant achievement in this study was a tool that autocorrects the exercises related to the subject. This tool allowed teaching staffs to realise and acknowledge the learning level and possible deficiencies of the students.

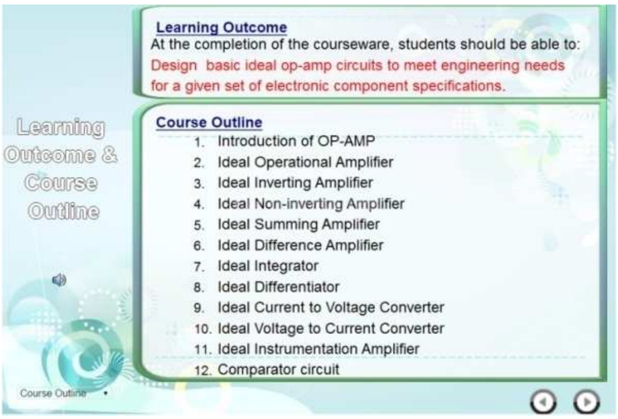
Some developments included a Computer-Based Assessment (CBA) e-learning platform distinguished by the automation of every teaching/learning feature of the student (Soler, 2010). With the CBA, it was found that an interaction existed between the lecturer and engineering students all along the evaluation process. In this process, the delivery of the course exercises, its correction and the feedback generated is performed by the system automatically. Rodríguez *et al*. (2013) proposed that the Artificial Intelligence techniques were integrated into the e-learning platform of the engineering laboratory practices (System and Automation Engineering Laboratories) to form a teacher-cognitive system combination.

E-learning can be used together with the traditional face-to-face learning as well. This mode of learning would then be known as blended learning. Many studies concur that blended learning is a hybrid mode of learning which harnesses both face-to-face learning and online learning (Bersin, 2004; Boyle *et al*., 2003; Garrison and Vaughan, 2008; Lim and Morris, 2009; Mortera-Gutierrez, 2006). For example, Graham (2006) in the first handbook of blended learning defined blended learning as the combination of two historically separate models of teaching and learning, namely the traditional face-to-face learning systems and distributed learning systems. It is worth noting that the term distributed learning systems is an umbrella term for any technology-led learning. E-learning can go hand-in-hand with traditional learning since it combines the Internet and digital media with conventional classroom structures which necessitates the physical co-presence of the learners and educator (Friesen, 2015).

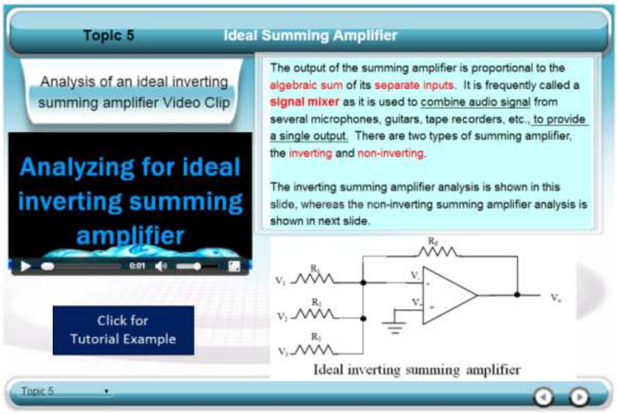
FUNDA OP-AMP E-Learning Module

This section demonstrates the implementation of the FUNDA OP-AMP module. This module is created using the mixture of several functions, namely Lecture MAKER NS, Video Scribe and Camtasia Studio 8. The complete version is found in an executable file (.exe format). Learners are able to access the courses at any computer using either a Windows or Linux operating system. The developed FUNDA OP-AMP e-learning module contains lecture notes, video demonstrations on derivations of circuit designs and circuit analyses, laboratory work video demonstrations (to encourage evidence-based learning), tutorial examples and a quiz with an autocorrect function to allow students to instantaneously learn from their mistakes.

Figure 1 shows some screenshots of the FUNDA OP-AMP module. The module's content page is shown in Fig. 1a. The syllabus covers topics such as the introduction of Op-Amp, ideal operational amplifier, ideal inverting amplifier, ideal non-inverting amplifier, ideal summing amplifier, ideal difference amplifier, ideal integrator, ideal differentiator, ideal current to voltage converter, ideal voltage to current converter, ideal instrumentation amplifier and comparator circuit.



(a)



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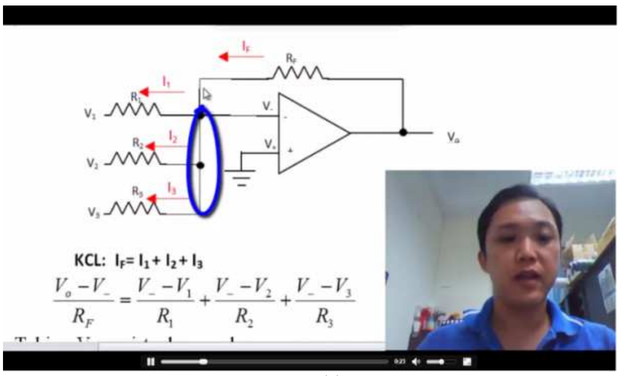

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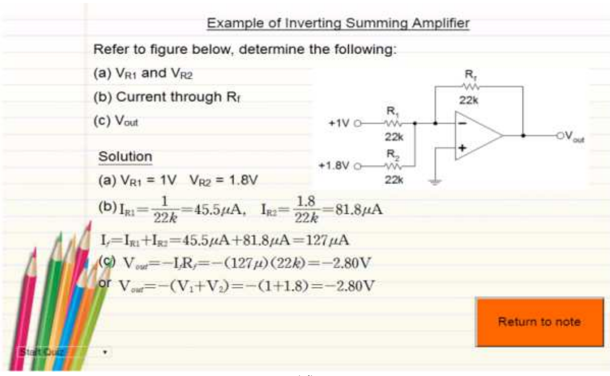

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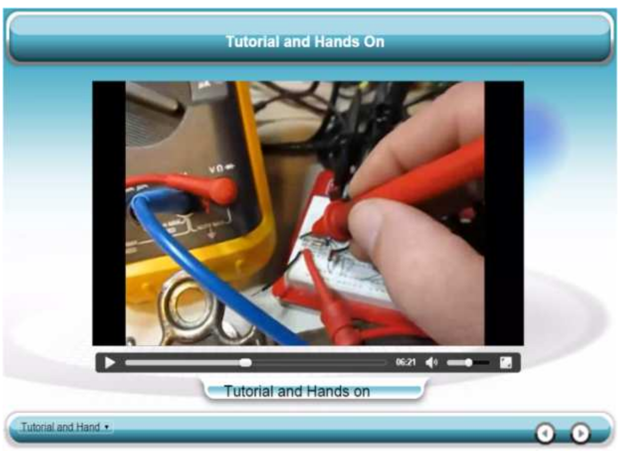

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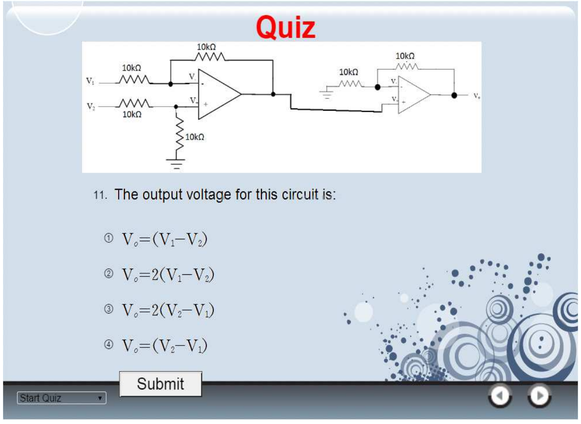
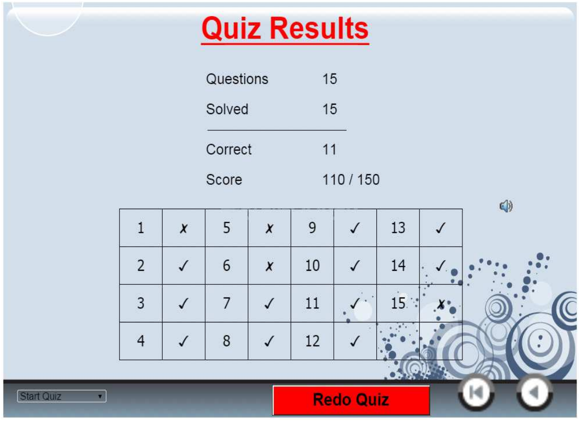


(g)



(h)

Fig. 1. Screenshots of the FUNDA OP-AMP Module; (a) Content Page of FUNDA OP-AMP Module; (b) Topic Example on the Ideal Summing Amplifier; (c) Video Guide for Step-By-Step Analysis and Derivation; (d) Tutorial Example; (e) Hands-on Laboratory Work; (f) Starting Page of Quiz; (g) Quiz Example Page; (h) Quiz Result Page

An example of a topic under the ideal summing amplifier is shown in Fig. 1b. The right-hand side covers the lecture notes for self study, while the left-hand side demonstrates a video guide to help the learners conduct a step-by-step analysis and derivation. This demonstration also contains face-to-face explanation with the instructor's face shown at bottom right of the screen as shown in Fig. 1c. Furthermore, a button is placed at the left-hand corner of Fig. 1b to link the learners to a tutorial example shown in Fig. 1d.

After covering all the twelve topics, the learners are directed to conduct 6 min long hands-on laboratory work as shown in Fig. 1e. The learners are instructed to prepare the components and measuring tools as demonstrated in the video and follow the step-by-step procedures given to conduct an experimental validation on the designed op-amp circuits and collect results.

The e-learning module ends with a quiz of fifteen questions, with both multiple choice and subjective questions included. The starting page of the quiz is shown in Fig. 1f. An example of a quiz question is shown in Fig. 1g while the quiz result page is shown in Fig. 1h. If the answer provided by a learner to a question is found to be incorrect, he/she is allowed to redo that particular question in order to learn from his/her mistake.

Methodology

This study is divided into two stages, namely the survey stage and the experimental stage. The participants, who are electronics engineering students are divided into 3 types of majoring, namely:

- BEng (Hons) Electronics majoring in Telecommunications
- BEng (Hons) Electronics majoring in Robotics and Automation
- BEng (Hons) Electronics majoring in Bio-Instrumentation

The participants are also differentiated by their gender (male or female) and status (repeater or non-repeater of the module). For both the survey and experimental stage, the participants are divided into two groups, namely the FUNDA OP-AMP group and the traditional learning group. The module delivered to both groups is known as the fundamentals of operational amplifiers. The FUNDA OP-AMP group is taught using e-learning strategies while the traditional learning group is taught using traditional lecturing strategies.

Each of the groups consist of 30 participants. For the survey stage, surveys on the lecturing methods are distributed to both groups at the end of the module. For the experimental stage, students of both groups are instructed to sit for a test on the fundamentals of operational amplifiers at the end of the module. The normality and reliability of the data are inspected before the parametric analyses. The results of the survey and experiment are then analysed using a one-way Analysis Of Variance (ANOVA). Two main hypotheses are established as such:

H_0: There is no significant difference between the FUNDA OP-AMP and traditional lecturing methods in the fundamentals of operational amplifiers.

H_1: There is a significant difference between the FUNDA OP-AMP and traditional lecturing methods in the fundamentals of operational amplifiers.

The results of the ANOVA are then discussed with reference to the *p*-values obtained. If the *p*-value is lower than 0.05, H_0 is rejected. In contrast, if the *p*-value is above 0.05, H_1 is rejected.

Survey Findings

The summaries of the participants' majoring, gender and status are tabulated in Table 1 to 3.

Before any parametric analyses are done on the survey data, normality tests are carried out first. The Kolmogorov-Smirnov and Shapiro-Wilk normality tests are used to investigate the normality of the data for the following categories:

- FUNDA OP-AMP category results (E-learning)
- Traditional learning category results (Traditional)

Table 4 shows the normality test results for the survey data. It is found that p-values for all the categories defined are greater than 0.05. This indicates that the possibility of the data set being not normal is rejected and the probability that the data is normal is greater than 95%. Hence, the data is reliable enough for further parametric analyses.

Table 5 shows the Cronbach's alpha reliability test results for traditional lecturing and FUNDA OP-AMP lecturing methods. It is found that the alpha coefficients for both the variables are well above 0.7, indicating that the internal consistency and reliability of the data are acceptable.

Table 6 shows the results of the one-way ANOVA for the survey data. The parametric analyses using the one-way ANOVA show that the p-value of the relationship is less than 0.05, indicating that the possibility of a significant difference existing between FUNDA OP-AMP and traditional lecturing methods in the fundamentals of operational amplifiers is greater than 95%. Hence, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted.

Table 1. Summary of majoring

	Frequency	Valid percent	Cumulative percent
Telecommunications	32	53.3	53.3
Robotics and Automations	26	43.3	96.7
Bioinstrumentation	2	3.3	100.0
Total	60	100.0	

Table 2. Summary of genders

	Frequency	Valid percent	Cumulative percent
Male	42	70.0	70.0
Female	18	30.0	100.0
Total	60	100.0	

Table 3. Summary of Status

	Frequency	Valid percent	Cumulative percent
Repeater	14	23.3	23.3
Non-Repeater	46	76.7	100.0
Total	60	100.0	

Table 4. Tests of Normality for Survey Data

	Kolmogorov-smirnov[a]			Shapiro-wilk		
	Statistic	df	p-value	Statistic	df	p-value
Results	0.095	60	0.200*	0.947	60	0.140

*. This is a lower bound of the true significance; a. Lilliefors Significance Correction

Table 5. Cronbach's Alpha Reliability Test Results

Variables	Cronbach's alpha	Number of items
Traditional	0.947	10
E-learning	0.963	10

Table 6. One-Way ANOVA for Survey Data

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23.438	1	23.438	28.385	0.000
Within Groups	47.891	58	0.826		
Total	71.329	59			

Further observations on the results in Table 7 show that the mean of the students' scores under the FUNDA OP-AMP learning group is higher than the mean of the students' scores under the traditional learning group (FO: 3.83, TL: 3.51). This clearly shows that the students' perception of the FUNDA OP-AMP lecturing methods is not only significantly different than that of traditional lecturing methods, but also condoned to be more important and agreeable in the fundamentals of operational amplifiers.

Supplementary analyses are also carried out to investigate if there are any significant effects from the majoring, status and gender of the participants on their perceptions of the importance of FUNDA OP-AMP and traditional lecturing methods. The one-way Analysis Of Variance (ANOVA) is used to examine the effects of gender, status and majoring on traditional and FUNDA OP-AMP methods.

Table 8 shows the effects of gender on traditional and FUNDA OP-AMP lecturing methods. It is found that the *p*-values are greater than 0.05, implying that these two lecturing methods are not significantly affected by gender.

Table 9 reveals the results on how status affects traditional and FUNDA OP-AMP lecturing methods. Since the *p*-values are found to be greater than 0.05, it can be concluded that the statuses of participants have no significant effects on both traditional and FUNDA OP-AMP lecturing methods.

Table 10 presents the results on the effects of majoring on traditional and FUNDA OP-AMP lecturing methods. Based on the *p*-values which are higher than 0.05, it is worth noting that there are also no significant effects from the majoring of the participants on traditional and FUNDA OP-AMP lecturing methods.

Experimental Findings

Similar normality tests are also done on the experimental data as a requirement before further parametric analyses. Table 11 shows the results of the normality tests conducted on the experimental data. It is found that *p*-values are greater than 0.05, indicating that the probability of the data being normal is greater than 95%. Hence, the data is reliable enough for further parametric analyses.

Table 7. Group Statistics for Survey Data

Learning_Method		N	Mean	Std. Deviation	Std. Error Mean
Scores	Traditional	30	2.5800	1.11491	0.20355
	E-learning	30	3.8300	0.63905	0.11667

Table 8. Effects of gender on traditional and FUNDA OP-AMP lecturing methods

		Sum of Squares	df	Mean Square	F	*p*-value
Traditional	Between Groups	1.128	2	0.564	0.932	0.406
	Within Groups	16.347	27	0.605		
	Total	17.475	29			
E-learning	Between Groups	1.883	2	0.941	2.552	0.097
	Within Groups	9.960	27	0.369		
	Total	11.843	29			

Table 9. Effects of status on traditional and FUNDA OP-AMP lecturing methods

		Sum of squares	df	Mean Square	F	*p*-value
Traditional	Between Groups	0.023	1	0.023	0.037	0.849
	Within Groups	17.452	28	0.623		
	Total	17.475	29			
E-learning	Between Groups	0.372	1	0.372	0.907	0.349
	Within Groups	11.471	28	0.410		
	Total	11.843	29			

Table 10. Effects of majoring on traditional and FUNDA OP-AMP lecturing methods

		Sum of Squares	df	Mean Square	F	*p*-value
Traditional	Between Groups	0.827	1	0.827	1.391	0.248
	Within Groups	16.648	28	0.595		
	Total	17.475	29			
E-learning	Between Groups	1.450	1	1.450	3.908	0.058
	Within Groups	10.393	28	0.371		
	Total	11.843	29			

Table 11. Tests of normality for experimental data

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	*p*-value	Statistic	df	*p*-value
Results	0.070	60	0.200*	0.980	60	0.439

*. This is a lower bound of the true significance; a. Lilliefors Significance Correction

Table 12. One-way ANOVA for experimental data

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1162.568	1	1162.568	4.627	0.036
Within Groups	14571.550	58	251.234		
Total	15734.119	59			

Table 13. Group statistics for experimental data

	N	Mean	Std. deviation	Std. error mean
Traditional	30	51.2080	14.07417	2.56958
E-learning	30	60.0117	17.44663	3.18530
Total	60	55.6098	16.33034	2.10824

Table 12 presents the results of the one-way ANOVA for the experimental data. The results show that the *p*-value of the relationship is less than 0.05, signifying that the likelihood of a significant difference existing between FUNDA OP-AMP and traditional lecturing methods in the fundamentals of operational amplifiers is greater than 95%. Hence, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted.

Additional observations on the results in Table 13 show that the mean of the students' results under the FUNDA OP-AMP learning group is higher than the mean of the students' results under the traditional learning group (FO: 60.01% TL: 54.79%). The difference between the two means is 9.10%. This clearly shows that the students who undergo FUNDA OP-AMP lecturing methods not only have significantly different results compared to the results of traditional learners, but also exhibit better performance in the fundamentals of operational amplifiers than that of traditional learners.

One of the reasons pointed out by the students of the FUNDA OP-AMP module is that the e-learning lecturing strategies are easily understood since many illustrative examples are provided. The findings of this study are supported by other studies, which suggest that illustrative instructions (represented by videos) have a significant influence on e-learning acceptance in courses (Hrtonová *et al*., 2015). The illustrative instructions and examples provided also appear to be compatible with the students learning strategies. This finding is consistent with the findings of Islam (2016) who mentioned that if the e-learning programme is compatible with the learning method, the students' e-learning system utilisation will in all likelihood be materialised and this will result in improved academic performance. As evidence, researchers found that the statistical interaction between e-learning usage and compatibility is significant when it comes to the prediction of academic performance ($p<0.001$) (DeLone and McLean, 2003; Islam, 2016).

The preceding findings appear to dispute the findings of Tawil *et al*. (2011) who found greater mean values for students' perception towards traditional lecturing methods than e-learning in Mathematics and Statistics. Traditional lecturing was also found to be better than e-learning for trainees in dentistry (Browne *et al*., 2004). However, it can be argued that the current context of the module and type of e-learning system used are different from those implemented in the two foregoing studies. Hence, different results may be yielded across different study areas. Besides that, the experimental findings of this study also agreed with the survey findings.

It is undoubted that e-learning can be a strong proponent in the progression of modern teaching and learning methods. However, there have also been evidences from other researchers who suggested that exam passing rates increased by about 12% with the introduction of e-learning alongside traditional learning techniques (Deschacht and Goeman, 2015). A combination between the two would hence be termed blended learning. Thus, it is also important to note that a balance between traditional learning and e-learning is essential in order to reap the full competitive advantage of e-learning approaches.

Conclusion

This study has successfully proven that there is a significant difference between the FUNDA OP-AMP and traditional lecturing methods in the education of fundamentals of operational amplifiers among electronics engineering students. The study also revealed that the students' perception of the FUNDA OP-AMP lecturing methods was also condoned to be more important and agreeable in the instruction of fundamentals of operational amplifiers.

For future studies, it is suggested that more actual or experimental data (pertaining to the students' academic results) are captured and analysed in order to verify the significance of e-learning effects in Fundamentals of Operational Amplifier. Furthermore, the cluster of students that participate in the study could also be broadened to include other fields of engineering, such as Mechanical, Electrical, Civil, Manufacturing and Chemical engineering for instance. Overall, even though more analyses are required to verify the existing findings and innovate future discoveries in e-learning, this study still serves as preliminary evidence on the versatility and performance of e-learning techniques in electronics engineering subjects.

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Author’s Contributions

Wai Kit Wong: Initiated the idea of this research and was involved in the planning, execution and data collection of this study. He conducted some literature research as well. He also constructed and designed the protocol of the experiments and administered the e-learning among the students for this study.

Poh Kiat Ng: Involved in the data analyses and write up of this study. He was also involved in a lot of the literature review compilation and methodology write-up.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all the other authors have read and approved the manuscript. Hence, no ethical issues are involved.

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