Improving Pre-University Students' Understanding of Basic Plant Tissue Culture Topic through Laboratory Teaching: A Case Study of UMS

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ABSTRACT Laboratory work is an important component in biology-based courses. In Malaysia, biology courses were offered to students from the upper secondary level to pre-university level. However, practical work and experimentation still not being fully emphasized in teaching and learning session. The objective of this paper is to demonstrate the effectiveness of laboratory teaching for basic plant tissue culture topic at Foundation Science, University Malaysia Sabah. Two hundred fifty-six pre-university science students had participated in this study. Test comprises of two sections (theory and practical) was given to the students before and after lab session. The data was analysed using R statistical software. Paired t-test and Pearson's correlation coefficient were utilized to make statistical interpretation of the Pre-lab and Post-lab test. The results showed that the average mean value for the Post-lab test was higher, with an increased to four questions answered correctly as compared to Pre-lab test. The results of the paired t-test also significant and there was a high correlation between Pre-lab test and Post-lab test. These findings prove that laboratory teaching did significantly improve the students' level of understanding after participating in the laboratory session.

KEYWORDS: Laboratory Teaching; Plant Tissue Culture; Biology Statistics; Paired t-test; Foundation Science

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INTRODUCTION

In Malaysia, science and technology are given the priority in order to prepare the country to join the ranks of developed nations by 2020. Therefore, science electives courses, which include biology, chemistry, and physics, were offered to students from the upper secondary level to pre-university level. However, the teaching was still proved to be teacher-centered and ignores the practical work and experimentation (Zin, 2003; Peen & Arshad, 2014; Sarina & Tengku, 2014). Laboratory works have been an essential component in teaching and learning of any science course (Linn, 1997; Blosser, 2011). It has been proven to develop problem solving abilities, intellectual development, scientific thinking, and practical skills (Aktamiş & Acar, 2010; Çifçili & Kırbaşlar, 2015).

Basic plant tissue culture is one of the topics covered in Development and Genetics (SB0034) course at Foundation Science, University Malaysia Sabah (UMS) during third semester. The topic covered includes the roles of plant growth regulators in plant growth and development. Tissue culture courses involve a very practical skills and lab techniques. Conventional teaching methods shown to cause undergraduate as well as pre-university students struggle when doing technical and analytical courses such as classic genetics, gene expression concepts, and phenotypic analyses (Awang-Kanak *et al*., 2016; Makarevitch & Martinez-Vaz, 2017). Modern biology classrooms must provide authentic research experiences to allow developing core competencies such as scientific inquiry, critical interpretation of experimental results, and quantitative analyses of large dataset using computational approaches (Makarevitch & Martinez-Vaz, 2017). Hence, the objective of this

study is to demonstrate the effectiveness of laboratory teaching in order to improve students' understanding on basic plant tissue culture topic.

METHODOLOGY

Two hundred fifty-six pre-university science students (109 males, 146 females) of UMS had participated in this study. These students were all at the age of 18 years old, and were in their third and final semester of their pre university course. They consisted of mainly Bumiputra (i.e., Malay, Bajau, Dusun, Sino Kadazan, Melanau, Iban, etc). The test comprises of two sections; i.e. theory and practical. The same test was given to the students prior and post lab session. These students were given 10 minutes to answer all the questions.

The analysis of the data was conducted using R statistical software. The analysis started by computing the means and standard deviations of the test results. Paired t-test was used to determine the significance of the variation in mean of the pre-lab test and the post-lab test. Paired t-test was chosen because of its suitability for the comparison of the means of two samples which assumes that the populations are normally distributed and undergone with two different treatments. To determine the relationship between the pre-laboratory test and the post-laboratory test, the correlation matrix was computed using Pearson Correlation Coefficient. All decision rules were based on calculated p-value (with α<0.05) where it is the probability that the test statistic will take on a value that is at least as extreme as the observed value of the statistic when the null hypothesis, H_0 is true.

RESULT

Means and standard deviations are presented in Table 1. The results showed that the average mean value for the Post-lab test was higher than the mean value for the Pre-lab. Furthermore, the mean difference of the Post-lab and Pre-lab test is slightly higher for the practical section (1.055) as compared to the theoretical section (1.054). These results indicate that the students' level of understanding on the basic tissue culture topic, especially the practical section has improved after participating in the laboratory session.

Table 1. Descriptive statistics for basic plant tissue culture topic test of pre-university science students of University Malaysia Sabah.

		Pre-laboratory Test			Post laboratory Test		
Section	n*	Mean	S.D.	Median	Mean	S.D.	Median
Theory	251	2.9102	1.047	3	3.964	0.850	4
Practical	251	3.084	1.158	3	4.139	0.825	4
Average	251	2.998	0.793	3	4.052	0.588	4

**Students with NA data were omitted.*

Table 1 also shows that the standard deviation for the Post-lab test is lower than the standard deviation for the Pre-lab test. The lower standard deviation indicates a more consistent result and higher standard deviation shows that the result obtained was less consistent. In addition, median for the Post-lab test increased to 4 questions answered correctly from 3 correct questions answered for the Pre-lab test (Table 1). These results suggest that the laboratory session has improved the students' ability to answer the test given.

Table 2. Paired t-test results for pre and post laboratory session test of basic plant tissue culture topic (n= 251).

Section	*t*	*df*	*p*<	Confidence interval	Mean difference
Theory	-14.41	250	2.2e-16	-1.1955516, -0.9080341	-1.051793
Practical	-14.193	250	2.2e-16	-1.2022813, -0.9092725	-1.055777
Average	-19.757	250	2.2e-16	-1.1588351, -0.9487346	-1.053785

The results of the paired t-test show there was significant difference between the means of the pre-lab test and post-lab test (Table 2). The paired t-test of both the theoretical (t = -14.41, p = 2.2e-16) and practical (t = -14.193, p = 2.2e-16) section also shows that difference between the means of the pre-lab test and post-lab test. These results suggest that the increment in the means is significant and it is plausible that the laboratory session results in better understanding of students on the basic tissue culture topic presented to them.

Table 3. Correlation matrix.

		Pre-laboratory Test			Post laboratory Test		
		Theory	Practical	Average	Theory	Practical	Average
Pre-laboratory Test	Theory	1.00					
	Practical	0.03	1.00				
	Average	0.68	0.75	1.00			
Post laboratory Test	Theory	0.27	-0.11	0.1	1.00		
	Practical	0.08	0.33	0.29	-0.02	1.00	
	Average	0.25	0.16	0.28	0.71	0.69	1.00

The correlation matrix calculated in Table 3 resulted in high correlation between the pre-laboratory test and the post laboratory test (values nearing -1 or 1) signifying that there is a significant relationship between the Pre-lab test and Post-lab test. This shows evidence on the effectiveness of laboratory teaching on students' understanding of basic plant tissue culture topic.

DISCUSSION

The results of the descriptive statistics of Pre-lab and Post-lab test indicate that the students' understanding on the basic tissue culture topic, especially the practical section has improved after participating in the laboratory session. Akani (2015) stated that laboratory session was able to developed scientific attitude towards learning and scientific skills for problem solving among secondary school students in thirteen local government schools in Ebonyi State of Nigeria. They conclude that the main development was the practical skills. Similar findings were obtained in the present study where the mean score for the practical section was slightly higher compared to the theoretical section. A similar approach by Aktamiş & Acar (2010) shown that laboratory practices in science teaching significantly improved scientific skills and knowledge. The practical work involved in the laboratory teaching sessions was more student-cantered compared to conventional teaching. The implementation of student-centered learning in Malaysian science classroom has been proven to promotes active learning, student thinking, and questioning (Peen & Arshad, 2014). This is similar to the study conducted by Armbruster *et al*. (2009) that conclude a more student-cantered learning activities significantly improved student performance.

The lower standard deviation of the post-lab test suggests that the students' ability to answer the questions was more consistent and less variable. In other words, they have mutual understanding of the topic as compared to previous test where the standard deviation is higher. These results suggest that the laboratory session has improved the students' ability to answer the test given. This is mainly due to the fact that practical works encourage students to attain manipulative skills, observational skills, the ability to interpret experimental data, and to plan experiments (Johnstone & Al-Suhaili, 2001). These cognitive skills enable the students to enhance conceptual understanding and promote higher order thinking skills. Hofstein & Lunetta (2004) emphasizes that the importance of assessments of students' skills in laboratory work based on their level of understanding. In the present study, it was proven that laboratory work significantly improved the students' competencies, based on the students' ability to answer the test after participating in the lab session. In other words, by developing their practical skills, they have improved their understanding on the particular topic as well (Cacciatore & Sevian, 2009; Shymansky *et al*., 1983).

The correlation matrix showed that there is a significant relationship between the pre lab test and post lab test. In other words, the effectiveness of laboratory teaching on the improvement of students' test score was proven, which reflected to their understanding on the topic. Thus, the objective of the study was achieved, where laboratory teaching successfully improve the understanding on basic tissue culture lab skills and techniques for pre-university students of UMS. In addition to performance and achievement, laboratory work also proven to increase the student learning attitude (Wolf & Fraser, 2008). Hence, the importance of practical work and experimentation should not be ignored in teaching and learning session. These preliminary data on the effectiveness of lab teaching can be used as a platform for a more conducive measure and practice in an effort to increase the importance of practical work and experimentation in science courses, especially biology.

CONCLUSION

In summary, based on the descriptive statistics and paired t-test, laboratory teaching did significantly improve the students' level of understanding on the basic tissue culture topic covered in Development and Genetics (SB0034) course at Foundation Science, University Malaysia Sabah. The students were able to answer on average four questions correctly as compared to three correct questions before their participation in the laboratory session. Further studies will be focused on the comparison between other teaching methods with the findings obtained from the present study. Moreover, other subtopics other than plant tissue culture should be considered and tested with similar research design to provide more data on teaching strategies for science courses among pre-university students in University Malaysia Sabah.

REFERENCES

[1] Akani, O. (2015). Laboratory Teaching: Implication on Students' Achievement in Chemistry in Secondary Schools in Ebonyi State of Nigeria. *Journal of Education and Practice*, **6**(30), 206-213.

[2] Aktamiş, H. & Acar, E. (2010). The effect of "laboratory practices in science teaching" course on development of prospective science teachers' self- regulation skills. *Procedia - Social and Behavioral Sciences*, **2**(2), 5549–5553.

[3] Armbruster, P., Patel, M., Johnson, E. & Weiss, M. (2009). Active learning and student-centered pedagogy improve student attitudes and performance in introductory biology. *CBE-Life Sciences Education*, **8**(3), 203-213.

[4] Awang-Kanak, F., Masnoddin, M., Matawali, A., Daud, M. A. & Jumat, N. R. (2016). Difficulties Experience by Science Foundation Students on Basic Mendelian Genetics Topic: A Preliminary Study. *Transactions on Science and Technology*, **3**(1-2), 283-290.

[5] Blosser, P. E. (2011). The Role of the Laboratory in Science Teaching. *NARST: Publications -- Research Matters - to the Science Teacher*, **97**(4), 13–15.

[6] Çifçili, V. & Kırbaşlar, F. G. (2015). Investigating Perceptions of Pre-service Science Teachers towards Laboratories by Using Phenomenological Pattern. *Procedia - Social and Behavioral Sciences*, **174**, 1371-1378.

[7] Hofstein, A. & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, **88**(1), 28-54.

[8] Hofstein, A. & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice*, **8**(2), 105-107.

[9] Johnstone, A. H. & Al-Shuaili, A. (2001). Learning in the laboratory; some thoughts from the literature. *University Chemistry Education*, **5**(2), 42-51.

[10] Makarevitch, I. & Martinez-Vaz, B. (2017). Killing two birds with one stone: model plant systems as a tool to teach the fundamental concepts of gene expression while analyzing biological data. *Biochimica et Biophysica Acta (BBA)-Gene Regulatory Mechanisms*, **1860**(1), 166-173.

[11] Platova, E. & Walpuski, M. (2013). Improvement and Evaluation of Laboratory Work for First-Semester Teacher-Students. *ESERA 2013 Conference Proceedings.*

[12] Tengku Kasim, T. S. A. (2014). Teaching Paradigms : An Analysis of Traditional and Student-Centred Approaches. *Jurnal Usuluddin*, **40**, 199–218.

[13] Shymansky, J. A., Kyle, W. C. & Alport, J. M. (1983). The effects of new science curricula on student performance. *Journal of Research in Science Teaching*, **20**(5), 387-404.

[14] Wolf, S. J. & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in Science Education*, **38**(3), 321-341.

[15] Zin, S. M. S. (2003). Reforming the science and technology curriculum: The Smart School Initiative in Malaysia. *Prospects*, **33**(1), 39-50.