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Effective Evaluation of Students Attainment in Assessment Components for the Unit Taught in Large Classes by Using SPSS v17

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Case Study

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ABSTRACT

In this paper, the authors used statistical methods on SPSS v17 software to identify the best predictor assessment mode for the overall performance in the Engineering Mathematics 120, unit taught at Curtin University Sarawak in Semester 1, 2011. The results of this case study are also shown to be useful in planning the continuous quality improvement (CQI) of teaching this unit. To enhance the students' learning and the lecturer's effective teaching, the authors suggest more emphasis on the learning mode with corresponding assessment mode, best correlated with the final examination results and the total assessment marks. The best predictor assessment mode is shown to be an effective formative assessment that forms an integral part of the students' learning process. To provide a more accurate and reliable assessment of the students' achievement of the learning outcomes, the authors suggest a revision on the distribution of assessment marks over the various assessment modes.

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1. BACKGROUND

The challenge in large classes (more than 100 students) is to create a learner centred environment, promote active learning and engaging learners when there are so many students. The simplest answer is to break a large class into small classes but it is quite difficult due to economic constrains. Many methods are suggested to address these issues, including encouraging class attendance, delivering well balanced course contests to keep learners interest on subject, knowing learners and creating interactive classes, identifying and making time to help learners at risk, getting/giving feedback and assess their learning [1]. The traditional assessment approach, in which one single written examination counts total score, no longer is effective in assessing the learning outcome [2]. Mastery Learning Assessment Model (MLAM) in teaching and learning mathematics has been examined and found that possible correlation exists between the MLAM and the final exam result [3]. A cybernetic model of learning assessment is proposed by viewing all the assessment as formatives in learning [4]. Assessment cycle model draws from the theories of self-assessment to elaborate how learning takes place through peer assessment and it contrasts from usual studies in peer assessment [5]. Behaviourist assessment model suits to basic courses and cognitive assessment model suits to advance courses in effective assessment of learning [6]. The combined model for teaching, assessment and learning in engineering educations working adults is addressed [7]. The assessment of students learning by cloud model is recommended for information engineering studies. In this model student test scores are regarded as cloud droplets [8]. The importance of formative assessments [9,10] and power of feedback [11] are in high priorities in effective learning assessments.

2. INTRODUCTION

Engineering Mathematics is an integral and important core teaching subject taken by students enrolled to Bachelor Degree in Engineering. At Curtin University Sarawak, the students are engaged in this unit, Engineering Mathematics 120 in various learning environments including lectures, tutorial workshops, laboratory sessions, online quizzes, peer discussions, self-study with support from Learning Management Systems (LMS) such as MOODLE, OASIS, BLACKBOARD and Online & Offline library resources. They are engaged very much in line with the modern trend of blended learning. The lecturer introduces the basic mathematical principles and concepts as well as demonstrates their applications in solving engineering problems during the lectures, normally in big lecture theatres housing 186 students. During tutorial workshops, the students in groups of 25 are engaged actively in discussions, problem solving sessions. As an assessment, students should be answering a half-an-hour tutorial quiz consisting of a few short mathematical problems on topics covered in the previous two weeks, under examination environment. A total of four tutorial quizzes are attempted by the students in the semester. In the two-hour laboratory sessions, the students learn to use mathematical software (Maple) in hands-on sessions under the instruction and supervision of a laboratory teaching assistant. They complete three laboratory assignments on their own time for submissions before certain pre-scheduled deadlines in the semester. The students also attempt twelve online quizzes administered through AiM (Alice Interactive Mathematics) where each online quiz is available only for a limited period (about 2 weeks). The students sit for a two-hour final examination which represents the summative assessment of the students.

The various assessment components contribute toward the total assessment mark in Engineering Mathematics 120 in the following manner: Tutorial quiz 10%, Online Quizzes 20%, Laboratory Assignments 10%, and Final Examination 60%. The criteria to pass this unit, students should score minimum marks 50 out 100 in total and score minimum 40% in the final exam.

The lectures, tutorial workshops, laboratory sessions and online quizzes provide different learning environments for the students. The formative assessment results based on the students' performance in tutorial quizzes, online quizzes and laboratory assignments provide very useful feedbacks to the lecturer on their strengths and weaknesses in relation to their achievement of the various learning outcomes under the teaching unit. Based on the students' performance, the lecturer would give timely remarks or feedbacks to the students to correct any misconceptions or procedural errors. As the tutorial quizzes, online quizzes and laboratory assignments differ in format, content, difficulty level, allowed time, and type of test as open or close, they are expected to contribute differently to the students' learning and to their achievements in the final examination and total assessment.

In this paper, the authors used statistical methods on SPSS v17 software to identify the best predictor assessment mode for the overall performance in the Engineering Mathematics 120 Semester 1, 2011, taught at Sarawak Campus. To enhance the effective learning and teaching, the authors suggest more emphasis on the learning mode with corresponding assessment mode best correlated with the final examination results and the total assessment marks. The best predictor assessment mode is shown to be an effective formative assessment that forms an integral part of the students' learning process. To provide a more accurate and reliable assessment of the students' achievement of the learning outcomes, the authors suggest a revision on weighted distribution of assessment marks over the various assessment modes.

3. METHODS

3.1 Data

The assessment marks for 186 students in the Engineering Mathematics 120, Semester-1, 2011, are used for the purpose of this study. The raw data consist of (a) tutorial marks (10%), (b) online quizzes marks (20%), (c) laboratory assignments marks (10%), (d) total internal marks (40%) ((a) + (b) + (c)), (e) final examination marks (100%), (f) final examination marks (60%), and (g) grand total marks (100%) ((d) + (f)). All the raw data above are normalised to a maximum of 10% each for further analysis.

3.2 Preliminary Descriptive and Scatter Plots

In the first stage of analysis, the frequency distribution histograms and comparison normal distribution curves are plotted for the various normalised data of assessment marks to illustrate the general distribution trends of these data with sample size N = 186. The mean, median, variance, standard deviation, minimum, maximum, range, inter-quartile range, skewness, Kurtosis values are then determined for each of the above normalised data. This gives a preliminary descriptive picture of the distributions of the various normalised data. The corresponding skewness and Kurtosis values serve to distinguish the near normal distributed assessment marks from those which are not. In the second stage of analysis, scatter plots of pairs of the various *normalised* assessment marks are plotted to give an indication of those with good or high correlations and those with low or poor correlations.

3.3 Correlation Analysis

In the third stage of analysis, the Pearson Correlation method on SPSS v17 is used to calculate the correlation coefficients between pairs of normalised data. This is to further confirm pairs of normalised assessment marks with good or high, medium, and poor or low correlations. A correlation coefficient of 0.60 – 0.79 would indicate a pair of normalised assessment marks with good or high correlation. A correlation coefficient of 0.20 – 0.39 would indicate a pair of normalised assessment marks with poor or low correlation.

3.4 Determination of Best Predictor Assessment Mode

The various learning environments, viz. tutorial workshops, online quizzes and laboratory sessions, are assumed to make unequal contributions towards the students' overall learning and performance in the final examination of the mathematics unit. The correlation coefficients are compared between the following pairs of normalised data: (a) tutorial quiz marks and final examination marks, (b) online quiz marks and final examination marks, (c) laboratory assessment marks and final examination marks, whereby in each pair of data, the first one being the contributor or cause for the second one as the result. The pair with the highest positive correlation coefficient serves to determine the best predictor assessment mode as associated with the first data of the pair: poor or good performance here would predict corresponding performance in the final examination. The comparison of correlation coefficients is repeated by replacing the final examination marks with the total assessment marks in each of the above pairs to confirm the best predictor assessment mode.

4. RESULTS AND DISCUSSION

4.1 Preliminaries

The frequency distribution histograms for the various normalised data of assessment marks are shown in Figs. 1 to 6. The normalised data of tutorial quiz marks, online quiz marks, final examination marks and total assessment marks are found to exhibit near normal distribution with only very slight skewness. However, the normalised data of laboratory assignment marks show a high degree of skewness to the right, i.e. a high frequency at the high end. The values of various descriptive for the data analysed are shown in Table 1. The 10%-weighted tutorial quiz marks, 20%-weighted online quiz marks and 10%-weighted laboratory assessment marks exhibit means of 6.70, 8.72 and 8.03 respectively, producing a mean of 8.03 marks for the total internal marks. The 40%-weighted total internal marks, the 60%-weighted final examination marks and the total assessment marks show means of 8.03, 5.09 and 6.26 respectively. In terms of standard deviations, the normalised data of tutorial marks, the online quiz marks, the laboratory assessment marks, and the final examination marks are 2.07, 1.63, 1.47 and 2.33 respectively. The smaller standard deviations of the normalised online quiz marks and laboratory assessment marks reduce the spread of the total internal marks which shows a standard deviation of 1.35 only. Similar effect is seen in the reduced spread of the normalised total assessment marks of standard deviation 1.78 only.

It appears that students perform better in online quizzes and laboratory assessments compared to the hand-written tutorial quizzes and the final examination. The online quizzes and laboratory assessments emphasize more on the use of computer software and interactive mathematics, testing the students more in terms of symbols, procedures, menus, commands, graphical methods, etc. The students complete the online quizzes and laboratory assignments on their own time, may be with a possible benefit of group discussions and peer help. Both the tutorial quizzes and the final examination covers all topics prescribed in unit outline. While tutorial quizzes provide small doses of formative assessment, made up of a few questions at regular intervals, the final examination gives a summative assessment at one go. Therefore, while online quizzes and laboratory assessments tend to raise the 40%-weighted mean total internal marks and introduce a skewness (-2.19 and -2.54 respectively) to the right, these effects are more or less balanced off by the 60%-weighted final examination marks with a mean of 5.09 marks and very small skewness of 0.181 and the 10%-weighted tutorial quiz marks with a mean of 6.70 and a very small skewness of 0.76 only, producing a mean of 6.26 and skewness of 0.004 for the total assessment marks. Both the normalised final examination marks and total assessment marks show very similar good normal distributions which only differ slightly in terms of means of 5.09 and 6.26 respectively, indicating the relative difficulty to score higher in the final examination. The Kurtosis values of the normalised data of tutorial quiz marks, final examination marks and total assessment marks are all small and of comparable magnitudes, viz. 0.261, -0.728 and -0.708 respectively, indicating their similar near normal distributions. In contrast, the normalised data of online quiz marks and laboratory assessment marks have very high Kurtosis values of 5.368 and 9.431 respectively, indicating excessively peaked distributions which are not reflected by those of the final examination marks and total assessment marks.

Therefore, the tutorial quiz marks, the online quiz marks and the laboratory assessment marks appear to be ranked in descending order of effectiveness as a predictor assessment mode in predicting the students' performance in the final examination and total assessment.

4.2 Scatter Plots

Figs. 7 to 12 show scatter plots for the relevant pairs of normalised data. Both the scatter plot of normalised tutorial marks vs final examination marks (Fig. 7) and that of normalised tutorial marks vs total assessment marks (Fig. 10) show good correlations, R^2 linear values of 0.436 and 0.562 respectively. In contrast, scatter plots for the normalised online quiz marks and laboratory assessment marks vs final examination marks or total assessment marks show very poor correlations, R^2 linear values of 0.4, 0.172, 0.4 and 0.172 respectively (Figs. 8, 9, 11 and 12). This indicates that, for example, many students nearly obtain the full normalised online quiz marks of 10 but their achievements in the normalised final examination vary very widely between 4 and 9 marks. Similarly, many students obtain very high normalised laboratory assessment marks (8 – 10), but their achievement in the normalised final examination vary widely between 3 and 9.

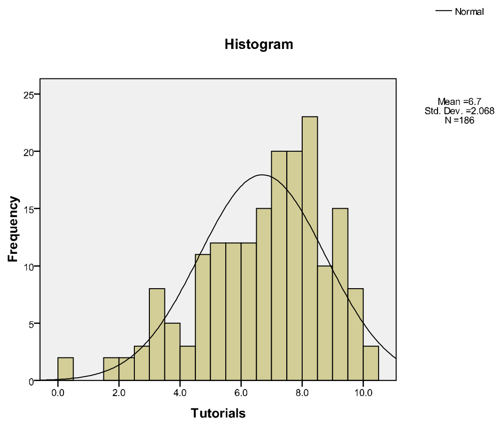

Fig. 1. Frequency distribution of normalised tutorial marks

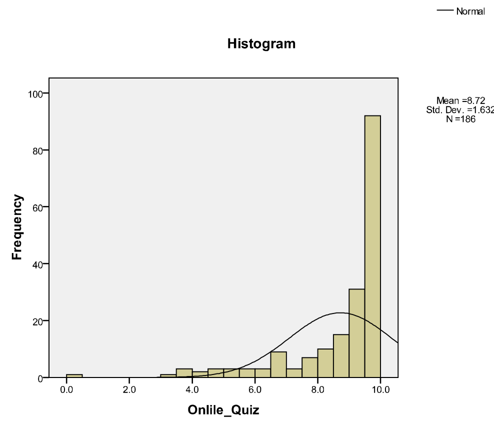

Fig. 2. Frequency distribution of normalised online quiz marks

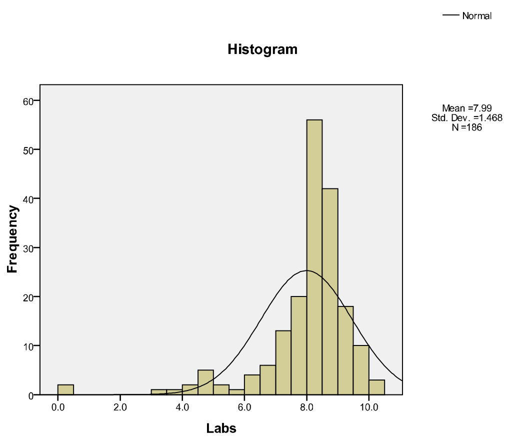

Fig. 3. Frequency distribution of normalised laboratory marks

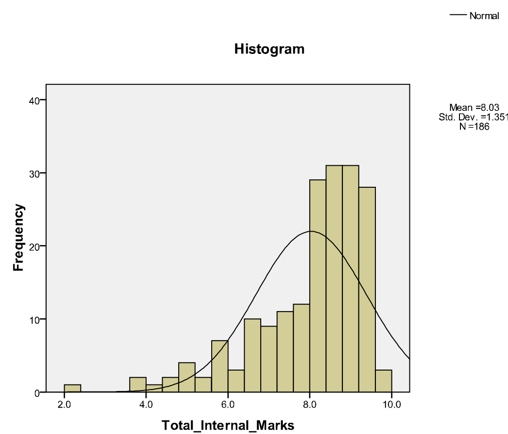

Fig. 4. Frequency distribution of normalise total internal marks

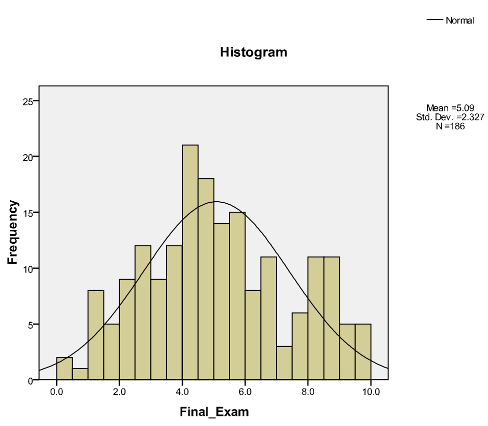

Fig. 5. Frequency distribution of normalised final examination marks

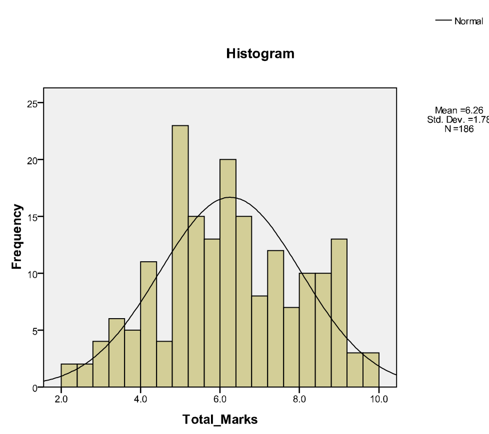

Fig. 6. Frequency distribution of normalised total marks

Table 1. Descriptives for the normalised data

Descriptives	Tutorial quiz marks	Online quiz marks	Laboratory assignment marks	Total internal marks	Final exam marks	Total marks
Mean	6.699	8.721	7.993	8.033	5.086	6.260
Median	7.125	9.480	8.222	8.392	4.850	6.126
Variance	4.276	2.663	2.154	1.824	5.416	3.167
Std. Deviation	2.0678	1.6320	1.4677	1.3507	2.3273	1.7797
Minimum	0.0	0.0	0 .0	2.3	0.0	2.2
Maximum	10.0	9.9	10.0	9.8	9.8	9.8
Range	10.0	9.9	10.0	7.5	9.8	7.6
Interquartile Range	2.9	1.3	1.1	1.5	3.2	2.5
Skewness	-0.765	-2.191	-2.544	-1.425	0.181	0.004
Kurtosis	0.261	5.368	9.451	2.080	-0.728	-0.708

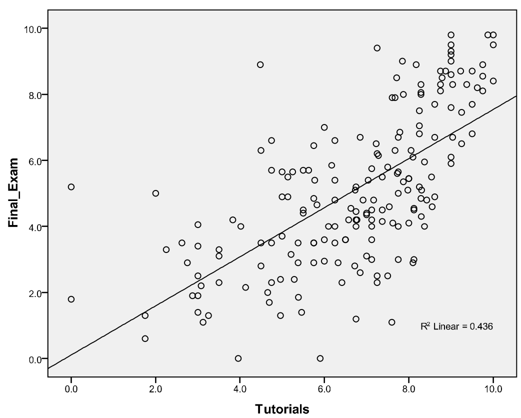

Fig. 7. Scatter plot of normalised tutorial marks (x-axis) vs final exam marks (y-axis)

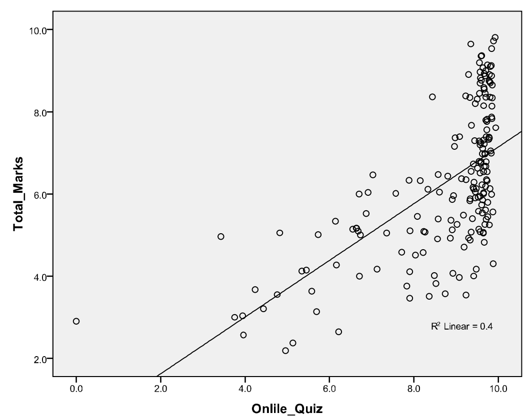

Fig. 8. Scatter plot of normalised online quiz marks (x-axis) vs final exam marks (y-axis)

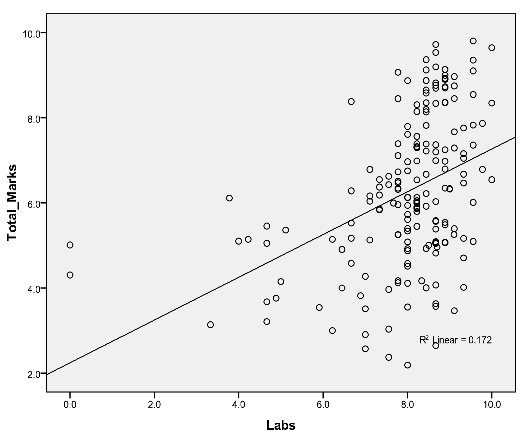

Fig. 9. Scatter plot of normalised Laboratory Assignment Marks (x-axis) vs Final Exam Marks (y-axis)

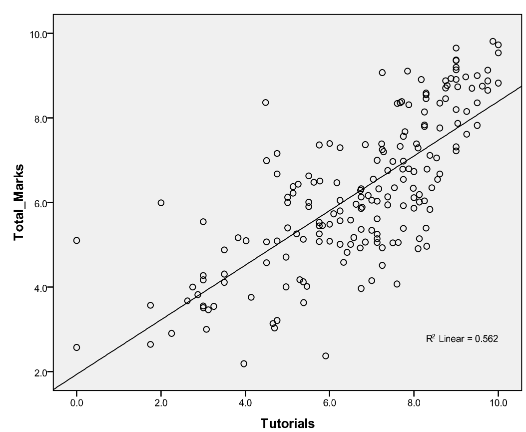

Fig. 10. Scatter Plot of Normalised Tutorial Marks (x-axis) vs Total Assessment Marks

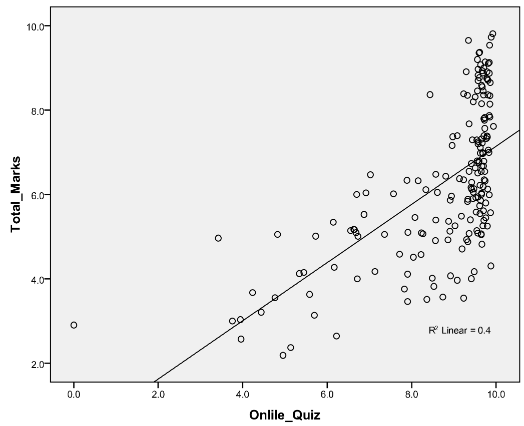

Fig. 11. Scatter plot of normalised Online Quiz Marks (x-axis) vs Total Marks (y-axis)

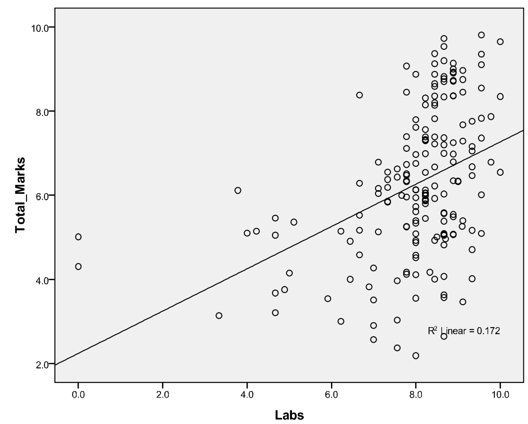

Fig. 12. Scatter plot of normalised Laboratory assignment marks (x-axis) vs Total Marks (y-axis)

The scatter plots and the linear regression lines indicate that the tutorial quiz marks, the laboratory assessment marks and the online qui marks are ranked in descending order in terms of correlations with both the final examination marks and the total assessment marks. Therefore, this further confirms the order of their effectiveness as a predictor assessment mode for the overall performance of the students in the mathematics unit.

4.3 Pearson's Correlations

Table 2 shows the Pearson Correlation Coefficients for Pairs of Normalised Data analysed. The normalised data of tutorial quiz marks show significant and very good correlation coefficients of 0.771 with the total internal marks, 0.66 with the final examination marks and 0.750 with the total assessment marks. Despite showing excellent correlation coefficient of 0.890 with the total internal marks (due to its large 20%-weight) and a good 0.632 with the total assessment marks, the normalised data of online quiz marks show only a low correlation coefficient of 0.461with the final examination marks. The normalised data of laboratory assessment marks turn out to be the worst, showing comparatively lowest correlation coefficients of 0.615, 0.293 and 0.415 respectively. This is yet another confirmation of the finding that tutorial quiz is the best predictor assessment mode for the overall performance of the students, the online quizzes being the second best and the laboratory assessments being the worst one.

Table 2. Pearson correlation coefficients for pairs of normalised data

	Tutorial quiz marks	Online quiz marks	Lab Assess. marks	Total internal marks	Final exam marks	Total Assess. marks
Tutorial Quiz Marks	1	0.494	0.331	0.771	0.660	0.750
Online Quiz Marks	0.494	1	0.352	0.890	0.461	0.632
Lab Assessment Marks	0.331	0.359	1	0.615	0.293	0.415
Total Internal Marks	0.771	0.890	0.615	1	0.611	0.781
Final Exam Marks	0.660	0.461	0.293	0.611	1	0.970
Total Assessment Marks	0.750	0.632	0.415	0.781	0.970	1
N	186	186	186	186	186	186

*** Correlation is significant at the 0.01 level (2-tailed).*
All Sig. (2-tailed) values are found to be 0.00

5. CONCLUSION

The finding that the tutorial quiz is the best predictor assessment mode for the students' overall performance in the Engineering Mathematics 120 unit carries the following implications. Firstly, tutorial quizzes provide very effective formative assessments for the students in helping them to achieve the learning outcomes of the unit tested in the final examination, the summative assessment. Secondly, tutorial quiz marks of the students could be used to give a reasonably good prediction on their achievements in the final examination and the total assessment for the unit. Thirdly, to enhance the effectiveness of teaching and learning, more emphasis has to be placed upon the tutorial workshops, especially in actively engaging the students in group discussion, do-it-yourself problem solving, hands-on working using white board followed by peer feedbacks. Comments from students in teaching evaluation report (TER) reflect a general request for more tutorials. The results of this case study are also useful to set the continuous quality improvement (CQI) plan for teaching this unit. The finding that the online quiz marks and laboratory assessment marks show poorer correlations with the final examination marks. and total assessment marks implies that a better redistribution of assessment marks should be suggested to reflect better the students' performance in the various components, e.g.: (a) tutorial quizzes – 15%, (b) online quizzes – 15%, (c) laboratory assessments – 10%, (d) final examination – 60%. The coverage and depth of the online quizzes and laboratory assessments should also be reviewed to improve their relevance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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