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Effectiveness of Pre-Test in Determining Students' Achievement in Department Fundamental Courses

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ABSTRACT

Students' understanding of foundational concepts in fundamental courses is important as it is a pre-requirement for proceeding to any advanced and specific courses in any degree programme. Despite high passing rates in most universities, students actually do not really have a good understanding of the course content, especially in fundamental courses. This paper aims to discuss how the pre-test of basic knowledge in mathematics and physics learnt during pre-university or matriculation level can be used to determine and predict student achievement in the fundamental courses of the two subjects. The pre-test questions were distributed to the first-year students at the beginning of semester one (1) of their study at the Department of Civil and Structural Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia. In this study, two fundamental courses were selected from first- and second-year programmes, namely, Static & Dynamic (KH 1044) and Fluid Mechanics (KH 2134), respectively. A total of 35 students from the test sample of 43 students successfully obtained the pre-test scores of over 40%, while only one student scored more than 80%. However, students who did well in the pre-test did not necessarily obtain good results in the final examination of both fundamental courses and vice versa. Therefore, necessary action or improvement to the teaching and learning process of the identified courses need to be taken to ensure that students have deep understanding of the subjects before they proceed to the advanced courses.

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INTRODUCTION

In line with rapid economic growth, whether in manufacturing or industry, the need for professionals and highly skilled employees becomes crucial. To meet the needs and requirements of the country, the Ministry of Education, Malaysia has formulated a strategic plan to nurture world class knowledgeable, innovative and first-class human capital by 2020 (Nuraini Khatimin et al., 2012). The plan emphasises the importance of improving the quality of the national education curriculum and enhancing teaching and learning experience.

Institutions of Higher Learning (IHL), which are the primary agents for generating and producing skilled manpower in response to the government's requirement, have to ensure the quality of these graduates. Thus, the Engineering Accreditation Council (EAC) was established to monitor engineering programmes offered at public universities to ensure that they are appropriate and meet the accreditation standards (Azrilah et al., 2012). Various methods are used to monitor the quality of graduates and the curriculum. The main measurement is student achievement of course outcomes (CO) as established in Outcome-Based Education (OBE). Based on the OBE curriculum, student performance throughout the year is consistently evaluated, which is an exercise that is crucial in continuous improvement policy (EAC, 2008). Therefore, students have to excel in their studies consistently every semester; to do this, they will need a good understanding and strong basic knowledge of fundamental courses.

Deep understanding of mathematics and science courses is a necessity for any student wishing to pursue education in the field of engineering. The application of science and mathematics plays an important role in developing latest technology, especially in the engineering field. According to Pyle (2001), engineering as a career requires an understanding of mathematics, science and technology. Although mathematics and science would have been learnt from primary school up to matriculation level (pre-university), students' understanding in fundamental courses at university level remains a concern. In fact, according to a study by Zulkifli et al. (2013), student understanding in mathematics in pre-university does not help or guarantee that they will understand the course better. Students always experience difficulty in studying mathematics as they have to understand theories and memorise formulae (Yushau, 2006). Understanding concepts comprehensively rather than remembering formulae blindly is a better strategy for students in solving mathematical problems (Wong et al., 2001). In engineering, mathematics is a key component subject and acts as a medium for expressing physical, chemical

and engineering laws (Sazhin, 1998). This is the same for science education, which is not only closely linked with the development of science, but also with society's demands for science, technology, engineering and mathematics (STEM) education. It can be used much more practically, especially in industry, agriculture, crafts and military applications (Trna & Tronova, 2015). According to Sagakumar (2012), science is a prime course in technology and both courses are the key to development and community building.

Therefore, this study aimed to assess the level of student understanding in year one before they start their studies in engineering at the university. As mathematics and science courses are a necessity in the study of engineering, a pre-test should be administered to gauge students' understanding and prior knowledge at the beginning of the semester of their study. The pre-test questions that were prepared focussed on mathematics and physics as these two fields were foundational in fundamental courses taught at the Department of Civil and Structural Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia. Good understanding and background in mathematics and physics would help students to excel in the fundamental courses and simultaneously, allow them to use basic knowledge that they have learnt to solve engineering problems in advanced courses or specific courses in the department. Results reported by Devlin et al. (2013) suggest that although the rate of students who pass the examination at the university is quite high, most students do not understand the course content at great depth. The majority of students simply memorise the syllabus content merely to pass the examination. However, students with strong basic knowledge in fundamental courses can easily solve any engineering problems given to them compared to those who simply memorise course content for examination purposes (Osman et al., 2012).

METHOD

In order to evaluate whether the pre-test questions could be used to assess students' level of understanding and knowledge in mathematics and physics to predict student performance on basic courses at the department, three stages of assessment were carried out. In the first stage of assessment, pre-test examination was administered to first-year students at the beginning of Semester 1 of their study. In this study, 47 students (admission for year 2012/2013) at the Department of Civil & Structural Engineering, Faculty of Engineering and Built Environment (JKAS), UKM were chosen. Pre-exam questions were prepared to investigate whether the students could use their basic understanding and knowledge acquired in pre-university

or matriculation level for continuing their studies in fundamental courses in year one and year two at the university. Six questions were designed that were mainly focussed on mathematics and physics as shown in Table 1.

Table 1
Pre-Test Questions

Question	Field
1	Mathematics (Logarithmic)
2	Mathematics (Trigonometry)
3	Mathematics (Matrix)
4	Mathematics (Differential)
5	Physics (Linear Motion)
6	Physics (Forces)

Every question in each field was prepared to test the students' understanding of a certain topic among those most relevant to the civil engineering syllabus. The validity and reliability of the question were also checked using the Rasch Measurement Model. The Rasch model provides item (question) difficulty as well as ability of the student (Nuraini Khatimin et al., 2012). The Rasch analysis found that the questions were appropriate for measuring student ability and the researcher's need. Detailed findings of the validity and reliability of the questions are discussed in Siti Aminah et al. (2015). For the purpose of this study, two courses, which were Static & Dynamics (KH1044) and Fluid Mechanics (KH2134), were selected to represent the important fundamental courses offered in year one and year two, respectively. Both courses were selected because they are compulsory courses for students who are registered in the Civil and Structural Programme and Civil and Environmental programme offered by the department.

The second stage of assessment involved collecting marks from the final examination of the Static & Dynamics (KH1044) course for the target group of students. The course content was divided into two parts, with 50% of the questions focussed on Static and the other 50% on Dynamics. Throughout the semester, students were required to carry out laboratory experiments, complete assignments and sit examinations. Thus, the overall marks were divided into 10% from laboratory work, 15% from assignments, 25% from the mid-semester examination and 50% from the final examination. The final examination for the course took place at the end of the semester of the first year of their study.

In the third stage of assessment, the Fluid Mechanics (KH 2134) course was selected and the same students were evaluated throughout the semester, which was in year two of their study. The overall marks for the course consisted of 10% from quizzes, 15% from laboratory work, 30% from the mid-semester examination and 45% from the final examination. For the purposes of this study, the marks from the final exam for the course were recorded. A period of approximately two years was taken to compile all the required marks simultaneously in completing the entire study. Further analysis of pre-test marks with Static & Dynamic (KH1044) and Fluid Mechanics (KH2134) courses was carried out to determine the correlation between the results of the pre-test and those of the fundamental courses of year one and two.

RESULTS AND DISCUSSION

The marks for the pre-test, Static & Dynamics (KH1044) and Fluid Mechanics (KH2134) courses for 47 students are plotted in Figure 1. From the whole class of 47 students, only four students did not sit the pre-test examination. The plotted pre-test marks shown in Figure 1 are arranged in ascending order where the lowest is 12% and the highest is 88%. A total of eight students obtained pre-test marks of 40% and below, 20 students had marks from 41% to 60%, 14 students obtained 61% to 80% and only one student scored 81% and above. This shows that the students did not have impressive pre-test results, with more than half of them obtaining marks of 60% and below. The marks given for these two courses, as shown in Figure 1, are the overall marks obtained by each student. It shows that all the students successfully passed both courses with more than 40% marks, with the highest score being 96%. The relationship between the pre-test and final examination marks for both courses is shown in Figure 2. There is no direct relationship that can be made between the pre-test and the final examination marks for both courses. Generally only eight students obtained final exam marks lower than 50% for Fluid Mechanics compared to 13 students for the final exam of the Static & Dynamics course.

Further analysis and discussion focussed only on the 43 students who underwent the pre-test examination. Figure 3 shows the distribution of the pre-test and the final examination marks for the Static & Dynamics (KH1044) and Fluid Mechanics (KH2134) course for these students. The highest score in the final examination for the Static and Dynamic course was 79% (student number 23) while for Fluid Mechanics it was 93% (student number 18). Figure 4 shows the distribution of the difference in marks between the pre-test and the final examination for both courses against the number of students. In Figure 4, the left axis refers to the percentage of pre-test marks arranged in ascending order and

it is shown by a curve, while the right axis refers to the difference in course marks compared with the pre-test scores. Positive values indicate higher marks for the course compared to the pre-test scores, while the negative values indicate lower marks for the course compared to the pre-test scores. The results indicate that 49% of the total number of students (21 students) scored higher for both courses than they had done on the pre-test marks. The range of the difference in marks between the pre-test and both courses varies from 0 to 46%. On the other hand, 11 students (25.5%) scored lower for both courses than they had done on the pre-test; here, the difference in marks ranged from -4 to -9%. Eleven students (25.5%) obtained course marks that were inconsistent with the pre-test marks. This finding illustrates that students with higher pre-test marks are not guaranteed of obtaining higher marks for both courses and vice versa. For example, student number 42 and 43 had pre-test marks above 70%, but their final exam scores were not satisfactory. This is in contrast to almost half of the class who had low pre-test marks, but still scored higher for both courses. These results also show that the process of learning and teaching at the university as implemented for both courses during the semester was capable of helping students succeed and achieve high marks.

Figure 5 also shows left skewedness for pre-test marks 60% and below, where 19 out of 28 students managed to raise their marks in both courses compared to their previous low marks on the pre-test and right skewedness for pre-test marks 61% and above, where only two of the 15 students managed to raise their marks in both courses. Figure 5 shows the correlation between the pre-test marks and the final examination marks for Static & Dynamics and Fluid Mechanics. It shows that the correlation between Statics & Dynamics and the pre-test marks is 0.085 while that of Fluid Mechanics and the pre-test marks is 0.050. These results prove that the pre-test marks did not correlate with the basic course marks. High pre-test marks did not guarantee high marks in the basic courses. Therefore, it may be concluded that the pre-test given to the students cannot be used accurately to predict student achievement in basic courses.

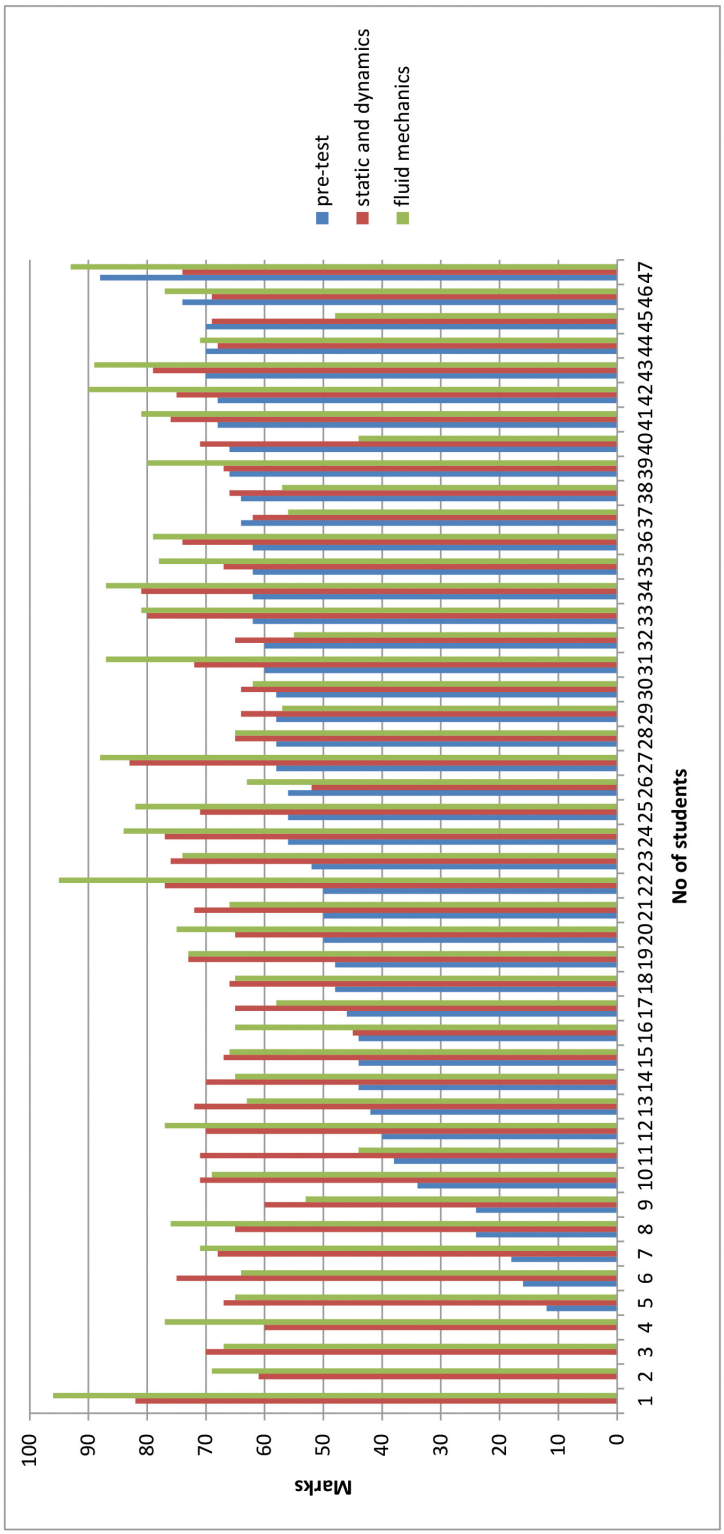

Figure 1. Pre-test and total course marks for Static & Dynamics and Fluid Mechanics courses for each student.

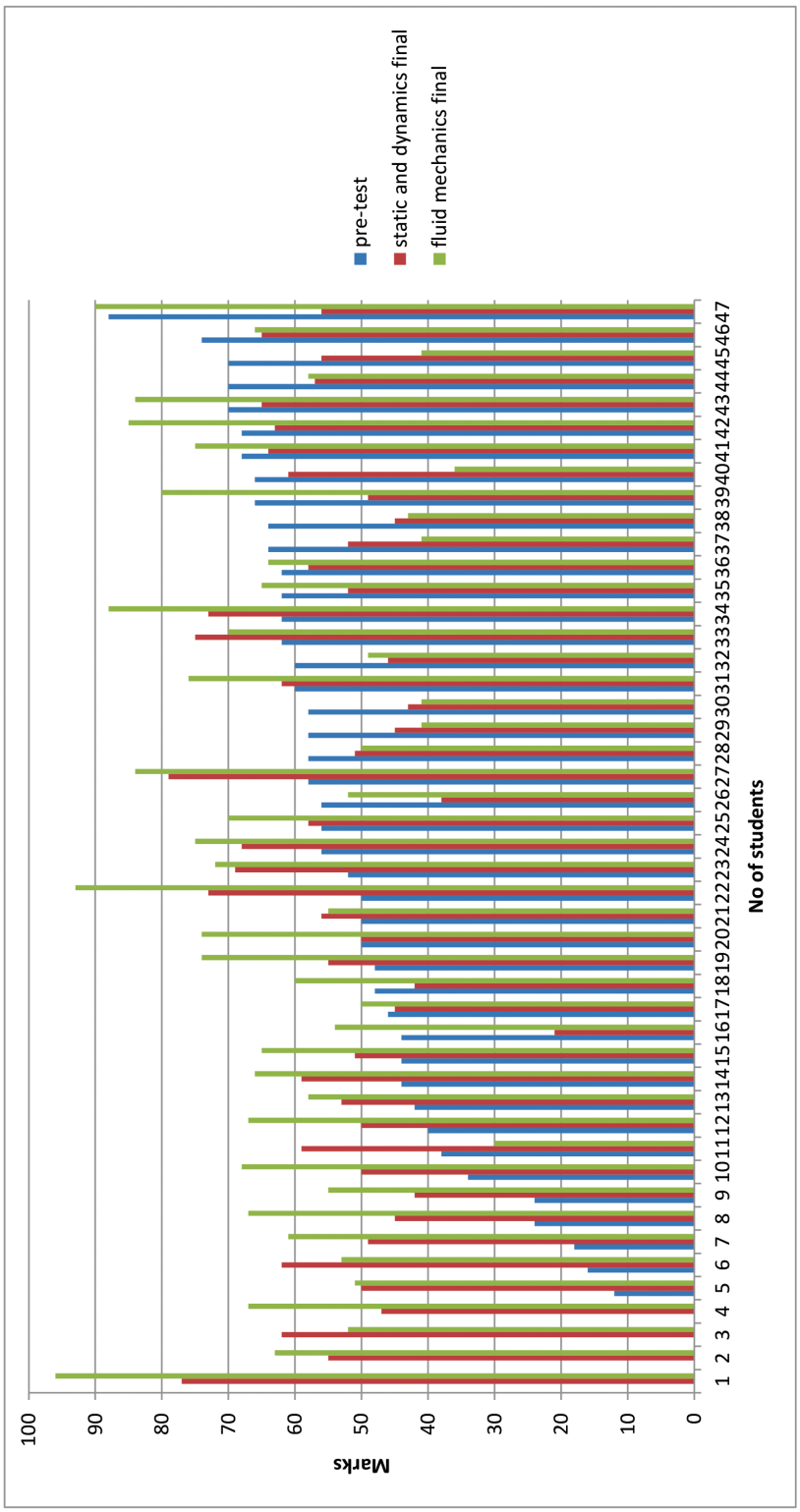

Figure 2. Pre-test and final examination marks for Static & Dynamics and Fluid Mechanics courses for each student.

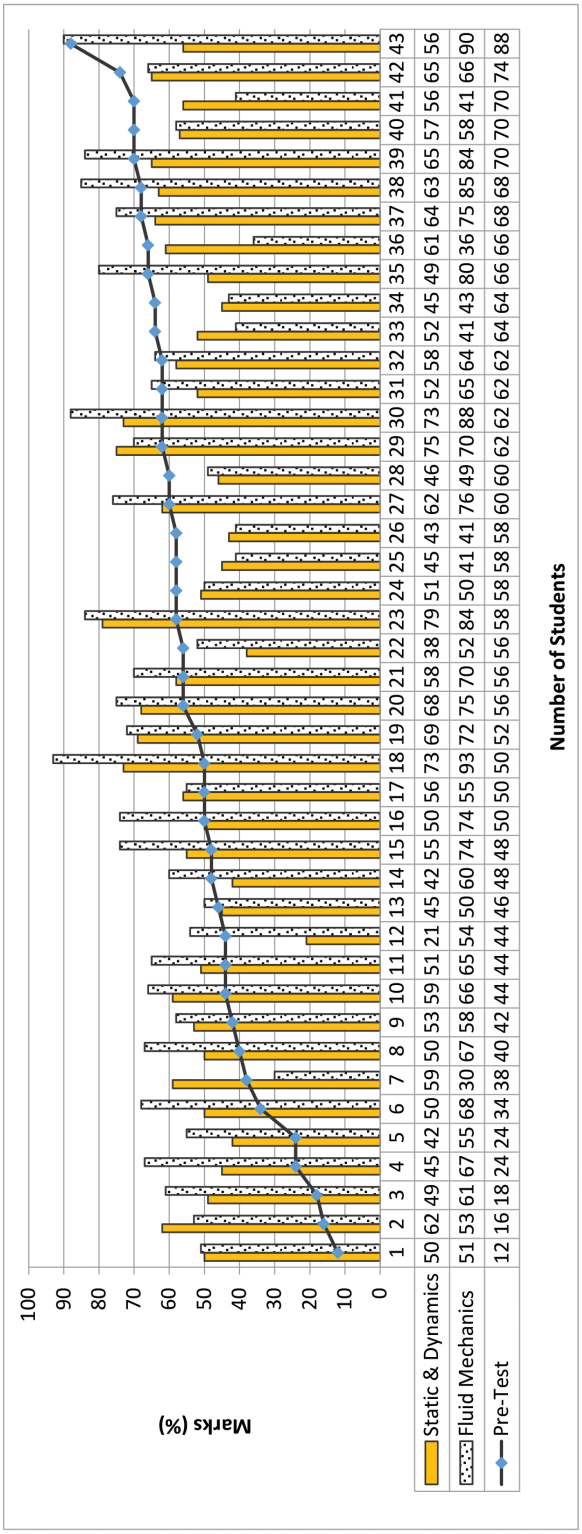

Figure 3. Pre-test marks with final examination marks of Static & Dynamics and Fluid Mechanics courses for each student.

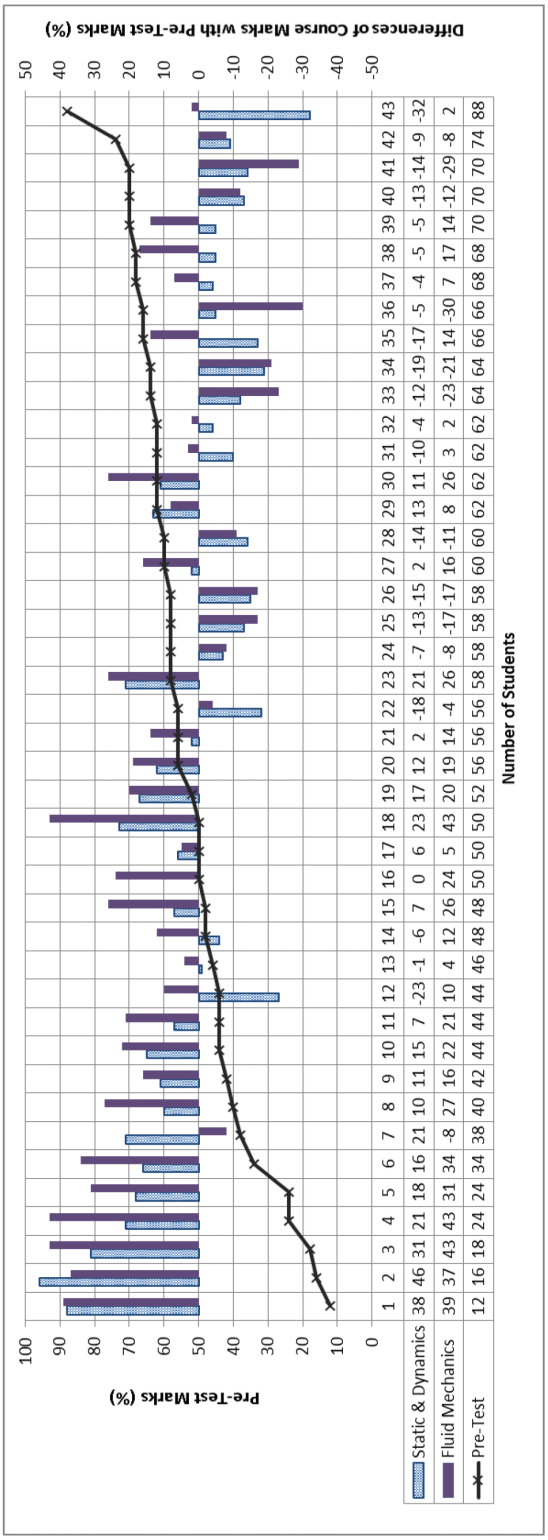

Figure 4. Pre-test marks and differences in course marks compared to pre-test marks for each student.

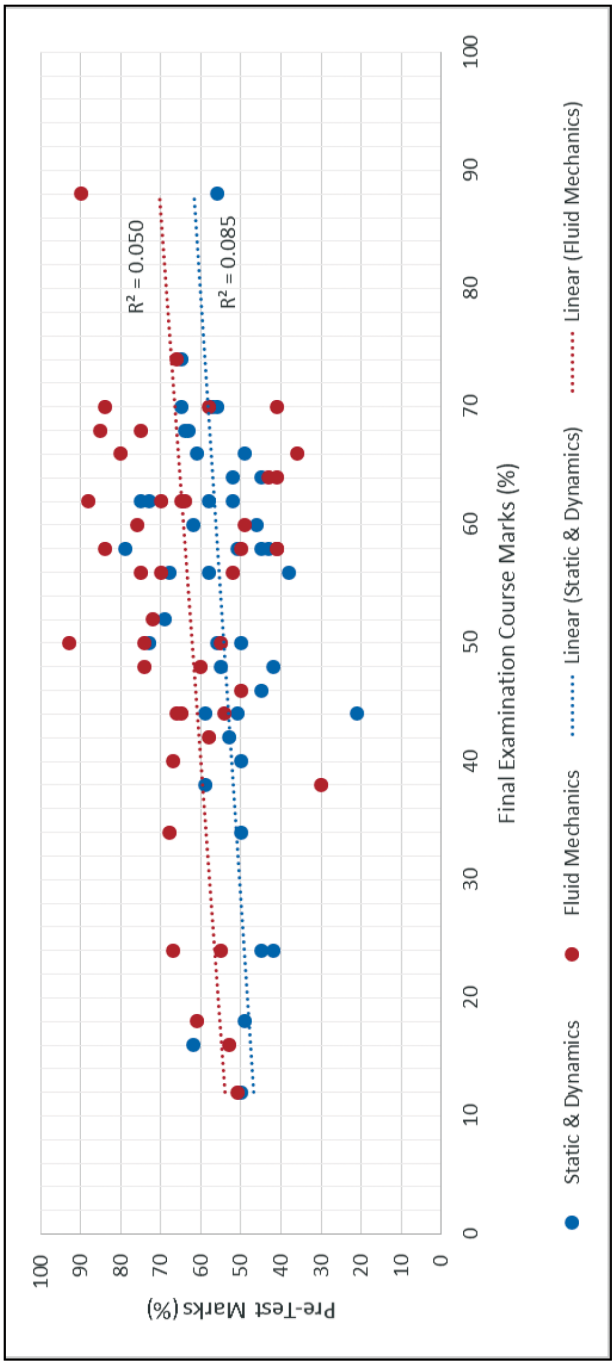

Figure 5. Correlation between pre-test marks and final examination course marks for all students.

CONCLUSION

The results of the pre-test examination given to a group of 43 students from year one in the Department of Civil and Structural Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia were analysed. The aim of administering the pre-test questions was to assess the level of understanding and knowledge of the students in mathematics and physics as well as to find out the correlation between the results of the pre-test and two of the department's fundamental courses. Statistical analysis found that there was no direct correlation between performance on the courses and the pre-test. Students who had a high level of understanding in mathematics and physics courses were not guaranteed of excelling in the courses. Nineteen students did not obtain high marks in the pre-test but still managed to pass and excel in both courses, suggesting that the learning process had indirectly helped them to succeed. Validity and reliability of the questions outlined in the pre-test was investigated using the Rasch Measurement Model to ensure the suitability of the pre-test as a model to determine students' level of understanding in the early stages of their study.

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