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Linking Course Outcomes and Grade Achievement for Students Undertaking a Laboratory Course

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ABSTRACT

The Chemical Engineering Laboratory 2 (KKKR2412) course offered by Universiti Kebangsaan Malaysia's Department of Chemical and Process Engineering, Faculty of Engineering and Built Environment, to students of Chemical Engineering in their second year of study is aimed at training them to handle basic experiments in chemical engineering. In this course, students are taught how to conduct practical training, data collection, results analysis, conclusion making and subsequently, how to write technical reports. Clear assessment is also conducted throughout the course to measure students' understanding via concise and comprehensive report writing, either individually or in a group, oral presentation and peer assessment with an appropriate grade given at the end of the course. However, so far no studies have been conducted on evaluating the relationship between the course outcomes of the subject and the students' grade achievement in order to see the effectiveness of the outcomes and assessment outlined. Therefore, in this paper, the relationship between the learning outcomes of the Chemical Engineering Laboratory 2 course for Year Two students and their grade point obtained for two academic sessions (i) 2012/2013 and (ii) 2013/2014 were linked and investigated by means of a survey form that was distributed to students at the end of the laboratory course. This study shows that mastering the practical content of the course is the most important factor in determining student grades, followed by communication and group work that was carried out throughout the course.

Keywords: Grades, group work, laboratory, learning outcomes, practical work

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INTRODUCTION

KKKR2412, a laboratory course, is a compulsory course offered to students of Chemical Engineering in the Department of Chemical and Process Engineering during the second year of study. Through this course, practical training is given to the students on how to apply the lecture-based learning courses such as Organic and Physical Chemistry, Chemical Reactors, Fluid Mechanics and Heat and Mass Transfer, which they have learnt throughout their studies (FKAB, 2012). Practical exposure is needed to develop students' skills in applying the knowledge of mathematics, science and engineering, communication ability, engineering problem solving ability, leadership and managing group members (Yuhana & Kofli, 2012). Practical work undertaken is designed to train students in conducting experiments, analysing data, producing a technical report from the experimental results obtained, and finally, presenting the findings orally. Through this course, students are exposed to the work experiments in a chemical engineering laboratory, laboratory safety, experimental techniques and teamwork. Besides that, the most important element is report writing, which is emphasised because all the results obtained from the experimental work can only be understood and shared to all through good reports.

It is very important to measure the learning outcomes of this course in order to evaluate the performance of students at the end of the course. It is also important for educators to master learning outcomes in order to design and use various learning methods and effective teaching tools to better help students (Rahman & Kofli, 2013). According to Hamid (2004), learning outcomes are defined as the expectation on students' ability of knowing how to implement the executed programme after completing their course of study. This is the basis of Outcome-Based Education (OBE), which is now being applied in institutions of higher learning in Malaysia. Student achievement is typically measured by grade point and is used to directly measure student learning outcomes (Arshad et al., 2011) as well as it contributes to students' cumulative grade. It is debatable whether or not learning outcomes are the same as or different from grading; it depends on several factors (Unknown, 2015). Grading mostly covers aspects such as attendance, improvement, effort, participation etc., which are not considered in the learning outcomes of a course. However, some educators do consider these criteria in their grading and learning outcomes thus it is possible to identify the relationships between the two. The common ways to measure learning outcomes are via different assessment schemes (i) summative (examination), (ii) formative (on-going) and (iii) indirect (survey) (Walvoord, 2010). Since the course studied in this paper involved practical work, the

formative and indirect assessments were judged to be the best way to measure its learning outcomes.

The aim of this research was to study the relationship between the achievement of learning outcomes in a course involving laboratory work and student grade results measured through formative assessment. The course selected was Chemical Engineering Laboratory 2, which is undertaken by Year Two Chemical Engineering Bachelor Degree students in Universiti Kebangsaan Malaysia. The cohorts studied were from the two consecutive academic sessions of 2012/2013 and 2013/2014. The learning outcomes and grading for this course were prepared and measured based on the same criteria (practical content, communication, group work).

METHODOLOGY

This study was conducted partly through a survey in the form of a 5-point Likert test distributed to two different batches of chemical engineering students at the end of the KKKR2412 course in order to measure the attainment of learning outcomes. The survey was given to 31 students from the academic session of 2012/2013 and 24 students from the session of 2013/2014. The survey was divided into four major sections, namely: (I) Student General Information, (II) Practical Content, (III) Communication and (IV) Group Work. Part II to IV from the survey were evaluated by the level of agreement with statements using a Likert scale of 1 to 5 from 'strongly disagree' to 'strongly agree' (Abdullah et al., 2011). Table 1- 3 present the given statements.

The final part of the study discussed the students' marks, grade and achievement from direct assessment. The distribution of marks is presented in Figure 1 and was assessed through a short report (individual), a long report (group) oral presentation and group work. The short and long reports, which accounted for 85% marks, were also indirectly measured in the learning outcome survey from Part II (Practical Content) while the oral presentation (10%) and group work (5 %) were measured indirectly from Part III (Communication) and IV (Group Work) of the survey, respectively. Oral presentation was assessed by a team of at least two lab coordinators (course lecturers) based on a specific presentation rubric formally used for the assessment. Meanwhile, group work was assessed through a peer assessment survey that was given to the students at the end of the semester for each student to assess group members' performance individually throughout the semester. The grade obtained at the end of the course was compared with the attainment of the learning outcomes as evaluated through the survey. Grades were given from A, A-, B+, B and so on in the marks range of 100-80%, 79-75%, 74-70%, 69- 65% and so on, respectively.

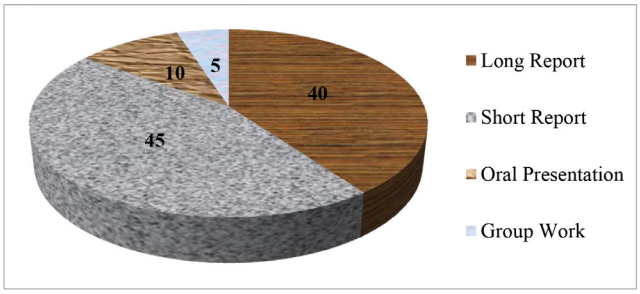

Figure 1. Distribution of the student's marks from direct assessment in percentage.

DISCUSSION

Part 1: Student General Information

Figure 2 (a) shows the percentage of students in Year Two enrolled in the Chemical Engineering programme who were involved in the survey. There were 31 and 24 respondents who responded to the survey for the respective academic session of 2012/2013 and 2013/2014.

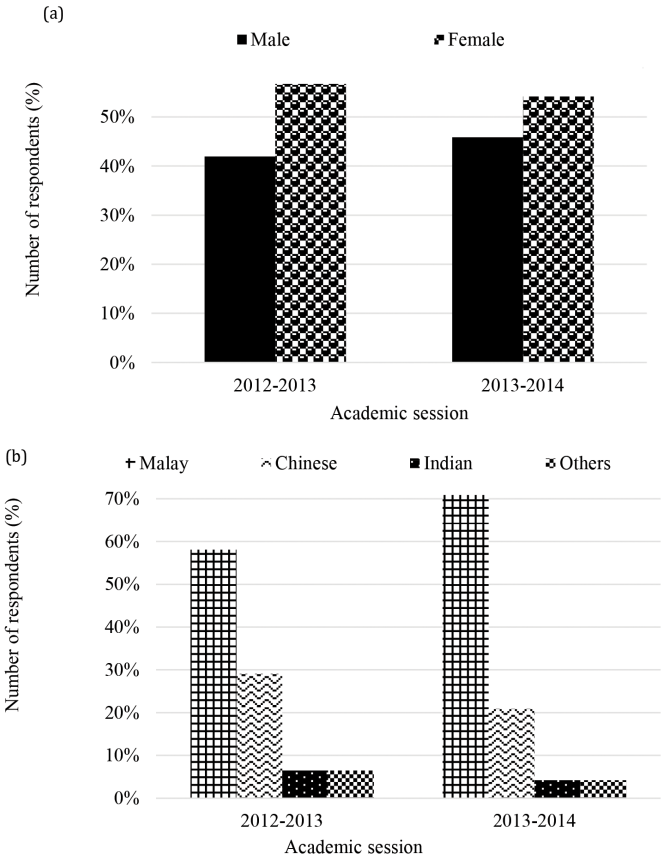

Figure 2. Distribution of respondents for the academic session of 2012/2013 and 2013/2014 by (a) gender (b) race.

A relatively uniform percentage of male and female respondents took part in the survey for both sessions. Figure 2 (b) shows the distribution of students who responded. Malay respondents totalled the highest percentage for both sessions (around 60 - 70%) followed by Chinese (about 30%). The number of Indian and respondents from other races was the lowest.

Part II: Practical Content

The practical content of the laboratory courses are outlined in Table 1. There are seven (7) statements on the course content that were answered by the respondents from the two academic sessions (2012/2013 and 2013/2014). The statements were on the laboratory courses, the topics given, the benefit of the lab work, knowledge application from the courses, necessary readings and references, data analysis and finally, the quizzes that could benefit lab planning/preparation. Figure 3 shows the respondent's agreement with the practical content in Table 1.

Table 1
Practical Content

Number	Content
S1	I understand the purpose of laboratory courses held.
S2	Practical topics are appropriate to the courses offered.
S3	I benefit from the implementation of practical work undertaken.
S4	I can use the knowledge base of courses in conducting experiments.
S5	I need to make appropriate references in understanding the practical topics that I do.
S6	I was able to obtain and analyse data.
S7	Quiz questions help me to make arrangements about who will do the practical.

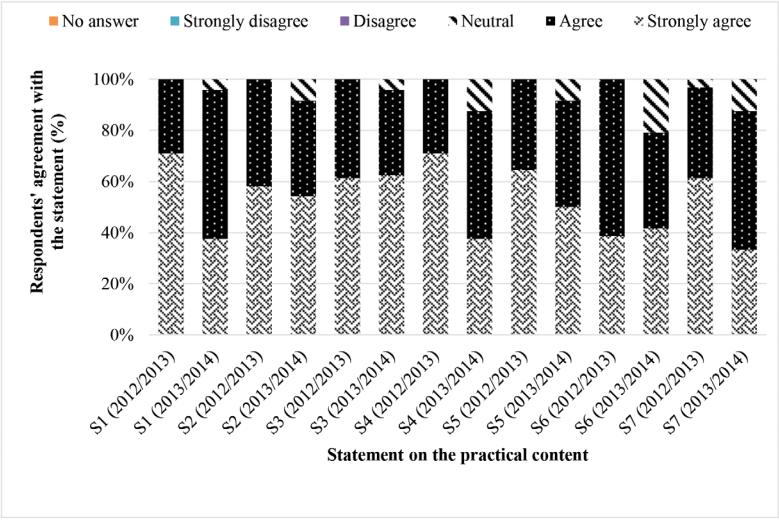

Figure 3. Respondents' agreement on practical content.

It was found that the percentage of respondents for the 2012/2013 session who 'strongly agreed' with all the statements, was higher compared to the group that 'agreed' only on almost all statements. Meanwhile, the percentage of respondents in the 2013/2014 session who 'strongly agreed' with all the statements, was found to have decreased between 5 and 35% compared to the 2012/2013 session. Around 5 to 20% of the respondents in the 2013/2014 session were 'neutral' on all statements especially statements number S6, S4 and S7 (refer to Table 1). The decline in the percentage of students in the 2013/2014 session who 'strongly agreed' with almost all the statements (S1-S7) compared to the respondents in the 2012/2013 session is an early indication that their understanding of the practical content was possibly not as good as that of the respondents from the previous session. Essentially, statements S4 to S6 represent different cognitive levels of Bloom's Taxonomy on the analysis and application of the courses learnt (Bloom, 1956). Thus it can be seen that the percentage of those who 'strongly agree' and also those who 'agree' fell compared to the other statements measured, and the results were more significant for the later academic session. These results are later linked with the grade achievement of the respondents (refer later section), considering that the practical content (Part II) contributed to the highest percentage for marks (up to 85%) and thus highly influenced the grade obtained.

Part III: Communication

There are two types of communication assessed through the course, which were vocal (via oral presentation) and written (via report writing). The communication content in the form of statements measured from the respondents is presented in Table 2, while the respondents' percentage of agreement with the statements are shown in Figure 4.

Table 2
Communication

No.	Content
S1	I was given the opportunity to make a presentation in the course.
S2	I loved the presentation.
S3	I prepared for the presentation.
S4	I can write a report using the appropriate procedure (UKM Style).

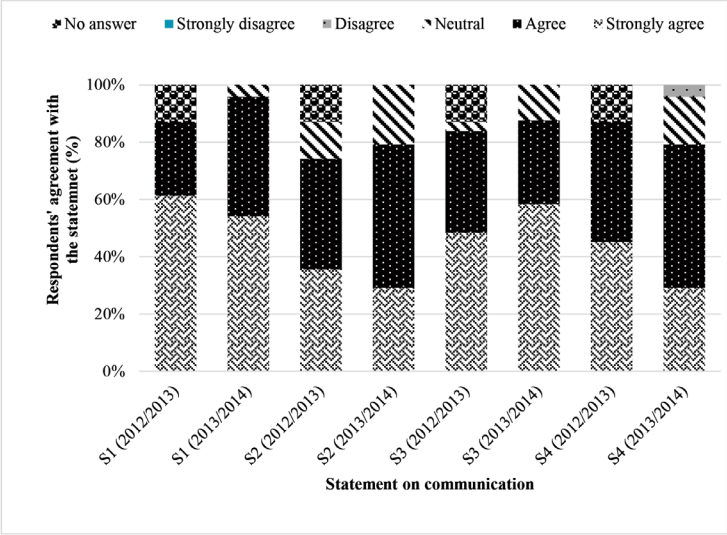

Figure 4. Respondents' agreement on communication during practical courses.

It was found that approximately 50-60% of the students were 'strongly agreed' on the communication opportunities given, either through oral presentation or written practical reports. Only about 30-40% of the respondents were 'strongly agreed' that they loved to do presentations (S2) and they could write a report using the UKM style (S4). The rest of the respondents were either 'agree' only with each of the statements or being 'neutral'. There are also some students who 'disagree' with statement S4 on writing using the UKM style. The disagreement could be possibly due to several factors such as that the respondents had less exposure and/or awareness about the importance of writing using the UKM style. Students are supposed to be aware from the beginning of their programme that writing reports in the UKM style is important because they will be using the same writing style especially for integrated projects, design projects and final-year projects later on, until they completed their degree programme. Therefore it is beneficial for students to get used to the style for writing technical reports as it would make things easier for them as the programme unfolded. One way to effectively implement this is either to guide students through a workshop on writing in the UKM style or to supply the students with a book on Guidelines for Thesis Writing using the UKM Style (*Pusat Pengurusan Siswazah*, 2010), which is available at the university bookstore. Effective communication skills (oral and written) are essential for students as for all aspects of their life ranging from the professional to the social. According to a survey by the National Association of Colleges and Employers (NACE) (2015), communication skills are ranked the first among a job candidate's 'must-have' skills

and qualities. Therefore, these skills must be developed and polished during their years of study if they are to be properly prepared for life after graduation.

Part IV: Group Work

The learning outcome for group work was measured either in active or passive statements, as shown in Table 3. S1, S4 and S5 were the active statements while statements S2 and S3 were presented in the passive. Referring to Table 3 and Figure 5 shows that more than 90% of the respondents 'agreed' and 'strongly agreed' with the active statements for S1 (share ideas), S4 (help members of the group) and S5 (do the practical work and reports together) connected with the laboratory courses. For passive statements, S2 (silent during the internship) and S3 (members of the group did not do any work), there were variations in the answers given by the respondents, from 'strongly disagree' to 'strongly agree'. On average, about 20-40% of the respondents 'agreed' and 'strongly agreed' with the statement S2 and S3 while the remaining (60-80%) 'disagreed' with these statements or did not give any answer. The respondents' agreement with statements S2 and S3 shows that there were many respondents who were reluctant to work in a group, and this may have caused problems for group members as they would have had to put in extra effort. This lack of teamwork is, of course, very unhealthy. Group work means students should work in a team, be cooperative, share and transfer knowledge and most importantly, be able to minimise error in laboratory results through discussion and shared planning and problem solving throughout the process (Kroft, 2014), without which, efficient team work will not be achieved. Thus, students should always be given the opportunity to work in a team as this too helps them develop and hone essential social skills for life in the real world.

Table 3
Group Work

No	Content
S1	I always came up with ideas during the experiment.
S2	I kept silent during practice runs.
S3	Some of the members in my group did not do any work.
S4	I was always willing to assist other members during practice.
S5	I did a lot of practical work and report writing.

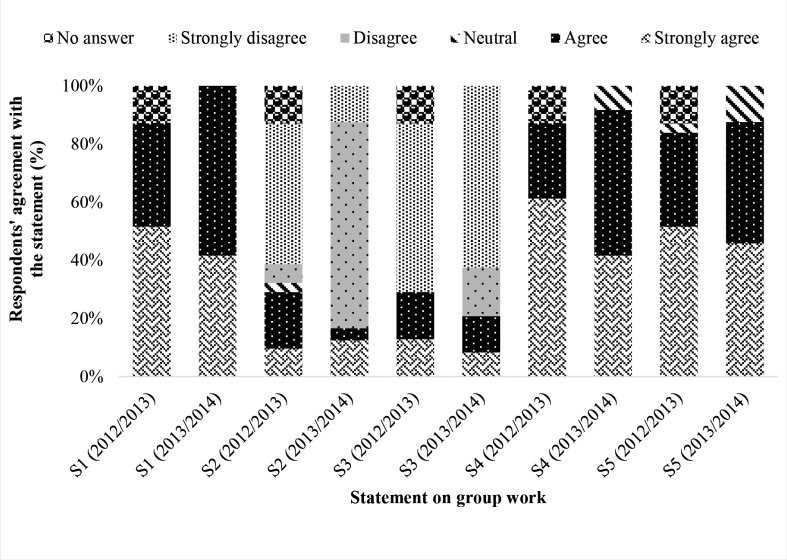

Figure 5. Respondents' agreement on group work.

Part V: Grade Achievement

In terms of student results, the percentage of students in session 2012/2013 who obtained a Grade A were more than double those who did so in session 2013/2014 (refer to Table 4). All the students in the 2012/2013 session received only Grades 'A' and 'A-', while students in the 2013/2014 session obtained a wider distribution of grades from 'A' to 'B' compared to the former session. The decrease in percentage of students receiving grades 'A' and 'A-' for session 2013/2014 was in line with the results of the survey on learning outcomes especially with regards to practical content (Part II). Survey results of the learning outcome for the KKKR 2412 laboratory course for students in session 2013/2014 taken from the percentage of their agreement to the given statement were lower than in the 2012/2013 session. This decreasing percentage from session 2012/2013 to 2013/2014 was significant especially for statements S1, S4, S5 and S7 (from Table 1) where almost half of the respondents 'strongly agreed' with them but the rest either 'agreed' or were 'neutral'.

The correlation of the respondents who 'strongly agreed' regarding the practical content (Part II) with their grades of 'A' and 'A-' in session 2012/2013 and 2013/2014 are presented in Figure 6. The figure shows that the decrease in the percentage of students who received Grade 'A' decreased from 78 to 33% and the percentage of those who received Grade 'A-' increased from 22 to 42% for session 2012/2013 and 2013/2014, respectively. The decrease in Grade 'A' correlated with the respondents' strong agreement with the statements in Part II,

which dropped from 61 to 48% for session 2012/2013 to 2013/2014, respectively. In simple words, the decrease in the total of respondents who 'strongly agrees' with the statement resulted in a decrease in the number of respondents obtaining Grade 'A' and vice versa. This result suggests that the students' level of agreement with statements may indirectly indicate their performance in their grades especially for those who obtained Grade 'A'.

Table 4
Overall Student Achievement Grade

Session 2012/2013		Session 2013/2014	
Grade	Percentage of students (%)	Grade	Percentage of students (%)
A	78	A	33
A-	22	A-	42
B+	0	B+	17
B	0	B	8

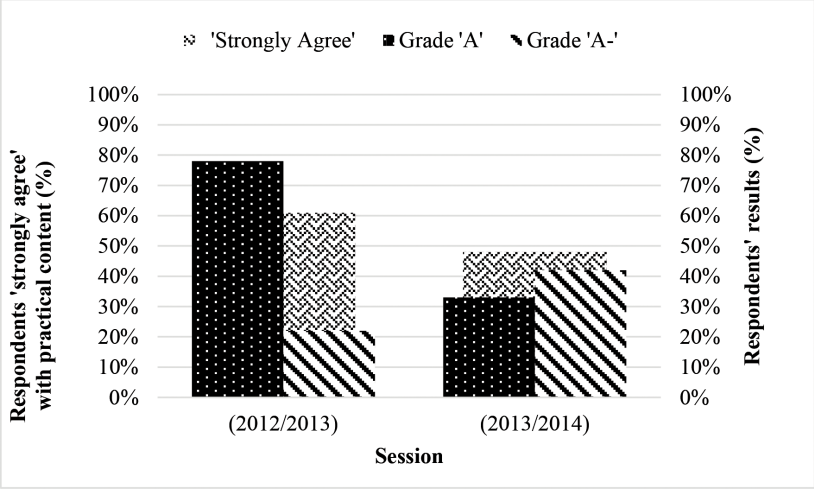

Figure 6. Correlation of respondents who 'strongly agree' on practical content with their grades in session 2012/2013 and 2013/2014.

CONCLUSION

The most important factor in determining student achievement grade for the laboratory course is the mastering of practical content as, in this study, this contributed to 85% of the total marks (Grade 'A' from 80%). The higher the respondents' agreement with statements outlined in the practical content (Part II), the better their results obtained i.e. students

from session 2012/2013 who achieved better grades (A and A- only) had a higher agreement percentage (almost double) than those in the later session. Apart from that, other criteria such as communication and teamwork were also continuously assessed to determine the students' achievement in these areas due to the importance of both skills in a laboratory course. Therefore, it was necessary for students to understand the practical content of the course during the laboratory course in order for them to achieve good grades. This can be possibly improved in the near future through effective lectures, practical briefings, meetings/discussions with students and others.

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