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The Flipped classroom technique to improve students' understanding of concepts in Physical Chemistry coursework

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Abstract

Physical chemistry (PChem) students often have negative perceptions and low expectations for success in PChem, attitudes that likely affect their performance. Students mostly struggle in understanding the fundamental theoretical concepts and their application in solving complex numerical problems in PChem during their first year in undergraduate programme. To help students in learning to solve the problems related to PChem course, flipped classroom modules was implemented for small number of PChem students (CEB1023/CDB1023). The flipped classroom is a pedagogical approach that moves course content from the classroom to homework, and uses class time for engaging activities and instructor-guided problem solving. It is a strategy in which students must undergo self-study prior to the actual classroom. Learning materials such as video, notes and postcards would be given to students prior to the commencement of the class. While, during the class more collaborative activities to engage student learning such as group activities and face-to-face (F2F) engagement with lecturer. The main motive of this study is to increase students' motivation and understanding of PChem course by implementing the computer technology (particularly internet applications multimedia properties) during their teaching and learning process. Besides assessing the students' deeper understanding, the findings from this study will be utilized to assess the impact of flipped classroom as well as the effectiveness of the computer technology on students' exam performance and motivation. Also, the findings may enhance lecturers' understanding on how to apply the flipped classroom model in ways that are most beneficial both for students and lecturers. By combining collaborative activities and F2F approach (during the class), it would enhance students' learning and finally becomes independent learners which is one of the main attributes of UTP graduates.

***Keywords*— Physical chemistry, Flipped learning, engineering, learning outcomes, course portfolio.**

I. INTRODUCTION

Physical Chemistry (PChem) is one of the required main courses in Chemical Engineering programme. It is important for Chemical engineering students to pass and to understand the contents of PChem course as this course is a pre-requisite of chemical engineering thermodynamics, Reaction engineering and separation process for Chemical Engineering Program in UTP. Based on the feedback from the students taking Chemical Engineering, the students attributed difficulties associated with the course to superficial conceptual understanding and its application in solving complex numerical problem and plus having no motivation or interest in the topic. From lecturer observation and literature, for example, students had difficulties with conceptual understanding of ideal gas law concept and how to drive the ideal gas equation

and further limited understanding on application of ideal gas equation in complex problems in PChem [1-4]. This problem basically comes from limited understanding of what basic rules of Calculus, Algebra and Psychometric issues such as reliable assessments and addressing correlations with other factors Students with conceptual understanding know more than isolated facts and methods.

PChem students often have negative perceptions and low expectations for success in this course. Students mostly struggle in understanding the fundamental theoretical concepts and their application in solving complex numerical problems in PChem during their first year. To help students in learning to solve the problems related to this course, flipped classroom modules was implemented for 184 students (CEB1023/CDB1023). The flipped classroom is a pedagogical approach that moves course content from the classroom to homework and uses class time for engaging activities and instructor-guided problem solving [5-7]. It is a strategy in which students must undergo self-study prior to the actual classroom. Learning materials such as video, notes and postcards would be given to students prior to the commencement of the class. While, during the class more collaborative activities to engage student learning such as group activities and face-to-face (F2F) engagement with lecturer. The main motive of this study is to increase students' motivation and understanding in PChem course by implementing the computer technology (particularly internet applications multimedia properties) during their teaching and learning process. Besides assessing the students' deeper understanding, the findings from this study will be utilized to assess the impact of flipped classroom as well as the effectiveness of the computer technology on students' exam performance and motivation. Also, the findings may enhance lecturers' understanding on how to apply the flipped classroom model in ways that are most beneficial both for students and lecturers. By combining collaborative activities and face to face approach (in class), it would enhance students' learning and finally becomes independent learners which is one of the main attributes of UTP graduates. In recent years, flipped based active learning strategy, also known as inverted instruction, has attracted growing attention from both teaching and research groups as the promising learning and reaching techniques. A flipped classroom can be defined as a class content which is traditionally delivered by a teacher/lecturer, will be replaced with activities and the content would be given prior to the commencement of the class in form of notes, video, slides, computer technology, etc. Due to recent improvements in Information communication technology (ICT) tools, web pages, interactive video properties and recorded videos are generally preferred to introduce content outside the classroom. The flipped classroom also is one of the techniques in the area of instructional innovation that lead to the increased use of active learning in science, technology, engineering, and mathematics (STEM) disciplines [3, 4, 5, 6]. Over the years, researchers have proposed several benefits of flipped classroom/instruction such as an increased of students' satisfaction, improvement of students' lecture attendance and improvement of students' academic performance (as measured by improved examination results and/or overall grades) [6-8]. Qualitative feedback obtained from student evaluations also suggested they have improved opportunities for developing communication skills, preferences for working in teams and increased teacher encouragement and learning as compared to the traditional method [9-10].

Based on the discussion above, flipped classroom can be defined as having three features: (i) mandatory pre-class learning of new material followed by (ii) in-depth explanation, practice, and productive use of knowledge in class through active learning techniques, where (iii) class attendance is mandatory [11-15] as shown in Figure 1 and that of non flipped classroom method in Figure 2. All these three features are necessary in this study.

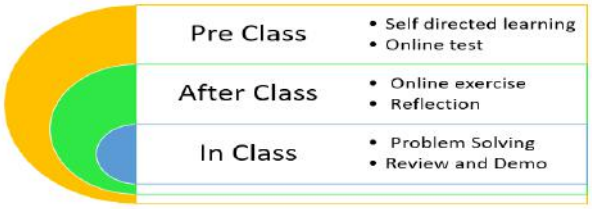

Fig.1: Flipped classroom method.

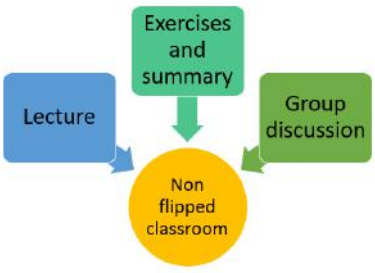

Fig.2: Non flipped classroom strategy

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Physical Chemistry course is one of the core disciplinal in Chemical Engineering offered by Department of Chemical Engineering at Universiti Teknologi PETRONAS (UTP). A typical class of this course at UTP consists of approximately 150-200 students. Based on the experience of the lecturers teaching this course, most students faced some misconceptions and difficulties in the area of conceptual understanding and formula application; and thus they lacked ability to solve complex numerical problem especially at higher order level of knowledge (K4 apply, K5 evaluate and K6 create). Students found that mathematical derivations and their formula applications are the toughest area in in this course.

II. TEACHING-LEARNING METHODOLOGY

In this study, action-research methods were conducted. The activity proposed was conducted in in one semester of September 2023 with the implementation of flipped module and further compared with the coursework of May 2022 without implementing flipped module at Universiti Teknologi Petronas.

The study focuses on the effectiveness of information communication tools (ICT) and techniques used in the flipped classroom that would improve students' conceptual understanding on PChem while working on basic derivations and their application in complex numerical problems. This study involves:

- ✓ Identify and design
- ✓ Teaching and learning approach
- ✓ Assessment/Evaluation on the activities

The methodology is comprised of three stages: (1) Pre-class, (2) In-class and (3) Post-class. Details of each stage is elucidated as follows:

(1) Pre-class

The students are provided with relevant learning materials such as video lectures, notes power point presentation, assigned readings and selected appropriate video lectures relevant to the topics and they are expected to study/view the lecture materials prior attending the lecture class. After reviewing the lecture materials, students are introduced to in-class quizzes or on-line quizzes. Evaluation was made based on the answers of in-class quizzes or on-line quizzes by means of well-structured rubrics.

(2) In-class

In the flipped classroom, the time distribution was used to oversee the collaborative activities as follows.

(i) Group activities – Students are divided into small groups each comprising of 5-6 students with one of the students from each group representing as leader. Each member in the groups is advised to actively discuss about the content provided in a pre-class mode. Students was assigned problems of pre-class mode to discuss and solve the problems in group. These activities and discussions was facilitated by the lecturer. These activities was recorded so that the students can do the revision outside the class from the recorded activities, particularly the recorded activities of question and answer sessions with the lecturer.

(ii) Face-to-face (F2F) activities – In order to discuss mathematical derivation and solve the complex numerical problems of pre-class mode, group was selected randomly to avoid the delay due to restricted mobility in the classroom. Each member of the group was asked to report answers by writing them on the white board as well as explaining the answers verbally to the class using correct terminology. The lecturer was facilitate the problem-solving sessions and at the same time to clarify any misunderstood concepts, derivation or numerical to further strengthen the students' understanding on thermodynamics, phase behavior and chemical kinetics, catalysis and electrochemical system. A video recording was conducted for each group discussion. Peer evaluation was made for each of the groups based on the rubrics.

(iii) Attendance – Students earn participation points by coming to class on time and actively participating in discussions during the problem-solving activities for the day.

(3) Post-class

In this stage, the students was given the questionnaire survey in order to obtain the feedback from the students on their understanding concepts/ derivation/ formula application, a survey to analyze or quantity the learning outcomes during the flipped classroom activities. The survey was use on-line tools such as goggle forms (may change this tool based on the current need of students). The interview session was conducted after the group discussion (in-class) as a form of feedback from students.

Both the students and lecturer was also require to list their reflections on the activity in order to determine whether the teaching and learning materials, and the

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activities conducted helped the students' in understanding the concepts/ derivation/ formula application. The perception of the students was analyzed qualitatively and quantitatively based on the percentage attainment and further the changes for improvement shall be proposed to be implemented by using a different approach based on the feedback.

In order to study the academic performance, the results of coursework for September 2023 semester for the PChem course was analyzed and compared to batches that experienced non-flipped course, i.e. batches of May 2022 to analyze the percentage impact and further are compared with January 2022 students without implementing flipped module.

III. RESULTS AND DISCUSSION

From Figure 3 it is evident that students outperformed by implementing flipped module compared to earlier semester. By using flipped learning students advanced better by 48.27 % in securing an A grade compared without applying flipped module. However, by applying flipped module students have presented better between A – C+ grades in in-class activities. The results show that there has been an increase in percentage by 62.96%, 8.6% and 60.49% in achieving A-, B+ and C grades compared with January 2022 semester based on coursework. Similarly, Figure 4 shows that when compared for final exam students outperformed in September 2023 with an increase in percentage of 40.42%, 32.87%, 10%. 38.21% respectively from A-B grades compared to May 2022 final exam without implementing flipped module.

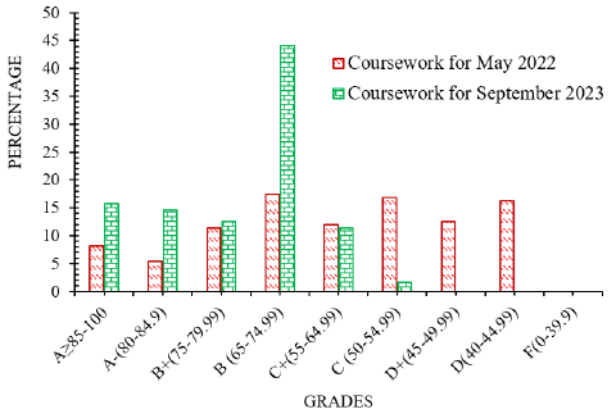

Fig.3: Percentage attainment with and without flipped learning for coursework.

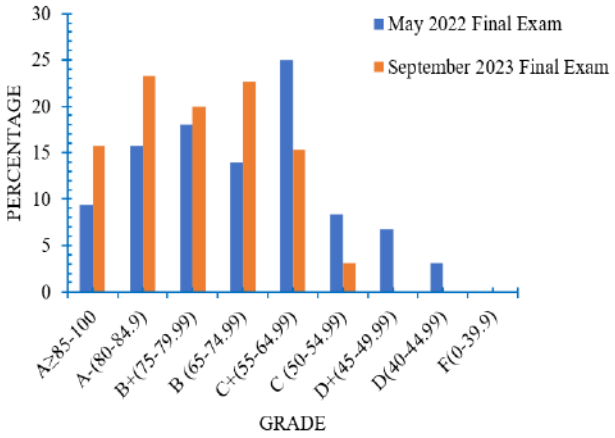

Fig.4: Percentage success for final exam with and without flipped learning.

Above Figures 3&4 shows that flipped module has altered the students to execute better by dynamically being active in groups, and as well as individually to improve their overall advancement of skills. The cause of students failure without implementing the flipped classroom might be as students have no enthusiasm to perform their work and do not take it seriously while responding to test/quiz because they know that teachers will not give them a zero. This inception makes them be unserious. The practice of flip module in solving complicated problems has enriched student's core expertise and cognitive expertise. Furthermore, students acquired involvement skills and appreciated online learning meetings. Students knew to work among their peers. This approach helps teachers to provide a more modified tactic to specific students. Overall, it has great potential in promoting students' critical creative thinking capabilities and transmuting passive learners into active learners. The suggested future research approach will be of interest to educators, academics, and researchers.

IV. CONCLUSION

This research focuses on the importance of flip learning in improving engineering education, especially for first-year engineering students in PChem coursework. Student feedback shows a positive learning experience, which indicates that flip learning increase understanding in students about the application of their theoretical knowledge to industrial application related to physical chemistry. This approach not only enhances practical learning but also helps in developing problem-solving,

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decision-making skills for students for future professional challenges.

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