

## Students' Perspectives on the Effectiveness of Problem-Based Learning with Inverted Classroom Assistance in Improving

### *Persepsi Pelajar Terhadap Keberkesanan Pembelajaran Berasaskan Pemasaalahan dengan Bantuan Inverted Classroom untuk Memperbaiki Pemahaman Pelajar*

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#### ABSTRACT

*This study aims to evaluate the impact of implementing a hybrid teaching strategy combining an Inverted Classroom (IC) with Problem Based Learning (PBL) called Inverted Problem-based Learning (IPBLC). In this study, PBL cases are delivered to large groups of up to 150 students facilitated by a single course instructor within pre-university science courses. Lecture time is reduced using inverted classrooms (IC) with minimal effect on content. It is a multi-subject research made up of 4 smaller research involving the application of IPBLC in the teaching of Physics, Chemistry, Biology and Mathematics. The researchers were responsible in researching and developing an IPBLC module for teaching 150 students each, wherein the impact of hybridizing PBL and IC on students' achievements, learning attitude and conceptual learning of the subjects involved are investigated. Focus group interviews were used as a qualitative approach to gain an in-depth understanding of the issue at hand. This research aims to gain an understanding of the needs, motivations and experiences of Foundation students, focusing on their experience with IPBLC and providing lecturers with a better insight into the effectiveness and issues faced by students in the implementation of this teaching method. The results of this study facilitated the identification of issues that were not apparent from the purely quantitative data, thus providing a deeper understanding of the curriculum and teaching effectiveness that was constructive and detailed.*

*Keywords: Problem-based learning; inverted classroom; Science courses; foundation students; Mathematics*

#### ABSTRAK

*Kajian ini bertujuan untuk menilai impak pelaksanaan strategi pengajaran hibrid yang menggabungkan Inverted Classroom (IC) dengan Pembelajaran Berasaskan Masalah (PBL) yang dikenali sebagai Inverted Problem-based Learning (IPBLC). Dalam kajian ini, kes-kes PBL diberikan kepada kumpulan besar iaitu 150 pelajar yang diketuai oleh seorang tenaga pengajar untuk kursus sains pra-universiti. Masa kuliah dikurangkan menggunakan Inverted Classroom (IC) dengan kesan minimum terhadap kandungan kursus tersebut. Ia merupakan penyelidikan pelbagai subjek yang terdiri daripada 4 penyelidikan kecil yang melibatkan penggunaan IPBLC dalam pengajaran Fizik, Kimia, Biologi dan Matematik. Para penyelidik bertanggungjawab untuk meneliti dan membangunkan modul IPBLC dalam pengajaran mereka terhadap 150 orang pelajar masing-masing. Kajian ini melihat kepada kesan atau impak PBL dan IC hibridisasi terhadap pencapaian pelajar, sikap belajar dan pembelajaran konsep subjek yang terlibat dianalisis. Wawancara kumpulan secara fokus telah digunakan sebagai pendekatan kualitatif untuk mendapatkan pemahaman yang lebih mendalam tentang isu ini. Kajian ini bertujuan untuk mendapatkan pemahaman tentang keperluan, motivasi dan pengalaman pelajar, memberi tumpuan kepada pengalaman mereka dengan IPBLC dan memberikan penerangan impak yang lebih baik mengenai keberkesanan dan isu yang dihadapi oleh pelajar dalam pelaksanaan kaedah pengajaran ini. Hasil kajian ini dapat mengenalpasti isu-isu yang tidak jelas dari data kuantitatif semata-mata, sehingga memberikan pemahaman yang lebih mendalam tentang keberkesanan kurikulum dan pengajaran yang lebih konstruktif dan terperinci.*

*Keywords: Problem-based learning; inverted classroom; kursus-kursus Sains; pelajar-pelajar asasi; Matematik*

#### INTRODUCTION

Science, Technology, Engineering and Mathematics (STEM) Education has always been a priority for

Malaysia. Malaysia Higher Education Institution is implementing one of the goals which were to establish a scientific and innovative society. STEM provides students with the opportunity to investigate

the information provided to them through inverted classroom (IC), in order to understand it based on their own experiences and makes learning more relevant as students are exposed to the concept of problem-based learning (PBL).

In the Traditional Teaching Method (TTM) frustration has arisen when students were not able to translate information given during lectures into useful information that would allow them to complete their homework. Lecturers are continually being challenged to think about how best to integrate digital technologies meaningfully and effectively in their lectures. At the pre-university education level, this problem is further elevated by the English language requirement for the students to function in their daily learning.

Second language learning is a difficult process. Many people around the world are learning the second language to better equip themselves with skills to compete in the larger globalised world.

English as a second language has an important place in Malaysia Education System and is seen as a tool to gain knowledge field such as science and technology (Pillay 1995). In fact, English has been outlined as a compulsory subject for all students in primary and secondary school by the Ministry of Education (MOE). In recent years, the Ministry of Education has implemented many transformational programs in order to enhance the quality of pupils' academic performance.

The students' challenge in grasping the science concepts may be compounded with the teachers' teaching strategies and students' learning styles and it has been reported by various studies. Some students found it hard to understand simple genetic related topics, such as mitosis and meiosis, genes and chromosomes, and Mendelian genetics in Biology are some examples. Hence, more practices in making science and technology learning interesting should be promoted not only to overcome the challenges but also to aid learning (Tekkaya et al. 2001; Cimer 2012).

Research has shown that the teaching strategies currently used are indeed teacher-centred and do not manifest the needs, concerns, and requirements of the teachers and students. The subject content, which is mainly depended on the disciplinary content, must be presented. Science teaching does not only require the attention of the course but also concerns the value of student input in understating the process of moving students from their initial state of knowledge and understanding to the desired level.

Increasing interest in learner's individual differences had developed due to the change from the traditional teacher-centred to student-centred approach (Etorbo & Fabinu 2017). Besides, the academic achievement of students is also known to be directly influenced by individual differences. Awareness of learning styles and their roles in academic achievement can benefit educational psychologists, teachers and researchers (Al-Zoubi & Younes 2015).

Problem based learning is a student-centred pedagogy approach based on the constructive theory of learning that reflects on their experience and fosters critical, creative and also cooperative learning, and has shown positive results in improving students' overall grade but only effective for small groups (Rosalind et al. 2013; Sulaiman & Eldy 2014; Condliffe et al. 2015).

This approach was initially developed, over 30 years ago, as a general model for instruction for students in the medical field and replaced traditional instructional approaches, such as lecture (Savery 2006; Savery & Duffy 1995; Savin-Baden & Major 2004; Torp & Sage 1998). In such cases, students attended to a situation in which a real problem is presented and collaborated to "seek out a variety of resources, technological and otherwise, to help them arrive at possible solutions" (Driscoll 2005: 405). After intense growth in challenges, other disciplines, such as schools of law, business and education began adopting the model in their own approaches to learning (Savery 2006; Savery & Duffy 1995; Torp & Sage 1998).

Today it is used within undergraduate and postgraduate provisions around the world successfully (Barrows & Tamblyn 1980; Lai 2000; Thomas 2000; Barron & Darling-Hammond 2008; Candela et al. 2009; Strobel & van Barneveld 2009; Walker & Leary 2009; Sulaiman & Baco 2012; Rosalind et al. 2013; Sulaiman 2013; Sulaiman & Eldy 2014; Condliffe et al. 2015). Many report that PBL improves long-term knowledge retention (Strobel & van Barneveld 2009), problem-solving skills (Kanet & Barut 2009), analytical and reasoning skills (Michel et al. 2002), interpersonal skills (Kumar & Natarajan 2007), self-directed learning skills (Thomas & Chan 2002), and attitudes towards the course subject (Ferreira & Trudel 2012).

Savery (2006) offers a brief synthesis of several researchers' uses and methods of PBL. Through this synthesis, he outlines these key components to creating a true PBL environment within a learning environment:

1. Instruction must be learner-centred; learners take on responsibility for their own learning.
2. Problems must be messy and ill-structured; this model problem in the real-world that is often hard to define and the goal is often unknown.
3. A tutor/mentor must be present to facilitate learning; generally, the teacher fills this role and is available to help with metacognitive components and questioning strategies and does not provide information or resources.
4. The experience should end with a debriefing and evaluation of the problem, learners and solutions; this helps learners process the experience and come to understand what they have learned.

However, as with any approach to learning, there are many perspectives and perceptions of the role of PBL in instruction. While this approach is increasingly adopted through the medical field as well as other professions (Savery 2006; Savery & Duffy 1995; Savin-Baden & Major 2004; Koh et al. 2008; Pourshanzari et al. 2013; Distlehorst et al. 2005), it has also been met with some challenges and opposition (Savery 2006; Savin-Baden & Major 2004). Savery (Savery 2006: 10) references opposition regarding the preparedness of students under the PBL approach; some medical schools “questioned whether or not a physician trained using PBL was as well prepared for professional practice as a physician trained using traditional approaches”. He indicates that while PBL may be preferred among students and yield stronger problem-solving skills, there is no evidence in terms of actual knowledge gains. In addition, the author also describes the gap in research as a result of the lack of “well-designed research studies” and indicates the need for further study.

These concerns are expressed as challenges such as creating a collaborative environment, altering roles within the classroom, supporting performance, and student learning (Ertmer & Simons 2006). In addition, other researchers raise concerns about the best context in which to present material and curriculum time constraints (Savery, 2006; Savery & Duffy, 1995; Torp & Sage, 1998).

Today, a variety of technologies are used in face-to-face, blended and online provisions with differing numbers of learners. These enable a more participatory and rich way to connect, interact, learn and co-create with others when and how it suits them best. Increasingly we see learners choosing

digital tools and platforms, as well as digital devices for their formal and informal learning needs. While learning online is flexible, it can also be extremely challenging (Lian, 2011; Mohamad Nasir & Ahmad, 2015; Geok Lian, 2011). Social media is frequently used to connect learners outside formal learning situations, and to engage learners in a variety of collaborative learning activities as well as connect with peers and experts around the globe using networks of different kinds.

An inverted (or flipped) classroom, on the other hand, can free class time with minimal effect on the content and hence provides a promising framework for PBL instruction. In an Inverted Classroom (IC), lecture material is moved outside of the class, freeing in-class time for learner-centred activities. Course content is delivered through a variety of mediums including screen-capture videos, simulations, interactive problem solving and other online materials (Mason et al. 2013; Roselli et al. 2007).

In contrast with the traditional class settings, the flipped classroom is a pedagogical approach which inverts the conventional notion of classroom-based learning. The students are introduced with topic materials before the class, with the classroom time then being used to demonstrate an active learning activity, mainly problem-based learning activities. To fill the gap regarding the shifting nature of teacher-to a student-centred approach, these activities are conducted with the assistance of instructors to clarify unfamiliar concepts, resolve the problems, or pose new questions. Introducing the content of the topic involves video lectures and readings. Hence, this model increases the interaction between the instructor and students during class and transfers the learning responsibility and ownership to the students instead of by participating in interactive activities (Pierce & Fox, 2012; Olson, 2014).

Mason et al. (2013) shared the three main catalysts to implement IC. IC allocates class time for interactive activities. As discussed earlier, it allows an educator to present materials of topics without any shortcut in various forms (i.e., video, online forum, reading materials) suitable to students' capacity and lastly students' self-learning drives it. The goal of an inverted classroom is to encourage students who are usually disengaged in their learning and rely more on copying notes, focusing on facts and immediately jumping to conclusions without any judgment (O'Flaherty & Philips, 2015). Baepler et al. (2014) also emphasised that the students'

satisfaction towards their learning is higher when the inverted classroom was implemented over the traditional approach.

As the conventional teaching method had a less impressive impact to overcome the misconception (Bahar, 2003), attempting to integrate active learning strategies into the lessons could be highly beneficial for the learners. Implementing active learning into science courses have been extensively studied to increase the learning outcomes among students compared to traditional chalk and talk method (Morevac et al. 2010). One of the strategies in active learning for science subjects is through problem-based learning (Allen and Tanner, 2005). Inverted classroom, primarily through a case study or problem-based learning had contributed to the increasing number of students' learning gains in biology subject (Anderson et al. 2005; Bonney, 2015). Students work in groups to solve the real complex scenarios using their previous knowledge thought in class through independent discovery and inquiry-based format.

In recent years, IC has gained attention to be applied during the learning and teaching process as it can substitute the conventional pedagogy approach. An IC is the independent learning process, as the students were exposed with the lecture contents outside of the classroom through the lecture videos or readings (Smith 2013; Teo et al. 2014; Fitzgerald and Li 2015). In other words, students can self-learn the course contents at their own learning time and learning pace (Flaherty and Phillips 2015). For this model, a lecture period in the classroom was substituted with the active learning activities such as the PBL activities, discussion and debates, as the instructor was involved only for guiding problems solving and clarifying information (Christiansen et al. 2017; Fautch 2015).

Current literature shows the significant results in applying the IC model as it enhances the students' engagement, participation, level of interest, enthusiasm and performances as well (Bishop, Beach, and Engineering, 2013; Teo et al. 2014; Fulton 2012). The support system and technology in this model provide the flexible and interactive conditions to promote students to think effectively and creatively, fast-feedback and students' commitments to their learning process (Herreid and Schiller, 2012; Lo, Hew, and Chen, 2017; Flaherty and Phillips, 2015).

The combination of new technologies in this model are practical tools since it provides

comfortable and flexible approaches to the students in the learning process, as it is appropriate in the 21st century (Fitzgerald and Li, 2015; Revell, 2014). Furthermore, the problem-based solving activities and discussions during classroom enhanced the interest level and soft-skill materials of students due to their engagement and participation in the activities, resulting in the improvement of their comprehension of the topics (Bergmann and Sams 2012; Fautch 2015). As a result, it increases the performance of students on the summative assessments (Fautch 2015).

Furthermore, the difficulties of learning and teaching process for the students in Pre-University are not similar to other levels due to the structure of course contents, teaching styles and the behaviour of students.

Integrating flipped classroom with the problem-based learning in science related education does suggest that the students' learning styles have not only improved, but it may have substantial influences on their academic performance (Luo et al. 2017).

The Inverted Classroom approach has been shown to be an effective delivery method in several studies (Mason et al. 2013; Roselli et al. 2007; Lage et al. 2000). The IC does not negatively affect students' performance on traditional class and standardized tests, as does PBL alone. In addition, an IC can effectively address multiple learning styles by delivering the content in different formats. In addition, IC can promote self-directed learning and help develop professional problem solving skills because the format teaches the students to find and interpret the information needed to solve problems.

Challenges, however, exist with the Inverted Classroom regarding students' (a) preparedness for a class; (b) attention span while watching online videos, and; (c) misconceptions of fundamental principles. Basic guidelines, by Zappe et al. (2009) and Rais-Rohani et al. (2010), to overcome these challenges include:

1. requiring an online quiz before class to ensure preparedness;
2. keeping videos less than 30 minutes;
3. fixing student misconceptions by spending the first 10 minutes of class answering questions or holding mini-lectures, and;
4. using multi-media for online content to engage students.

The results from IC studies provide promising evidence that an IC can be used effectively to deliver

traditional course content, even when class time is used for learner-centred activities. Furthermore, existing research points to the benefits of PBL (Yadav et al. 2011; Prince et al. 2006). Together, these results suggest that an IC and PBL could be successfully integrated to improve student self-directed learning and problem-solving skills without sacrificing a strong understanding of fundamental principles of the various subjects.

Therefore, this study broadly aims to explore and evaluate if, and how, the hybridization of PBL and IC can be used effectively within Academic Development provision to create an open networked learning environment. This type of environment can enable learning beyond the institution, in the spirit of open education, bridging formal and informal learning. It also provides enhanced and extended opportunities for connectedness and peer learning. This multi-disciplinary study intends to look at the effectiveness of the integration of Problem Based Learning with Inverted Classroom format. Due to the strengths of these two pedagogies, this research aims to explore the effect of combining them in the teaching of foundation courses namely Physics, Chemistry, Biology and Mathematics.

#### PROBLEM STATEMENT

The recently released Malaysia Education Blueprint 2015-2025 (MEB) by the Education Ministry highlights in its first shift, the issue of graduates lacking the critical thinking and communication skills, and also language proficiency (especially in English) that are essential for success in the 21st century (MEB 2015). In order to achieve the Ministry's aspiration to increase the current 75% graduate employability rate to more than 80% in 2025 and to achieve these outcomes, the Ministry and Higher Learning Institutions (HLIs) are asked to focus on developing more holistic and integrated curricula and enhancing the ecosystem for student development.

At HLIs, one of the challenges of university education is that programs must address not only technical topics but also prepare graduates to work on open-ended and ill-defined problems. Furthermore, at the pedagogical level, these two goals can sometimes be in conflict. University education has traditionally relied on lecture and textbook type problems whereas teaching students how to address open-ended problems requires an approach with less apparent structure.

The educational value and impact of using small group learning, a student-centred approach and PBL have all been supported by both practice and research (Koh et al. 2008; Pourshanzari et al. 2012; Schmidt et al. 2006; Novelli et al. 2007; Distlehorst et al. 2005). Graduates of PBL curricula may retain their knowledge over a longer period of time and maybe better prepared for life-long learning.

However, research on its implementation with a large group of students and pre-university students are lacking. PBL requires extra class time for solving open-ended problems too, which may lead to a reduction in the total number of concepts covered in a course. This problem is exacerbated because new information and concepts are added to the field every year. Finding time to cover these new topics places increasing demands on class time, and instructors are often hesitant to relinquish class time. This can limit the effectiveness and adoption of PBL in classes.

The integration of PBL and IC make a fundamental shift from a focus on teaching to a focus on learning. The active learning is a learning process in which the learner takes the responsibility of his learning and he is given the opportunity to make decisions about various dimensions of the learning process and to perform self-regulation (Açıköz 2003). More importantly, it would be potentially beneficial and interesting to find out whether the study that we are proposing to be conducted within a course delivered through hybridization of PBL and IC format would have any significant improvement of students' basic knowledge and problem-solving skills, from now on will be referred to as IPBLC.

#### THIS STUDY

Research focusing on evaluating the effectiveness of instructional designs that involve the development of skills best suited to prepare learners for success in a rapidly changing world is timely given the urgency with which many stakeholders in Malaysian education are calling for a re-evaluation of the objectives of the institutions serving our students. Instructional designs that promote skills related to critical thinking, problem solving, collaboration, and self-direction in addition to encouraging students to acquire flexible knowledge about specific content via the approximation of real-world situations are well-positioned to meet these needs.

The current study contributes to the mission of identifying the educational practices that are best

suiting to accomplish the goal of preparing students to for successful outcomes in life by examining the aspects of problem-based learning that contribute to its effectiveness. This type of research is essential, as it is imperative that educators at all levels choose to implement instructional strategies that are empirically based. Ideally, the outcomes to be reported in the current study will provide some degree of clarity and direction as to the instructional methods that constitute educational "best practice" in the implementation of PBL instruction.

In this capacity, previous studies' findings indicate that the PBL approach provides a significantly better conceptual learning than traditional didactic instruction (Lasry 2006; Lasry & Aulls 2007; Capon & Kuhn 2004; Bilgin et al. 2009). Therefore, one of the tasks of this research is to design assessment systems that are meaningful to students and are aligned to PBL and the subjects' context. Academic achievement, on the other hand, refers to standardized test scores, grades, and overall academic ability and performance outcomes.

Since there is a possibility that students may show different academic achievements, learning attitude and levels of conceptual learning for different academic subjects, the teaching intervention to be developed in this study is tested with pre-university students registering in four different courses, i.e. maths, physics, chemistry and biology. This research employs purposive sampling made up of four research groups with five to six lecturers in each group. Each subject involved 150 students. As for the focus group interviews, they conducted in three sessions with 25 students each.

This research was conducted in two phases. In the first phase, questionnaires were distributed to 1,000 ex-pre-university students (they then will be in their first to the final year of degree at Universiti Malaysia Sabah) to reflect the relationships between students' learning attitude, behaviour and difficulties during PBL sessions in the four subjects and their scores in the pre-university examinations. The objective of this phase of the study was to glean information from the 1000 ex-pre-university students who have gone through three semesters of PBL during their pre-university year via looking at variables that cover their attitude, behaviours and difficulties when doing PBL. The researcher relied on the quantitative outcomes to measure the effects of PBL and the students' performance in the PBL assessments. This data is also, in addition, provide data for triangulation and to validate the construct of the intervention.

These findings were then the base in guiding the development of the intervention, i.e. IPBLC modules that ensure that the modules consider the students' perspectives. The second phase investigated the implementation of the intervention. In this phase, the quantitative data followed the qualitative strand separately in a sequence and merged at the point of interpretation. However, this paper reports the findings of the second phase of this research.

This paper, however, concentrates on students' opinions in evaluating the pros and cons of IPBLC. Students' opinions in rating a pedagogical module help in providing indicators of effective instruction, providing a valuable tool to improve teaching. Yet, data from interviews has been used mainly as a triangulation data and not analysed comprehensively. This paper reports the findings from the interview data that systematically analyse text-based feedback relating to student perceptions of and experiences with recently developed pedagogical modules. The semantic analysis tool Leximancer enabled a critical interrogation across units of study, mining the cumulative text for common themes and recurring core concepts. The goal is to provide a deeper understanding of the effectiveness of the pedagogical modules that was constructive and detailed.

This study looks into the implementation of PBL in a pre-university program involving four subjects, namely Physics, Biology, Mathematics and Chemistry that are taught using an IPBLC framework. The aim is to improve self-directed learning and students' problem-solving skills while maintaining the number of topics taught in a course and student understanding of fundamental principles of the subjects involved.

## METHODOLOGY

As qualitative research generates a significant volume of rich data, especially with in-depth interview transcripts, a qualitative computer program was utilized. The data sets were subject to analysis via Leximancer; a software program that facilitates thematic content analysis techniques (Loosemore & Galea 2008). This provides the framework for discussing the identified themes, concepts and patterns that are the basis for all qualitative research analysis. The software is a proprietary mathematically based text mining and text analytic tool that can be used to identify the true meaning from text, and to display the extracted information visually (Leximancer 2010).

In addition to quantifying and coding text segments, Leximancer develops a thesaurus of words around a set of initial seed words, and incorporating the proximity of the words in the transcripts, displays the data in a 'concept map' (Loosemore & Galea 2008). The qualitative data analysis moves from the particular (text transcripts and codes) to the general (concepts and themes) (Creswell 2005).

In the Leximancer concept map, the themes are represented by the circles, with the size and depth of colour used to illustrate the dominance of the theme. The level of overlap between the circles demonstrates the co-occurrence of these themes in the data. Within Leximancer, the theme name is derived from the most significant concept within the theme circle, and the concepts themselves are the most frequently used words by the students in the interviews. The various sizes of the concept points, and their locations, indicate the relationship and connection to other concepts and the colour indicates its thematic group. In addition to the concept map, a supporting table provides a list of the concepts and quantitatively ranks them by their frequency of occurrence based on the interviewee's responses (Loosemore & Galea 2008). Once the data sets are input into the software auto tags are applied to exclude from the analysis, for example, the dialogue of the interviewer. As such, the presented results only include the themes and concepts based on the Foundation Program interviewee responses.

The clustering was run several times in the software in order to establish the validity and stability of the concept map. Again validity, for

qualitative research, is best approximated by alternative concepts, notwithstanding the 'counting' nature of the Leximancer program. Although there were some changes in regards to positioning, the key themes and concepts remained the same assuring trustworthiness, confirmability and credibility (Denzin & Lincoln 2005; Henderson 2006). The results and discussion, which situate the findings in the context of the literature, confirm the transferability of the data in terms of its theoretical validity (Kirk & Miller 1986).

Three groups of participating students were questioned about their experience with IPBLC by means of expert interviews that were half-standardized (semi-structured), i.e., the interviews were conducted using a guideline that only provided subject-related questions (Table 1). The groups consisting of randomly allocated participants ( $n=20$  students) were exposed to the three subjects IPBLC sessions. These students participated in a focused group discussion to share their view about their experience with the IPBLC modules. The setting of an open discussion allowed each participant to freely express his/her personal view and impression.

## RESULT

The interview data were grouped by Leximancer into related concepts that co-occur with other concepts in the map. As a result, similar concepts are clustered together, as illustrated in Figure 1, 2 and 3.

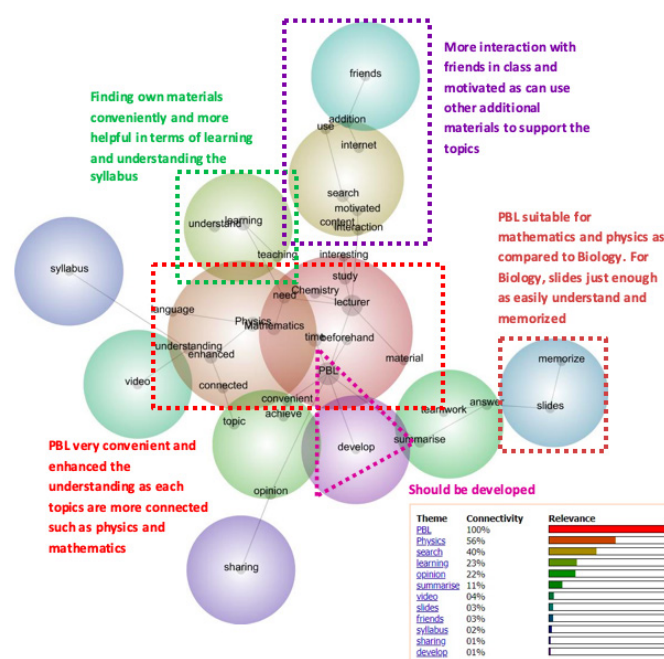


FIGURE 1. Focus Group Interview 1

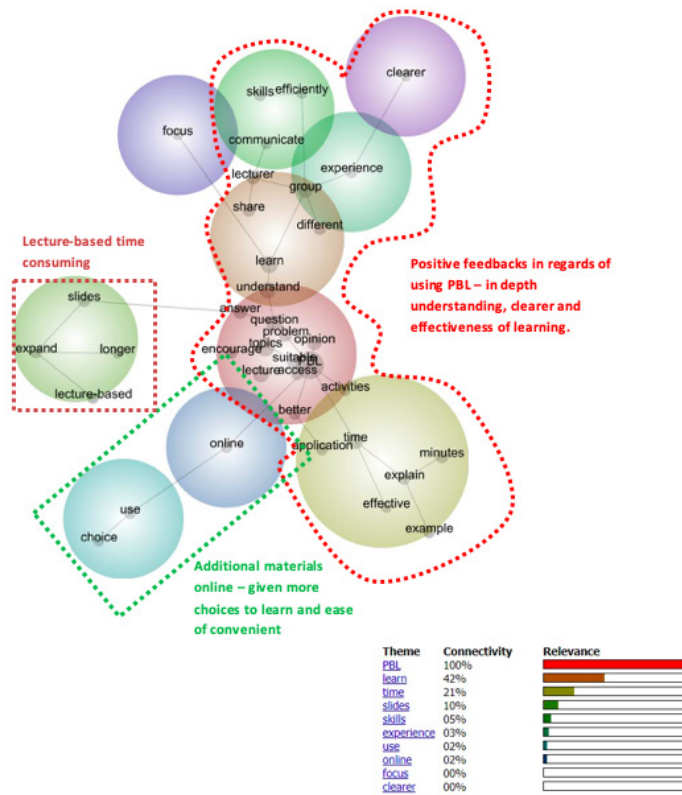


FIGURE 2. Focus Group Interview 2

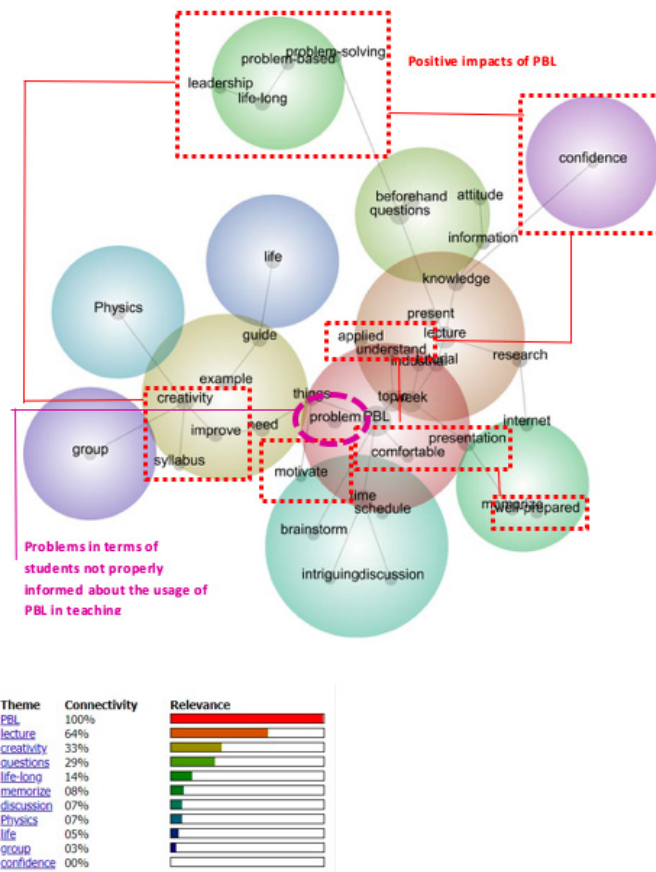


FIGURE 3. Focus Group Interview 3



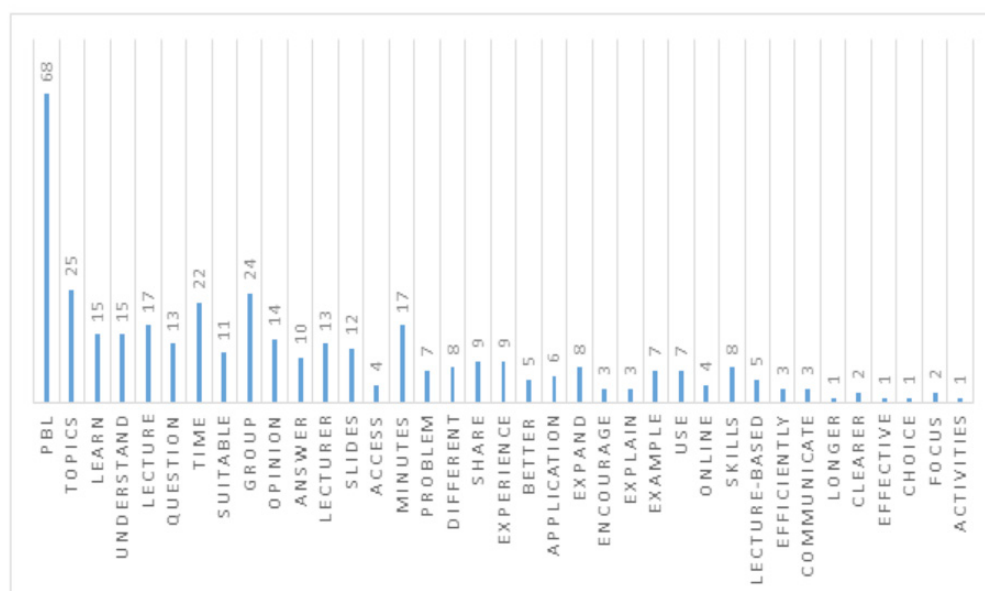


FIGURE 4. Clusters Based on Frequency

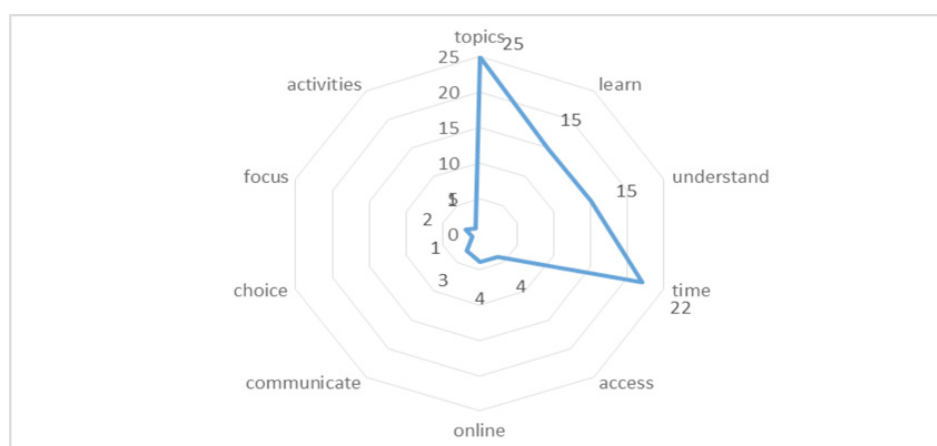


FIGURE 5. The Characteristics of PBL that of Important Based on Students' Interpretation

The concepts can be further analysed by frequency as in Figure 4. Next, the concepts are clustered and most relevant labels were given to each cluster. They are:

1. Students' understanding of IPBLC's important characteristics;
2. Students' concerns on IPBLC's problems; and
3. Students' understanding of what is needed for a successful IPBLC.

These are going to be further elaborated below.

1. Students' understanding of IPBLC's important characteristics;

The spider-web configuration shows the visual representation of the first focus group responses

interpretation of IPBLC's characteristics that are of importance to the students. The visual representation provides a "snapshot" of the strengths and weaknesses of each domain and of IPBLC's characteristics as a whole. Activities, focus, choice, communicate, online and access were given a low rating by the students of 1 – 4, were identified as being weak because the concepts are not of importance to the students. The interpretation of the spider-web in Figure 5 above gives 'topics' the highest rating of 25 because the students agreed that not all topics are suitable to be used in IPBLC. Time is given the second highest rating and followed by learning and understanding.

As for the analysis of the responses from the second focus group.

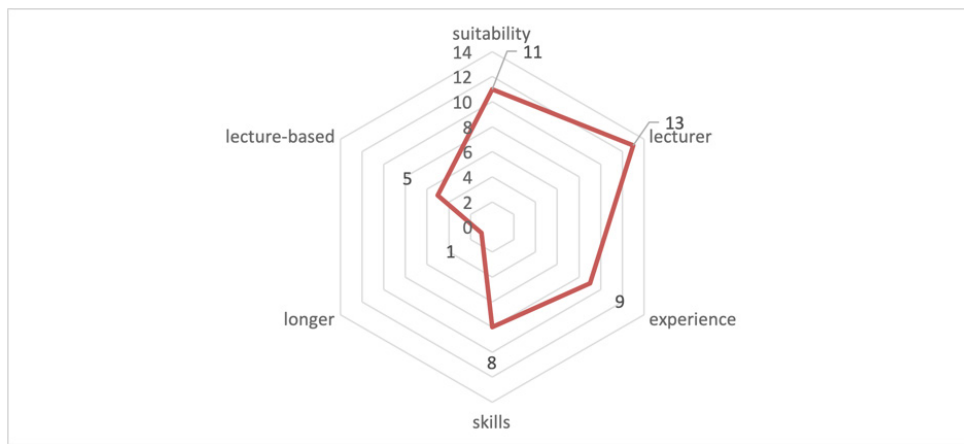


FIGURE 6. The Problems of PBL that of Concerns Based on Students' Interpretation

Figure 6 illustrates a “big” spider-web in which the domains demonstrated in the figure were given a value based on the frequency of students mentioning the domains during the interview. They seem to indicate that domains like suitability, lecturer,

experience and skills are the major obstacles in IPBLC.

The next figure shows the result of the third focus group interview.

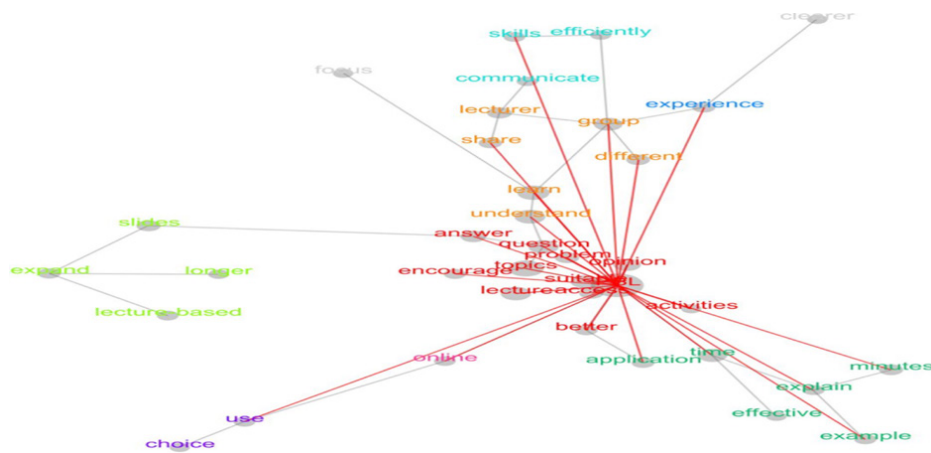


FIGURE 7. Concept map generated by Leximancer on students' opinion of IPBL

The concept map in Figure 3 shows that the concept IPBLC is the central concept within the intended curriculum. It is also a concept that a number of other concepts cluster around. This means that these concepts (learn, time, slides, skills, design, experience, use, online, focus and clearer) occur frequently together within the intended curriculum. The concept IPBLC also has a number of word-like that co-occurring around it (refer to related word-like in Table 1). For example, IPBLC is 100% likelihood in terms of co-occurs with the concept “activities”, which indicates that IPBLC is an activities-based learning system. The concept “access” has 75% of co-occurring with IPBLC that shows students understanding that IPBLC is easily accessible in terms of learning materials.

Related Word-Like	Count	Likelihood
activities	1	100%
access	3	75%
suitable	7	64%
online	2	50%
lecture	8	47%
problem	3	43%
better	2	40%
encourage	1	33%
explain	1	33%
question	4	31%
answer	3	30%
opinion	4	29%
topics	7	28%
learn	4	27%
different	2	25%
experience	2	22%
time	4	18%
application	1	17%
example	1	14%
use	1	14%
skills	1	12%
share	1	11%
understand	1	07%
minutes	1	06%
group	1	04%

FIGURE 9. Related Word-Like for Students' Opinion on IPBLC

## CONCLUSION

Generally, the feedback with regards to the implementation of IPBLC was very positive. The students informed that IPBLC provided an in-depth and clearer understanding of the topics and was very effective for learning. They stated that the traditional lecture-based pedagogy was very time-consuming. They stressed on their ability in finding own materials conveniently when doing IPBLC and that IPBLC was more helpful in terms of learning and understanding the syllabus. IPBLC also promotes more interaction with friends in class and motivated to do more search on their own as IPBLC allows the use of other additional materials to support the topics.

They also stated that IPBLC was very convenient and enhanced their understanding as the topics were more connected especially in Physics and Mathematics. Their opinion was the opposite for Biology and Chemistry because, for Biology and Chemistry, they felt slides were more than enough as these two courses are more easily understood and memorized. They believed that IPBLC helped them to think step by step in solving problems presented in the module from the stage of identifying real problems, collecting information, formulating hypotheses, investigating / testing, discussing to the stage of presenting the results. These activities involve science process skill and in the end, enhance students' problem solving ability and critical thinking ability.

Thus, the students generally agree that the use of IPBLC method enhances their understanding of Physics and Mathematics better than using the conventional teaching method. IPBLC promotes their skills of group work, and self-directed learning better than using conventional teaching, among the foundation students.

The findings of this study should also be generalised to the wider population. One goal of developmental research is to link theory, research and practice (Richey et al. 1996). The research will help to more accurately ground the module design in research-based design ideas. In addition, it will also highlight issues about standards, student needs and classroom limitations. Each of these will be elemental in the overall design and development of the module and the advice received will lead to a sounder product.

Instructional designers should also benefit from the model produced in this study. However, they will

need to allow for some flexibility as the instruction evolves. The target content and audience will drive the needs and goals of the instruction and the design model should remain flexible to adapt as such.

To teachers, this research aims to investigate a smoother transition among teaching styles through the incorporation of some level of support, for example, IC; therefore, the outcome of this research may be able to recommend teachers what to be done if they want to engage in a PBL environment.

To students, this study will allow them to appreciate diverse views, think critically and be innovative, and have problem solving initiatives.

Last but not least, this research also benefits the Ministry of Education. This research will help to address students' aspirations in the Malaysian Education Blueprint 2015-2025, i.e. the fifth primary attributes, thinking skills, which the higher education system is anchored on.

This study has shown that the performance of pre-university students does benefit from the Inverted Problem-based Learning Classroom. The outcome of the study is consistent with past literature on the inverted classroom in science subjects. Potential future study of this is the extension to a larger size of students and a more extended period of implementation.

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