



[pbl] Reflections on problem-based learning **[pbl]**

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Contents

Editorial: A Multi-Faceted Approach in Shaping the PBL Environment	3
Research Article 1: Is the Study Process Questionnaire a Good Predictor of Academic Achievement? <i>Jeanette Choy</i>	4
PBL Review: The Importance of Being Assessed <i>Lim Li Yin</i>	10
Research Article 2: Problem-based Learning, Graduates' Competencies and Career Success <i>Bhina Patriat</i>	15
Problem Showcase: Heart Rate Filters <i>Hong Lim Tim</i>	22
Conference Announcement and Upcoming Courses	25



A Multi-Faceted Approach in Shaping the PBL Environment

We have a problem. The Problem-based Learning (PBL) pedagogy has been around for more than two decades and has been described as “the most significant innovation in education for the professions for many years” (Boud & Feletti, 1997, p. 1). Institutions have stepped up on the intentionality and efforts in incorporating the elements of PBL in their curriculum, assessment and even the spatial design of classrooms. The shift has been significant – from an emphasis on content-knowledge to a focus on metacognitive strategies and critical thinking, and from teacher-centred lectures to learner-centred facilitation styles. Herein lays our problem: Critical thinking, self-directed learning, team building, collaborative learning, reflection are all qualities salient in a PBL classroom; however, these very qualities that we seek to develop and assess are not immediately apparent or easily measurable. What makes it so challenging?

Curriculum design, feedback and assessment of student learning in the Problem-based Learning environment take on a multi-faceted approach. As practitioners of PBL, it is imperative that we wrestle with complex questions like:

“Do the tests we administer complement the daily assessment that we give students? Or are they counter-acting what PBL sets out to achieve?”

“Do the problems that students work on in their classrooms correspond to real industry-related problems?”

“Does our feedback encourage (or discourage) students’ self-directed learning and motivation?”

“Can we accurately predict the levels of achievement-academic achievement for the student, and career success of graduates?”

In this issue of PBL Reflections, we have invited our colleagues to share their work in PBL in an attempt to give a thoughtful response to these questions. We feature a study conducted by Jeanette Choy (Republic Polytechnic) which examines whether student approaches to learning is a good predictor of academic achievement, and proposes a model that shows that observed classroom behaviours are a useful mediator between student approaches to learning and academic achievement. We have also included a review by Lim Li Yin (Republic Polytechnic) which will sufficiently provoke some thoughts about the kinds of assessment philosophies to adopt and how these paradigms may, in turn, mould the tangible forms of assessment instruments and methods. As with previous issues, we have selected an interesting problem crafted for students learning about Heart Rate Filters from a Linear Circuits and Control module offered by the School of Engineering at the Republic Polytechnic. It is significant that we mention that this problem was adapted from a real-life problem faced in the biomedical industry, and students were challenged to relate their solution to the medical equipment used in industry. Bhina Patria (Germany) shares his research on the differences in perceived competencies and work success between graduates from PBL and non-PBL environments. His paper confirms the effectiveness of PBL curriculum in enabling higher competencies in students, which manifest in higher performance in the workplace.

As we share with you this edition, we hope that the ideas will provoke your thoughts on your personal and organisational paradigms of PBL. While it may be easy to let many of the above questions go unanswered, it is in answering them that we gain a deeper pedagogical awareness that shapes our decision-making in the classroom and focuses our attention on the learning outcomes we want achieved through education.

IS THE STUDY PROCESS QUESTIONNAIRE (SPQ) A GOOD PREDICTOR OF ACADEMIC ACHIEVEMENT? EXAMINING THE MEDIATING ROLE OF OBSERVED CLASS-ROOM BEHAVIOURS

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ABSTRACT

Studies have shown that the Study Process Questionnaire (SPQ) – which provides a measure of student approaches to learning – is a relatively weak predictor of academic achievement. The present study sought to explore whether students' classroom behaviours, as observed by teachers, can be used as a mediator between students' approaches to learning and academic achievement. The SPQ was administered to 1,639 students enrolled in six different diploma programmes offered by a polytechnic in Singapore. Data was analysed by means of correlation and path analysis. In line with existing studies, the results revealed that student approaches to learning was a weak predictor of academic achievement. However, observed classroom behaviours turned out to be a significant mediator between student approaches to learning and academic achievement, effectively improving the explained variance in academic achievement from 4% to 25%. Implications of these findings for using the SPQ are discussed.

Keywords: Approaches to learning; Study Process Questionnaire; Classroom behaviours; Student achievement.

INTRODUCTION

How students approach a learning task is expected to determine the quality of learning outcomes. For instance, Marton and Saljö (1976) were the first researchers to make the distinction between approaches to learning by distinguishing between *deep* and *surface* learners. Deep learners are students who have the intention to look for meaning in the study materials by closely examining the content to sieve out the underlying concepts and relating these concepts to everyday life and one's prior knowledge. Surface learners, on the other hand, are students who have the intention to only meet task requirements such as fulfilling course requirements or passing the examination. The most common strategy adopted by surface learners is rote learning or memorising the study materials. Generally it is assumed that the deep approach to learning results in "higher quality learning outcomes" and the surface approach results in "lower quality learning outcomes" (Gijbels et. al., 2005). Besides the distinction between the surface approach and deep approach to learning, Biggs (1976) and Ramsden (1981) introduced a third approach, the achieving (or strategic) approach to learning. 'Achieving learners' (or strategic learners) refers to learners who aim to get high marks by optimising their efforts

and by organising their time and study strategies to earn a good grade. Given that achieving students' focus is on doing well on the test, it is expected that they will generally perform better than surface learners (Biggs, 1987).

The concept of the three approaches to learning has been operationalised in many studies across different disciplines, educational contexts, and countries to measure how students generally approach learning and to make predictions about their academic achievement. An instrument that has been used extensively is the *Study Process Questionnaire* (SPQ) developed by Biggs (1987a). The SPQ is a 42-item self-report instrument that measures students' deep, surface, and achieving approaches to learning. Despite the general usage of SPQ in predicting students' academic achievement, it is not entirely clear whether and how different approaches to learning are linked to students' academic achievement.

There are several studies that found no (Jones and Jones, 1996; Groves, 2005; Gijbels et. al, 2005; Wildings & Andrews, 2006) or only a weak relationship (Ramburuth & Mladenovic, 2004; Snelgrove & Slater, 2003; Booth et al., 1999) between students' approaches to learning and academic achievement. In contrast, a longitudinal study conducted by Zeegers (1999) found a relatively strong correlation of .41 ($p < .05$) between deep approach to learning and academic achievement. However, the caveat to this outcome is that the relatively stronger correlation of .41 ($p < .05$, $n = 60$) was observed at the end of a three-year longitudinal study. The correlation coefficient between deep approach and Grade Point Average (GPA) was initially weak $r = .11$ ($p < .05$), but gradually increased over the three years to $r = .41$ ($p < .05$). This increase in the magnitude of the correlation coefficient could imply (1) that students become more deep learners over the three years of study or (2) that only the better students responded to the survey. Astin (1970) and Neilson, Moos and Lee (1978) observed the latter in their studies where they found that students who responded to follow-up surveys are more motivated and tend to do better academically as compared to those who do not respond. The same may have happened in the Zeeger study.

Finally, Watkins (2001) conducted a meta-analysis with 55 independent samples including 27,078 respondents from 15 countries. Overall, this meta-analysis confirms the findings from the earlier mentioned studies that the relationship between students' approaches to learning and academic achievement is generally weak, explaining only about 1% to 3% of the variance in academic achievement.

The results of the above studies indicate that students' approaches to learning (as measured by the SPQ) are a relatively weak predictor of academic achievement. One reason for the relatively low correlations may be related to the manner in which achievement is measured. In order to have an adequate measure of students' approaches to learning, the assessment system needs to measure students' corresponding learning behaviours that reflect surface, deep and achieving approaches to learning. Most assessments, however, mainly measure students' knowledge retention, and not their learning behaviours (Choppin, 1990). It may therefore be appropriate to include assessment measures, which provide a true picture of students' approaches to learning in the classroom. It may be possible that self-report measures of students' approaches to learning need to manifest themselves in an actual classroom before they can be considered an adequate predictor of academic achievement. Considering the above, we included a mediating variable – students' classroom behaviours – into the present investigation. This observational measure of classroom behaviours captured the degree to which students are actively involved in searching for meaning, relating and applying concepts to real life examples, engaging in discussions with

their peers, and identifying the main ideas to be learnt.

In summary, in the present study we examine whether these observed classroom behaviours is indeed an adequate mediator between student's approaches to learning and academic achievement. In addition, this study examines which approaches to learning have a bigger influence on how well a student performs academically.

METHOD

The SPQ was administered to a large cohort of 1,639 students that were enrolled in six different three-year diploma programmes at a polytechnic in Singapore. Three measures were obtained for the purpose of this study, namely Biggs' (1987) Study Process Questionnaire (SPQ), achievement-related classroom behaviour and academic achievement. The SPQ was administered to assess the extent to which students used the deep, surface and achieving approaches to learning. The achievement-related classroom behaviour measure was based on teacher observations in which teachers observed and rated how students acquired information, how engaged they were (e.g. searching actively for meaning in relevant resources), their understanding of the study topic, and how well they presented and applied their findings to the real world. As an academic achievement measure, written tests of thirty-minute durations were conducted every four weeks over the semester for all subjects to measure students' understanding of the concepts learnt.

Correlation analysis was conducted to examine the strength and direction of the linear relationship between students' approaches to learning and academic achievement. To determine if observed classroom behaviours are indeed an adequate mediator between students' approaches to learning and academic achievement, we conducted a path analysis to examine the relationships between the SPQ subscales, observed classroom behaviours, and students' academic achievement.

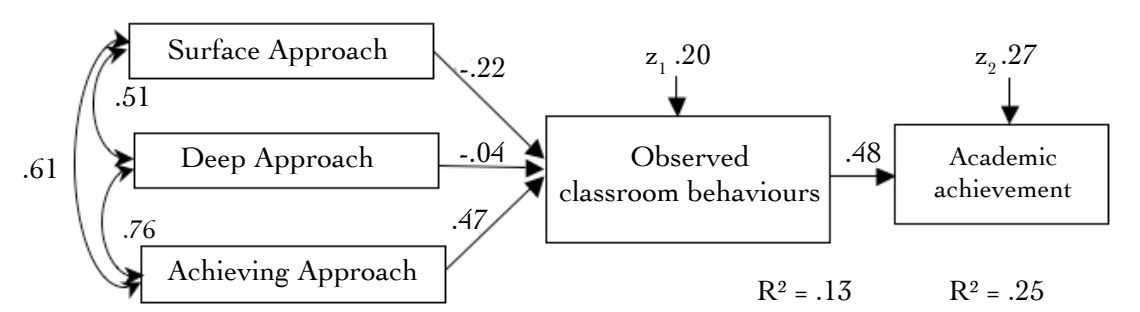
RESULTS AND DISCUSSION

As a first step in the analysis, we generated the correlation coefficients between the three approaches to learning and academic achievement. Similar to the findings of the previous studies mentioned, our data confirmed that the relationships between students' approaches to learning and academic achievement are generally weak, explaining less than 4% of the variance in academic achievement.

We argued earlier that the weak correlations could be due to a misalignment between students' approaches to learning and how these approaches are assessed by means of achievement tests. We proposed that the self-reported approaches to learning need to translate themselves into actual classroom behaviours first in order to be an adequate predictor of students' academic achievement.

The results of the path analysis in which we included a measure of observed classroom behaviours as a mediator, are depicted in Figure 1.

Figure 1: Path model depicting relationships between approach to learning, observed classroom behaviours and academic achievement



Note. Numbers above the arrows represent standardised regression weights.

The results of the path analysis revealed that the data fitted the hypothesised model very well, Chi-square/ df ratio = .45, p = .64, CFI = 1.00, RMSEA =.00. All factor loadings were statistically significant except for the factor loading between the deep approach to learning and observed classroom behaviours. In this model, about 13% of the variance in observed classroom behaviours could be explained by approaches to learning. This is considerably more than in the reported studies in the literature.

The achieving approach was the strongest predictor of observed classroom behaviours (β = .47, p < .01). A possible explanation could be that the assessment tends to be more favourable towards the achieving learners. Achieving learners are versatile learners and they will adapt the way they approach learning tasks to what the teachers or the assessment schemes want in order to get good grades. As such, they get cues from what they think they will be tested on.

Surface approach had a weak to medium strong inverse relationship with the observed classroom behaviours (β = -.22, p < .01). This inverse relationship was expected and indicates that students who follow a surface approach to learning do generally demonstrate less engagement in the learning activities.

An interesting finding is that deep approach to learning did not significantly predict students' actual behaviours in the classroom. We argue that this could be due to how deep approach to learning is being measured in SPQ. Examining the statements that are used to measure deep behaviours in the SPQ, we realise that they tend to be more cognitive and philosophical in nature even while they may not be that apparent in classroom behaviour. An example of such a statement is: "I believe strongly that my main aim in life is to discover my own philosophy and belief system and to act strictly in accordance with it". On the other hand, statements that are used to measure surface approach to learning tends to be more visible and easier for both students and teachers to identify with. An example is: "Lecturers shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined".

Observed classroom behaviours in turn was a strong predictor of academic achievement (β = .48, p < .01). The result of the path model lends support for our hypothesis that classroom behaviours, as observed by a teacher, are indeed an adequate mediator for the relationship between students' approaches to learning and academic achievement.

CONCLUSION

In this research, we have developed a model to show that using observed classroom behaviours as a mediator has effectively improved the variance explained in academic achievements by 6.25 times (from 4% to 25%). The findings of the study suggest that if one wishes to make predictions of academic achievement with the SPQ, it would be useful to include an observational measure of students' classroom behaviours. In this study we note that deep learning behaviours were not as easily picked up in teachers' observations as compared to achieving and surface learning behaviours. If one were to use SPQ to predict academic achievements, 'surface' and 'achieving' approaches to learning provide more consistent information relating to how well students perform academically.

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THE IMPORTANCE OF BEING ASSESSED: JUDGING OR DEVELOPING?

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Thou shalt be graded – a message drummed so deeply into the core of our consciousness – is ironically but not surprisingly a belief that is hardly questioned. The idea of a school that does not grade its students is almost sacrilegious to any man on the street, given that assessment is vital to the proper functioning of society. Who dares doubt this must surely be an educational crank with kumbaya-like pedagogies.

But wait. Grading and assessing - are they the one and same thing? This review argues that grading and assessment are not interchangeable ideas and that it is the common conflation of these two otherwise different concepts that has arguably perpetuated a one-dimensional view and practice of assessment. It is the continued drive in this direction that had roused passionate advocates such as Bryan and Clegg (2006) to campaign for the redefinition of assessment as “an instrument of liberation” (p. 1), and by this they mean that assessments ought to “enhance and enable self-regulated learning and judgments” (p. 1) rather than act as mere tools for measurement.

This review simply intends to return to the basics, to clarify our conceptions about assessment, to detect possible blind spots in our assumptions about the purposes of assessment and to disentangle what perhaps are fallacious ideas about assessment. The deliverable of this review is humble – to wax critical about ‘assessment’.

Assessment versus Grading

British philosopher Gilbert Ryle told the story of a student visiting a university. After being shown around on campus the various facilities such as the libraries, fields, buildings and laboratories, the student asks, “But where is the university?” Ryle called this “a categorical mistake” (Fearn, 2001, p. 152) that is, to equate the level of existence of the university with that of buildings and libraries. The being of the university does not belong on the same categorical level as mere buildings and libraries, but exists above such a level.

In this same fashion, the being of assessment does not belong to the same categorical level as mere examinations and the grades derived from it. Assessment, when thought of as a liberating instrument that transforms our youths into independent intellectuals, is just about everything

that the school does. Not separate from the learning experience. Not an item situated at the end of the semester. Not a dead-pan singularity. This brings to mind the notion of 'holistic assessment' that may go easy over morning coffee when one is not completely out of slumber, but when sober and tasked with making concrete decisions on assessment, the term 'holistic' turns menacing.

Emerging authors have called out for a rethinking about grades, and in doing so, pushed us all back to asking the fundamental question – What is assessment and what is its key purpose? In essence, the main thrust of the debates amongst assessment theorists is whether assessment can still 'happen' without grades. Several authors and educational theorists have hinted at the advantages of doing so, although they make no apologies about the need for the educational community to sort out our semantics lest all meaning skids to a halt. Strickland and Strickland (1997) are examples of those who pooh-pooed blind faith in grades, calling for the need to admit "how little grades actually tell us." They lament that "grading doesn't exactly fit in a transactional classroom with authentic assessment, yet teachers have to grade". Their provocative analogy of the "square peg in a round hole" suggests that the marriage of educational aspirations and grading traditions is but a royal disaster.

Yet, there must be a reasonable explanation for the endurance of grading systems in human society – some kind of survival advantage for society maybe?

What do you mean 'maybe'? It is absolutely so! So say the peeved defenders of grading and believers of the functionalist paradigm where the central purpose of assessment is primarily as a matter of issuance of license to proceed. Here, assessment is Supreme Regulator, responsible for society's efficient allocation of human resources, the arbiter of 'good' and 'bad' manpower to be channeled wherever appropriate. Assessment is the ultimate gatekeeper – telling society truths about qualified and unqualified employees, compressing complex information about people into economical symbols like alphabets and point-scores. The dominance of functionalist views of assessment best explains society's inertia in diminishing the ineffable position of grades. Imagine the consequences if we do away with examinations and grades. Horror of all horrors. One can easily exaggerate the implications – our schools would be meaningless, feckless youths running amok, society disorganised, doctors who make mistakes all the time, incompetent engineers and falling buildings – it would be the end of civilisation!

Judgment and Development – Mixing It

In Republic Polytechnic, Singapore, we grade our students every single lesson. This is reason enough for us to pay some urgent attention to the argument made by the aforementioned authors regarding the negative effects of grades on learning.

So sort we must, beginning with the recognition that assessment is doubly burdened with two functions, as articulated by Brown, Bull and Pendlebury (1997, p. 9):

"Developmental assessment is concerned with improving student learning and is founded on trust between individuals and in the system of assessment. Judgmental assessment is concerned with licenses to proceed to the next stage."

As with all kinds of sorting, unhealthy dualisms and polarised camps may form. One who prioritises the latter function may claw at the mumbo-jumbo enthusiasm of the developmental

camp and remind us to exercise the necessary pragmatism to ensure standards, while those in the developmental camp caution that the benefits to learning must never be compromised by the benefits of functionalist allocation. To maintain this tricky balance, some semantic lines need to be drawn. Otherwise, unconstructive dualism will persist. Strickland and Strickland (1998) asserts that each of these terms – assessment, evaluation, grading, reporting – means something quite different. Brown, Bull and Pendlebury (1997) highlighted the etymology of the word ‘assess’, noting, “*The term assessment is derived from ad sedere – to sit down beside. The implication of its etymology is that it is primarily concerned with providing guidance and feedback to the learner.*” (p. 11) More importantly, the authors warn that these two functions of assessment must never be conflated, for “*then trust is likely to diminish, concealment of developmental needs is likely to occur; risk taking and creativity may be reduced and compliance increased.*” (p. 11)

It may also be the case that both the judgmental and developmental aims of assessment are not contradictory in and of themselves, as may be implied by these authors. Naturally, in the ideal world, an assessment system that adopts developmental methodologies would (i) enhance quality of learners and (ii) be a better sorting mechanism to award those with real abilities and contribute to the functionalist expectations of an education system. In this ideal world, grades really do reflect objective truths. But this piece of idealism exists in the same continuum of actual constraints, be it time or resources. Teachers have limited amount of time with students and to mark assignments and exam scripts. Besides, understanding is still a poorly understood phenomenon; absolute objectivity is elusive. So, it becomes important not just to pay lip service to the importance of both and to conveniently assume that they might gel perfectly together in a destined bind, but also to decide: Do we swing to this side *more* or that side *more*? In short, the dilemma is one of how to mix these twin aims in a manner which does not encourage the binaries commonly thought of when we think of assessment, e.g. judgmental versus developmental, formative versus summative, and so on. What is needed instead is a coherent assessment philosophy that can translate to sound policies and practices and one that achieves important identified goals, without putting one at the expense of another.

There is No Escaping an Ideology

When it comes to providing a clear vision and centrality of an assessment philosophy, there needs to be a demonstration of what the primary aim is and the exhibition of confidence that this primary aim supersedes and naturally leads to the fulfillment of other secondary aims. This implies that whilst many determinants are at play, an ideology is quite literally, an ideology (and not two, or three). In other words, do not commit the fallacy of the middle ground.

As they say, the devil is in the details. For example, assessment practice that is devoid of feedback mechanisms (be it formative or summative assessment formats) would be hard-pressed to claim itself to be developmental in its assessment and pedagogical paradigm and beliefs. Similarly, an assessment system that does not align itself with industry goals and takes most of its evidence from too narrow a sampling domain like ‘effort shown’ would be hard-pressed to profess to be competent in issuing licenses. (For effort may not always lead to competency) Hence, while it may be easy to state the equal importance of learning and licensing of one’s assessment system, it is tougher to demonstrate the equal enactment of methodologies and practices that facilitates the aims of both. There needs to emanate a central purpose. So it seems, there is no escaping an ideology.

And surely, nobody would deny that developing students is the ruler of the roost. The judgmental function of assessment is the dependable deputy. But what exactly does a student-centered assessment system look like?

The Three Basic Steps of Student-centred Assessment

I have titled my review as *'The Importance of Being Assessed'* to bring to light how we have been valuing its importance so far, and to broaden this importance beyond (i) the candid pragmatism that inevitably associates grades with assessment and (ii) the uncritical assertion of the importance of both the judgmental and developmental aims without examining the relationships between them. I wish to open up a discussion of how best to juggle competing aims of assessment. To do this, we need to simplify the business of assessment, and here is an amazingly succinct definition of it.

"Assessment consists, essentially, of taking a sample of what students do, making inferences and estimating the worth of their actions." (Brown, Bull and Pendlebury, 1997, p.8)

These three steps not only characterise assessment, they also provide the framework for examining a whole range of problems and dilemmas linked to assessing. For example, in thinking about the sample, it should be recognised that formal end-of-semester examinations take a sample which may limit someone's judgment about students' capabilities. As lamented by Strickland and Strickland (1998, p. 55):

"I will merely ask...of all the knowledge available in the world – which by the way, according to experts is doubling about every eighteen months – how can we have the audacity to determine an individual's entire future by the way in which that individual answers one, three or twenty questions about a totally insignificant segment of all that knowledge?"

But neither should we suddenly develop a gargantuan appetite for every single piece of detail about students. No, that would be obsessive and too time-consuming to be fruitful. What is needed is first an understanding about what we want to assess and what qualities we hope to develop in our students. In a nutshell, what are you gunning for? Then we think about how glimpses of the individual can be revealed through different types of samples at different times. Finally, we need to consider the estimation of worth and how to represent it – in the form of written comments, grades and/or scores. How do these different ways of representing the estimation of worth affect students? Will they motivate them to reflect, to be told their relative intelligence as compared to their peers, or influence their hopes and fears about their future careers, or lack of?

The motivations behind the choices we make as we prod along these three broad steps as recommended by Brown, Bull and Pendlebury (1997) can help us reflect on our current assessment practices and suggest improvements that may more effectively encourage student learning. For example, we may discover that we have taken samples of students' work from a limited domain or from using the same type of test instruments. Perhaps such a realisation can help us see the possibilities for innovation and expansion when it comes to test construction, so that we can capture a more holistic view of students' abilities. Also, using a variety of sample(s) discourage learning that is one-dimensional and hence, may have the potential to raise the quality of learning and thus competency of students.

A Final Note

As with most reviews, this ends with an injunction to read more. Authors such as Bryan and Clegg (2006) have compiled a book that reviews many bold innovations in assessment policies and methods. It consolidates voices that call for more focus on the improvement of student learning via assessment practices. Key features include:

1. It introduces the possibilities of including students as active participants in the determining of assessment practices,
2. It recommends paying greater attention to self and peer assessment,
3. It actively promotes the strengthening of quality feedback mechanisms in even summative assessment formats, and
4. It looks at the support we can get from online technology.

The book marks a new generation of educational practitioners who want to decisively implement the student-centred philosophy in assessment, and insist on assessment as being structurally integral to the constructivist learning pedagogy, and not existing out of it.

I hope this review has provoked some thoughts about educational assessment paradigms and how they mould the tangible forms of assessment instruments and methods. I had emphasised the need to differentiate between assessment and grading. Also, I had highlighted the two functions of assessment and the trepidations as well as current innovations and attempts in trying to create a seamless assessment system that caters ultimately to student learning.

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PROBLEM-BASED LEARNING, GRADUATES' COMPETENCIES AND CAREER SUCCESS

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ABSTRACT

In this study, the differences in competencies and career success between two groups of medical school graduates were compared. Those groups were: Graduates who studied in institutions which have a high emphasis on Problem-based Learning (PBL) (group 1); and graduates who studied in institutions with less emphasis on PBL (group 2). The analysis was based on graduate survey data covering 11 countries with 3,476 total respondents. The result of the analysis indicates that there are generally significant differences in competencies between graduates in groups 1 and 2. In the indicator of career success, graduates from group 1 reported to have higher satisfaction with current work than group 2; but there is no difference in annual gross income between both groups. However, the result of the analysis with gender as control variable documented that male graduates in group 1 have higher annual income than male graduates in group 2. Female graduates in group 1 and 2 reported to have no difference in annual income. The result of the analysis by graduates' type of degree showed that among graduates with Bachelor degrees, group 1 has a higher income than group 2. No differences in income were found among graduates with Masters degrees. Graduates with Masters degrees in group 1 reported to have a higher satisfaction with current work than graduates in group 2. However, no differences were found in graduates with Bachelor degrees.

Keywords: Problem-based learning, Graduates' competencies, Career success, Graduate survey.

INTRODUCTION

The discussion of the effectiveness of Problem-based Learning (PBL) in preparing students for employment has been one of the main topics in PBL research. The issue has been generating a lot of interest, debate and controversy (Albanese, 2000; Albanese & Mitchell, 1993; Berkson, 1993; Colliver, 2000; Newman, 2003; Sanson-Fisher & Lynagh, 2005; Vernon & Blake, 1993; Wolf, 1993). Despite several studies on PBL, few studies have investigated the direct outcome of PBL in the world of work. Limited studies on the implication of PBL in employment are usually related to graduates' preference for certain types of work (Mennin, Kalishman, Friedman, Pathak, & Snyder, 1996) or performance of graduates' interpersonal skills in the world of work (Peters, Greenberger-Rosovsky, Crowder, Block, & Moore, 2000).

The empirical evidence from prior research highlighted the advantage of PBL as compared to conventional lecture-based curricula. A PBL approach has been argued to provide a learning

process with a cognitive psychology and educational theory base (Gijsselaers, 1996; Norman & Schmidt, 1992). Therefore PBL provides a better learning environment for students, which is then assumed to have an impact on educational outcomes. Students in a PBL curriculum reported to be more satisfied with their curriculum (Busari, Scherpbier, & Boshuizen, 1996; Norman & Schmidt, 2000). Students and graduates from PBL curriculum did not only achieve higher scores in clinical competencies (Distlehorst, Dawson, Robbs, & Barrows, 2005; Hoffman, Hosokawa, Blake, Headrick, & Johnson, 2006), but also rated themselves higher on general competencies (Cohen-Schotanus, Muijtjens, Schonrock-Adema, Geertsma, & van der Vleuten, 2008; Prince, van Eijs, Boshuizen, van der Vleuten, & Scherpbier, 2005; Schmidt, Vermeulen, & van der Molen, 2006).

Even though there were several studies of PBL which focused on the impact on graduates' competencies (Cohen-Schotanus, et al., 2008; Prince, et al., 2005; Schmidt, et al., 2006), the direct impact of the implementation of PBL on graduates' career success remains unexplored. Therefore the focus of this study on the long-term effect of the implementation of PBL to graduates' career success will certainly enrich research in PBL.

This study seeks to address the following question: Do graduates from a PBL curriculum have different competencies and career success compared to their colleagues from conventional curriculum? It is expected that PBL graduates have higher career success compared to non-PBL graduates. This expectation is based on the fact that the learning environment in PBL curriculum enables students to gain higher work competencies than students from conventional curriculum. These work-related competencies are manifested in the workplace, with the result that PBL graduates gain more career success in terms of income and work satisfaction.

METHOD

The analysis in this paper was based on the data collected in CHEERS (Careers after Higher Education: A European Research Study). This was a research project conducted from 1998 to 2000. Graduates were surveyed at about four years after graduation. The study was focused on the relationship between higher education and employment. Several variables were investigated in the survey, such as socio-biographic backgrounds, study paths, transition from higher education to employment, early careers, links between study and employment, job satisfaction, and perspectives of the graduates on higher education. This survey covered more than 36,000 graduates from nine countries in the European Region (Austria, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, and United Kingdom), one EFTA country (Norway), one of the Central and Eastern European countries in transition (the Czech Republic) and one economically advanced country outside Europe (Japan).

The analyses of this paper were based on graduates from the field of medicine. Graduates from France were excluded from the data set because they were under-represented in the data set (only 6 graduates). After excluding the non-medicine field and graduates from France, the data set consisted of 3,476 graduates. Female graduates dominated the dataset with 66% while only 34% of the respondents were male (see Table 1 for detail by country). The average age of participants at the time of the survey was 30.4 years old ($SD = 5.19$, $Mdn = 29$). From the total data set there were 40% graduates with short duration study degrees (equal to a Bachelor degree) and 60% graduates with long duration study degrees (equal to a Masters degree).

Table 1 Gender by Country (percentage)

	Country ^a											Total
	IT	ES	AT	DE	NL	UK	FI	SE	NO	CZ	JP	
Male	48	31	42	53	25	44	34	31	16	41	52	34
Female	52	69	58	47	75	56	66	69	84	59	48	66
Total	100	100	100	100	100	100	100	100	100	100	100	100
Count (n)	(350)	(309)	(298)	(238)	(283)	(304)	(198)	(275)	(872)	(197)	(152)	(3476)

^a IT: Italy, ES: Spain, AT: Austria, DE: Germany, NL: the Netherlands, UK: United Kingdom, FI: Finland, SE: Sweden, NO: Norway, CZ: Czech Republic, JP: Japan.

In the CHEERS study, graduates were asked to what extent project and Problem-based Learning were emphasised by their institution of higher education and their teachers. The rating scale of answer was from 1 = 'Not at all' to 5 = 'To a very high extent'. Graduates' responses were recoded to a dichotomous response. Responses 4 and 5 were recoded to '*high PBL*' and responses 1 and 2 were recoded to '*low PBL*'. Response 3 was not included in the dichotomy and classified as a missing value. Two groups were formed: Group 1 was the group of graduates who studied in higher education institutions which have high emphasis on Problem-based Learning; and group 2 was graduates who studied in higher education institutions which put less emphasis on Problem-based Learning.

Graduates' competencies at the time of graduation were measured with question E1a in CHEERS questionnaire. Graduates were asked to rate their competencies at the time of graduation with respect to 36 indicators of competencies. The rating scale of the answer ranged from 1 = 'Not at all' to 5 = 'To a very high extent'. Factor analysis was used to find out the underlying factor in graduates' competencies.

Factor analysis revealed seven factors of graduates' competencies: (1) Leadership factors including items such as leadership, initiative, assertiveness, decisiveness, persistence, creativity, problem-solving ability, taking responsibilities, and decision-making; (2) personal working skills such as accuracy and attention to detail, time management, power of concentration, working under pressure, working independently, and fitness for work; (3) organisational skills such as economic reasoning, applying rules and regulations, planning, coordinating and organising, understanding complex social, organisational, and technical systems, and documenting ideas and information; (4) interpersonal skills such as loyalty, integrity, tolerance, appreciating different points of view, adaptability, working in a team, and getting personally involved; (5) field-related knowledge such as field-specific theoretical knowledge, field-specific knowledge of methods, and analytical competencies; (6) basic communication skills such as broad general knowledge, cross-disciplinary thinking/ knowledge, written communication skill, oral communication skill, and critical thinking; (7) special skills such as computer skills, and foreign language proficiency. New factor variables were then computed from the factor analysis result. Each factor variable was formed by summing graduates' responses on items representing the factors.

Prior study suggested that career success should be measured by two dimensions: Objective/ extrinsic career success and subjective/ intrinsic career success (Rumberger & Thomas, 1993; Seibert & Kraimer, 2001; Vermeulen, 2006). In this study, the objective indicator of career success was represented by graduates' annual income and the subjective indicator was

represented by graduates' general work satisfaction. Graduates' annual income was measured from three variables: Graduates' annual gross income from current major job (including overtime and extra payments); from overtime and extra payments in graduates' major job; and from other jobs. Graduates' work satisfaction was measured by question G1: 'Altogether, to what extent are you satisfied with your current work?' The scale ranged from 1 = 'Very dissatisfied' to 5 = 'Very satisfied'.

Differences between the two groups in competencies and indicators of career success were tested using independent samples t-test. The effect of gender was studied by conducting the analysis separately on male and female groups. Using a similar procedure, the effect of types of degree (Bachelor and Masters) was studied as well. This step is necessary because the level of education (Dolton & Makepeace, 1990; Perna, 2003) and gender (Ng, Eby, Sorensen, & Feldman, 2005) have been found to be strong predictors of career success.

RESULT

The result of independent-samples t test analysis indicates that there were significant differences in competencies between graduates who studied in higher education institutions with high emphasis on PBL (group 1) and graduates who studied in higher education institutions with less emphasis on PBL (group 2). At the time of graduation, graduates who studied in higher education institutions with high emphasis on PBL had higher competencies in leadership $t(2113) = 11.06, p < .01$; personal working skills $t(2031) = 4.71, p < .01$; organisational skills $t(2078) = 17.09, p < .05$, interpersonal skills $t(2190) = 9.47, p < .01$; field-related knowledge $t(2036) = 8.25, p < .01$; and basic communication skill $t(2137) = 10.95, p = .01$. Conversely, graduates from group 2 reported to have higher competencies in special skills $t(1845) = -2.37, p = .01$.

In the indicator of career success, graduates from group 1 reported to have higher satisfaction with current work than did group 2, $t(1982) = 6.24, p < .01$. No differences were found in annual gross income, $t(1773) = 1.48, p > .05$.

The result of the analysis on graduates' competencies by gender reported similar finding with the analysis on global data, except for special skills. Male graduates in groups 1 and 2 reported no difference in special skills ($t(902) = -.46, p > .05$) and personal working skills ($t(882) = 1.57, p > .05$). Female graduates in group 2 reported to have higher special skills ($M = 4.94, SD = 1.58$) than female graduates in group 1 ($M = 4.80, SD = 1.75$), $t(1439) = -1.71, p < .05$.

Analysis of graduates' annual income found that male graduates in group 1 have higher annual income ($M = 37.06, SD = 31.88$) than male graduates in group 2 ($M = 30.50, SD = 20.99$), $t(747) = 3.30, p < .05$. Female graduates in group 1 and 2 reported to have no difference in annual income, $t(1177) = .97, p > .05$.

On the analysis of satisfaction with current work, male graduates in group 1 reported to have higher degree of satisfaction ($M = 3.86, SD = .93$) than male graduates in group 2 ($M = 3.61, SD = .96$), $t(820) = 3.43, p < .01$. Female graduates in group 1 reported to have higher satisfaction with current work ($M = 3.97, SD = .89$) than female graduates in group 2 ($M = 3.76, SD = .96$), $t(1468) = 4.42, p < .01$.

The analysis by type of degree revealed slightly different findings from the analysis on global data. Graduates with Bachelor degrees in group 1 reported to have a higher annual gross income ($M = 28.72, SD = 19.25$) than graduates in group 2 ($M = 23.57, SD = 11.69$), $t(928)$

= 3.97, $p < .01$. No differences in annual gross income were found in graduates with Masters degrees, $t(243) = -.305$, $p > .05$.

Graduates with Masters degrees in group 1 reported to have a higher satisfaction with current work ($M = 3.82$, $SD = .942$) than graduates in group 2 ($M = 3.65$, $SD = .961$), $t(1336) = 2.21$, $p < .05$. No differences in satisfaction with current work were found in graduates with Bachelor degrees ($t(992) = 1.36$, $p > .05$).

DISCUSSION

This study documented the impact of PBL implementation on graduates' competencies and career success. Generally graduates from PBL higher education institutions consider themselves to have higher competencies. This study confirms the effectiveness of PBL curriculum in preparing students for the world of work. There are some variations in the results when the analysis was conducted by gender and by types of degree. The variations of the result might be related to some unavoidable shortcomings of the study.

The findings in this study support prior studies on PBL and its impact on graduates' competencies (Cohen-Schotanus, et al., 2008; Schmidt, et al., 2006) which reported that PBL curriculum enabled students to have higher competencies such as problem-solving skills, self-directed learning, interpersonal skills, organisational skills and field-related knowledge.

This study, which was based on survey data, has several shortcomings compared with other studies with better methodology, i.e. true experimental design. First, one should be aware that this study was based on graduates' rating of PBL implementation and indicators of career success. Thus, it suffers from limitations of biased responses and social desirability. Nevertheless, the utilisation of survey data in this study also has several advantages compared to experimental design, namely more generalisability and the possibility of international comparison of PBL practices. It should also be noted that PBL measurement of graduates was based on the retrospective responses of graduates. Graduates rated their responses on competencies and on PBL implementation about four years after graduation. The accuracy in rating their responses might be weakened over this time span.

Another issue that needs to be addressed is the validity of the measurement. The measurement of the implementation of PBL in graduates' prior higher education was based on a single item rating. Even though the practice of using a single variable is common and reliable for measuring job satisfaction (Scarpello & Campbell, 1983), its application to PBL measurement still needs further research. Nevertheless, the division of two curriculum types (PBL and non-PBL) in this study could be the solution to the limitation of prior studies. Prior study (Schmidt, Dauphinee, & Patel, 1987) recognised the difficulty in international comparisons of PBL study, namely that the dissemination of PBL leads to a variety of implementation of PBL in higher education institution. To compare the implementation of PBL, one should first set the same standard of measurement of PBL. Students' or graduates' ratings on the implementation of PBL in their higher education institution could be the solution for measuring PBL implementation across different universities and disciplines. An instrument which is based on the criteria for analysing PBL and based on students' or graduates' ratings would enable multi-discipline and international comparisons of PBL study.

CONCLUSION

The characteristics of PBL, i.e. learning in a student-centred atmosphere, small group discussion, teacher as facilitator, and using real problems as the stimulus for the learning process (Barrows, 1996) have several advantages for students. The aspects of cognitive psychology in PBL curriculum (e.g. the activation of prior knowledge, elaboration of knowledge at the time of learning, and matching context between the learning process and retrieval) enhance students' learning outcomes (Norman & Schmidt, 1992). PBL characteristics, such as the ones mentioned above, match with Kember's (2004) criteria for curriculum, which motivates students to work hard toward high-quality learning outcomes. Higher competencies acquired by graduates from PBL curriculum manifest in a higher performance in the workplace. Employers appraise these competencies and compensate them with higher remuneration. With higher competencies, graduates from PBL curriculum will have more opportunities to have meaningful work that boosts their feeling of achievement, increased responsibility and more opportunities for advancement and growth. All these conditions, according to Herzberg's theory of job satisfaction, will increase the level of job satisfaction (Robbins, 2003).

Future study should include more mediator variables involved in the relation of PBL and graduates' career success. Those variables might be from the formal elements of employment such as employment status, employment conditions, economic sectors and occupation or position. It could also come from the higher education aspects such as level of degree, types of programmes, types of specialisation, and reputation of the institution. Individual differences such as personality trait and motivation could also contribute to the relationship.

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HEART RATE FILTERS

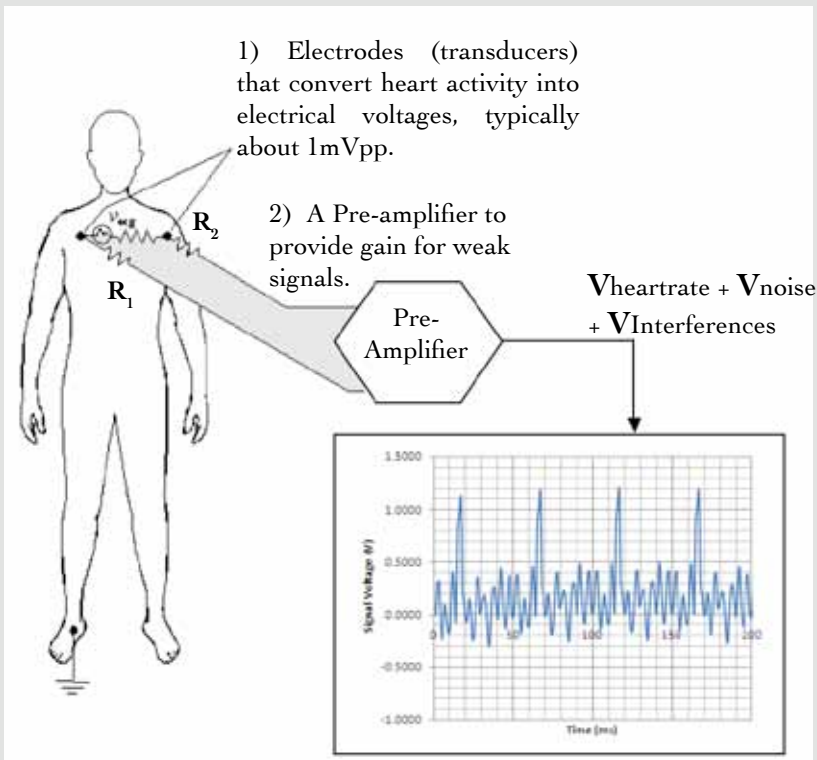
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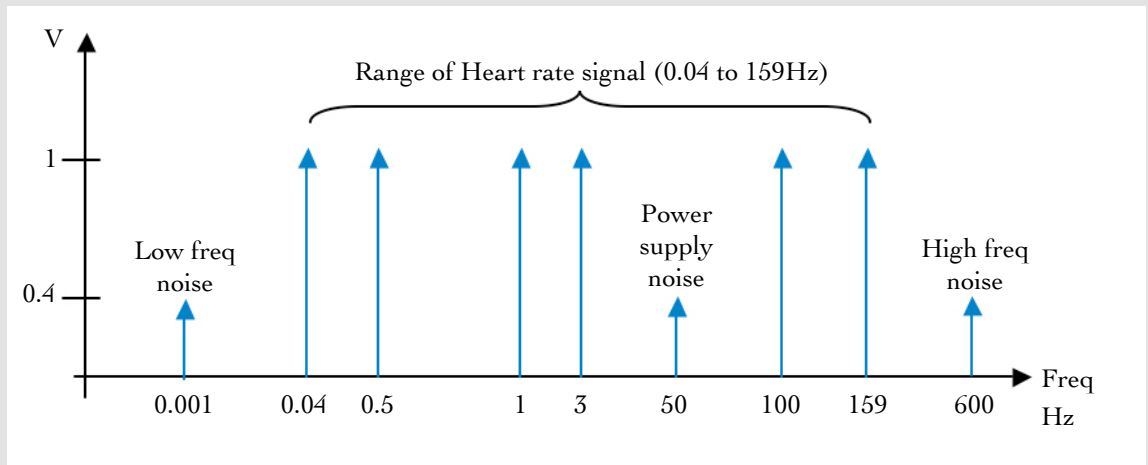
Every issue, we feature a problem from one of our schools or centres. In this issue, we showcase a problem from the E204 Linear Circuits and Control module, offered by the School of Engineering, Republic Polytechnic.

The Problem Trigger: Heart Rate Filters

Consider a heart rate circuit that was built to capture the electrical activity of the heart. This kind of circuit is meant for doctors to monitor the rate and regularity of heartbeats. However, the heart rate signal is weak in nature and is vulnerable to noise and interferences. Thus, the output of the pre-amplifier, measured with the oscilloscope is filled with noise and interferences. A simple illustration is as shown below.



Filters can be used to remove the unwanted noise and interferences so that the heart rate signal is clear. Supposing the frequency spectrum of the signal above is given below.



Your task today is to study different types of filters and propose an appropriate design so that low, high and power supply noise can be significantly attenuated and produce a good heart rate signal.

Present your filter selection, design and simulations results in a form of a lab report.

Discussion of the Problem

The 'Heart Rate Filters' problem was one of the sixteen problems presented to students in the module 'Linear Circuits and Control'. The learning objectives for this problem were for students to gain knowledge in filter designs and filter application. It should be noted that students had acquired knowledge of basic filters and common types of filters such as low and high pass filters, higher order filters in previous weeks.

The problem design begins with the forming of a problem trigger. Considerations for good problem triggers include motivational issues and authenticity. Whenever possible, it must also be kept relevant to the industry to better prepare students for future challenges. These characteristics of problem-crafting increase the student's willingness and desire to participate in the learning process. In this case, the problem describes the need for filters for the biomedical industry where heart rate signals obtained from electrodes are noisy in nature.

The Scaffold

Software or hardware scaffoldings are often created to aid students where certain areas of understanding are beyond the learning proximity of the class. Most students may have some ideas how heart rate signal is captured and displayed in medical devices in hospitals, but lack the experience of capturing, processing and displaying the signal. Thus a scaffold was created in Microsoft Excel to better illustrate the effects of unwanted signals (noise) which distort a desirable heart signal. The scaffold brought in experience from a simulated environment to facilitate students' reflective observation.

The worksheet is another key scaffold provided to students. The questions are carefully designed to help students build understanding of concepts requiring a high level of abstraction.

For this problem, students normally are able to figure out the formation of a band pass filter or a band stop filter by a high-pass filter, a low-pass filter and a summing filter, but have difficulties dealing with notch filter. Questions in the worksheet help students to jump from what they can comprehend to more abstract concepts such as central frequency, quality factor and the design of a notch filter. These questions are normally reviewed by a team of facilitators to adjust the level of guidance so as to complement the level of difficulties faced by the students.

Sharing Students' Responses

With the context of filtering noises from heart rate signal, students are more motivated to explore the new concepts brought up by the problem. This can be seen from their reflection journals after the class. Most students were able to relate the heart rate filter circuit design to the medical equipment used in industry. The problem scenario helped trigger students' interest in their learning, even for those students who may find it tough initially.

With contextualisation of abstract engineering concepts, engineering students can be more effectively engaged in their learning process. Properly designed problem triggers, scaffolding tools in the form of simulations and worksheets, class discussions and self-directed learning ensure that students in the Republic Polytechnic learn to effectively solve a problem a day. The experience prepares students for real-world challenges when students graduate from their studies.

If you have an inspiring PBL problem that you want to share with a broader readership, please contact the editorial team at PBLreflections@rp.sg.

3rd International Symposium on Problem-based Learning PBL and the Problematisation of Teaching and Learning

Date and Venue:

7 – 9 March 2012

Republic Polytechnic, 9 Woodlands Ave 9, Singapore 738964

The International Symposium on Problem-based Learning has always been a significant milestone for the Republic Polytechnic. Since its inception in 2007, the inaugural and second International PBL Symposia have been a global platform for more than 1,000 educators and practitioners of PBL to come together to exchange insights and experiences across a broad spectrum of ideas related to teaching and learning in PBL today.

The 3rd International Symposium on Problem-based Learning will be held on 7 – 9 March 2012, at Republic Polytechnic, Singapore. Please visit www.rp.sg/symposium for more information on the symposium, and the invitation to submit abstracts for consideration for presentation.

To find out more about the 1st and 2nd International Symposium on Problem-based Learning, please access www.rp.sg/symposium.

To view the papers written by CED staff that have been presented at international conferences, including the PBL Symposium and/or published in educational journals/ books, please access http://www.myrp.sg/ced/ns/research_paper.aspx.

Upcoming Courses in 2011

Conference/Workshop	Date	Location	Website
Problem-based Learning (PBL) Foundation: Introduction Workshop	28 Feb, 1 – 4 Mar	Republic Polytechnic, Singapore	http://www.myrp.sg/ced/ns/staff_ found.aspx
	21 – 25 Mar		
	4 – 8 Apr		
	20 – 24 May		
	20 – 24 Jun		
	18 – 22 Jul		
	15 – 19 Aug		
	5 – 9 Sep		
3rd International Research Symposium on PBL 2011	10 – 14 Oct	Coventry University, UK	www.coventry.ac.uk/pbl2011
	14 – 18 Nov		
	28 – 29 Nov		

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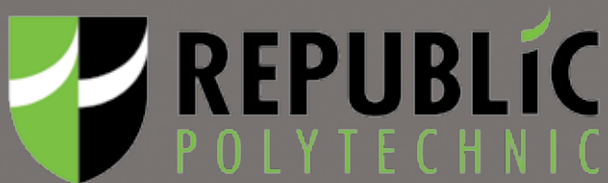


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YEAR ONE

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