

Reflections on Graduate Student PBL Experiences

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Abstract

The study designed to contribute to existing research on Problem-Based Learning (PBL) chose a focus group comprising 16 MSc. Petroleum Engineering students (six females). Using PBL as the method of instruction, students examined a real-life petroleum engineering problem that highlighted numerous areas of their existing curriculum. They worked in three small groups. Communication, management, editing, civic-mindedness, critical thinking and presentation skills were some of the honed skills. A pre and post test using a 15 item dichotomous opinionnaire revealed that student views did not change on issues like PBL being considered a fad, PBL being unsuitable for first year students, students need prior content knowledge and attitude towards PBL determined their success. On the other hand, there was an overall decrease in the number of students who felt that PBL was inappropriate for some disciplines, sufficient content was not taught using PBL and assessment in PBL was a complicated activity. More than 20% of students felt more confident about PBL and no one felt that PBL was too time consuming after the PBL experience. Further research on the long term effects of PBL usage would shed more light on the value of this teaching /learning methodology.

Keywords: Problem-Based Learning, skills, teaching, learning.

Introduction

Whilst the measurement of the long term effects of using Problem-Based Learning as a teaching tool for training students particularly graduate students could reveal the true potential of this pedagogical methodology, an evaluation of short term effects has its merits in the literature, if only to serve as a form of motivation for anxious, would-be practitioners. Formatively reporting the results of Problem-Based Learning experience could positively influence the course of direction of activities leading to a meaningful experience. This present paper reports on an entire day of a Problem-Based Learning experience conducted for graduate students pursuing a MSc. Degree in Petroleum Engineering at The University of Trinidad and Tobago in the Caribbean.

Background

The University of Trinidad and Tobago (UTT) is a four year old tertiary educational institution conceived to meet the growing demands of an industrial based twin island state of Trinidad and Tobago, situated the Caribbean, just north of Venezuela in South America. The university boasts of a flat administrative structure emphasising interdisciplinarity of programmes across the board and doing away with departments and faculties, an organizational structure well known in traditional universities.

The Centre for Assessment and Learning (CAL) was established to serve the psychometric needs of the entire university. CAL works across the university as it serves programmes like maritime studies, energy and offshore technologies, manufacturing and c-ideas, process and utilities, information and communications technology, institute of sports studies, institute of fashion and design, food production, NETD programmes, PUP programmes, education, the academy for performing arts, the academy for arts, letters, culture and public affairs and the library. CAL not only services the entire university but all other institutions (local and foreign) who wish to be engaged in its work. Numerous state-of-the-art approaches are being employed in its excellent and distinctive practice.

CAL embodies all four pillars of UTT which include Project Based Learning, Research and Development, Curriculum Integration and UTT organization. CAL aims to introduce, broaden and sustain the perspective that the place of assessment within learning is recognized and its full potential is realized. As partnerships are developed between UTT, other institutions and industries, CAL hopes to continue to increase the efficiency of its training as it promotes a culture of research and lifelong learning in the work place. Ongoing research is central to the operation of CAL. Research findings are used to inform

practice. The Centre works collaboratively with all interested institutions particularly in industry to use the range of backgrounds of its workers to enrich the dialogue about assessment. One central aim of CAL is to introduce new perspectives into what has traditionally been regarded as exclusively the precincts of the discipline of Education. Other goals include, research into assessment and learning, issues related to throughput and student success, the dissemination of research findings to staff and remaining on par with national and international trends in education.

Literature Review

PBL is often defined as a pedagogical method in which a real-life or authentic problem or situation is presented to students for investigation, analysis, solution, synthesis and evaluation. The students work individually or together in reasonably sized groups with the teacher acting as coordinator, facilitator, coach, resource person, referee and fellow learning partner rather than director, instructor, tutor or disseminator of information as is traditionally done. Boud and Feletti (1997, p. 15), have conceptualized PBL as a way of approaching a curriculum: *'Problem based learning is an approach to structuring the curriculum which involves confronting students with problems from practice which provide a stimulus for learning.'* The role of PBL in medical education has long been accepted. (Barrows and Tamblyn, 1980, 18) conceptually defined PBL as *'the learning that results from the process of working toward the understanding or resolution of a problem'*. First the problem is encountered in the learning process. This serves as a focus, catalyst or perhaps stimulus for the application of problem solving or reasoning skills and the quest for

the investigation and study of information or knowledge required to better comprehend what is responsible for the problem and how it might be solved.

Whilst PBL is not new to many educational institutions, this group of graduate Petroleum Engineering students may be considered as the first to have experienced PBL in a formalized setting as described in this paper. As mentioned earlier, the educational institution to which they belong is only four years in existence and has by institutional decree chosen to use PBL as its method of instruction. Accordingly, faculty receive training from CAL on an on-going basis as part of their professional development and evaluation for promotional opportunities.

Society today mandates that graduates should be able to solve complex problems (Engel, 1997; Gagné, Yekovich, & Yekovich, 1993; Poikela & Poikela, 1997; Segers, 1997). PBL by its nature of collaborative problem solving work involving communication in a collegial environment is poised to provide learners with the skills required to participate actively in real world situation. With unique pragmatic and pedagogic advantages, Barrett (2005); Helic, Krottmaier, Maurer and Scerbakov (2005) highlight improved student outcomes. Closer home, King and Puntambeker's (2003) who asynchronously conducted a project-based learning activity using three graduate level, constructivist project-based courses demonstrated the establishment of an online community of learners. The whole notion of group work is central to the PBL process as it cultivates an active rather than passive approach to student-centred learning. Says Barfield (2003:354), '*interactive peer-based methods promote student creativity, critical thinking and experiential learning*'.

Grounded in students' every day experiences, PBL in addition to providing a myriad of opportunities for learning with constant feedback (Black and Wiliam, 1998; Izard, 2004), provides scaffolding for students as they navigate their way through unknown territory whilst developing and honing numerous skills for every-day use. Lambros (2004) posits that work quality, content acquisition, reasoning and thinking processes and collaborating for effective outcomes is carefully considered for its value added effect on student growth and the group's performance. Because students have the facility of pursuing their personal interest whilst satisfying course requirements PBL affords them the satisfaction of excelling in their unique areas of competence. Accordingly, students urgently needing attention are motivated and encouraged to move to higher levels and accomplish much more than they would have done ordinarily. Simultaneously, facilitators pursue their professional development by improving their own competence and confidence in several instructional techniques and approaches that promote higher order thinking skills in their students who act like partners in the learning process. Referring to the fact that research is often conducted in teams, Gibbs (1995:3) contends that a number of the abilities honed through PBL have application in the academic world as well as the commercial environment.

Whilst many have subscribed to the values of PBL, others have underscored the negatives involved in group work. Livingstone and Lynch (2002: 219) believe that 'lazy' students are able to '*hide*' from faculty; there is unequal contributions from team members that could adversely impact on their grades; the learning process is inhibited by group activities like meeting times, personality clashes, etc. that could have debilitating effects on group members. Oftentimes, the better students are not sufficiently credited for their

contributions. Race (2001:17) on the other hand sees group work as having the capacity to develop attributes like interpersonal skills, leadership skills, “*followership*” skills, etc.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003, 550)

using the method of assessment as a moderator variable found that the larger the efficacy of an instrument to evaluate the student’s knowledge application, the larger is the ascertained effect of PBL. In another study the group went a step further to investigate the influence of assessment as the main independent variable. They examined 40 empirical and quasi-experimental studies in the literature by means of a statistical meta-analysis, supplemented by vote counts and the use of the statistical sign test, accompanied by appropriate narrative comments.

They used Sugrue’s (1995) model of the cognitive components of problem solving in an attempt to classify the methods of assessment by problem solving used in the various selected studies, *viz.* (1) understanding of concepts (2) understanding of the principles that link concepts and (3) the linking of concepts and principles to conditions and procedures for application. The researchers found that the method of assessment had a significant influence on the reported effects of PBL together with other moderators like study design, scope of implementation and year of study. PBL performed better (larger effect size) when assessment targets linking of concepts and principles to conditions and procedures for application (level 3 above). With this useful information the present study was designed to investigate what graduate Petroleum Engineering students perceived they obtained out of the PBL experience on a short term basis by using researcher-designed assessment instruments that targeted the higher levels of cognitive components of problem solving.

The Study

A focus group of 18 graduate pursuing a MSc. Degree in Petroleum Engineering at The University of Trinidad and Tobago (UTT) formed the subjects for this present study.

Sixteen of the eighteen students were present on the day of the PBL exercise. The students were told in advance that they would be having a PBL experience with the Coordinator for The Centre of Assessment and Learning (CAL) as facilitator.

All faculty who interacted with the group of students were invited to be an integral part of the process. An entire day was allowed for the interaction commencing at 8: 30 am and culminating at 4: 30 pm, with a one hour lunch break and two 15 minute tea breaks (one in the morning period and the other in the afternoon period). The PBL session was conducted in their normal classroom where furniture was rearranged to be fit-for-purpose.

Participants

Participants for the study were persons who had worked in industry and had chosen to further their studies in Petroleum Engineering in the hope of improved upward mobility in the workplace. All students entered the programme with a first degree with at least a second class honours classification. A few students had come straight out of a Bachelor's programme with limited work experience that they were expected to gain during the course of the masters programme. Participants emerged as winners from carefully conducted in-house interviews that targeted latent qualities like attitudes, dispositions, capacity for stress, resilience, etc. The students had worked in groups with each other for several weeks prior

to the formal PBL experience. Hence, in the interest of time, team building exercises were reduced to a bare minimum.

Method

Following the introductions and normal pleasantries, a ‘find your neighbour friendship hunt’ allowed participants to interact with all present on the day of the PBL exercise. Participants were expected to obtain signatures of persons who responded in the affirmative to the selected get-to-know-you statements. Prizes were given to participants who obtained the highest number of authentic signatures. Prizes were distributed shortly after the get-to-know-you session so that everyone was aware that active participation in all activities, apparently as unrelated to the main content, was expected. By always encouraging communication through active listening and verbal and non-verbal interactions, the *zone of proximal development* of each student where real learning takes place was skillfully exploited for maximum student benefits. Periods of sustained silent reading formed an integral part of the entire PBL experience.

Research Design

A number of assessment instruments (available upon request) designed and piloted by this researcher were used in the process. An uncaptioned sheet of qualities honed through PBL was circulated for discussion. Participants who were able to add to the sheet the highest number of additional qualities were awarded prizes. In particular, the research design was a pre/post test design involving an opinionnaire that provided data for this present paper. Table 1 comprised 15 dichotomous statements about participants’ feelings/attitudes about PBL. The statements attempted to link concepts and principles to conditions and procedures for application (level 3 of Sugrue’s (1995) model of cognitive components of

problem solving). As explained earlier, the opinionnaire sought to obtain information about the participants' perceptions of PBL before and after the PBL session. Open-ended questions regarding their views on teaching and any other information allowed participants ample opportunity to openly express themselves without fear of victimisation or reprisal. The instrument was pilot tested to ensure that items were simple to understand and devoid of ambiguity. Built into the instrument were statements that ensured internal consistency e.g. *'I consider PBL to be just a fad'*; *'I think PBL does not allow for individual learning'*; *'Given the course demands, using PBL will not be too demanding for me'* and *'I am presently confident about PBL'* vs. *'I have little knowledge of PBL'*; *'Sufficient content is not taught using PBL'* vs. *'Students need prior content knowledge'*.

The PBL Experience

Once the opinionnaires were completed and batched as 'BEFORE' students were placed into three groups of five each and presented with a PBL problem (Appendix A). The problem pictured (literally so) an enthusiastic MSc. Petroleum Engineering student named Joe who attended only three hours out of a total of eight hours at a one day PBL exercise.

'Joe reported that he had to attend to urgent business, submit an outstanding homework assignment, prepare for other classes and attend to pressing personal matters. Course marks for workshop were denied him. Joe insists that he should receive a grade, claiming that he has a 'feel' for PBL, he will get all the handouts from friends and that the group was aware of his situation.'

As group members participants were asked to arbitrate. The results of the arbitration are discussed in the results section. This initial exercise whetted the students' appetites for later PBL work. Faculty present were actively involved in all proceedings by distributing handouts, posing relevant questions, making suggestions, and generally facilitating the process. After much discussion following this initial exercise students were presented with a one-pager of the relevant learning objectives and a PBL problem that encompassed several areas of their MSc. Petroleum Engineering curriculum which was attached for easy reference and cross checking. The idea was that students were able to relate the PBL problem to their curriculum and to real-life issues in their discipline. A step-by-step guide facilitated the PBL process by offering prompts, like:

'The problem is----- The situation is-----, The circumstances related to the problem are-----, You know-----, You need to know-----, You are going to-----, Action plan is-----; Resources are -----; Persons identified for specific actions are -----, etc.'

Additional prompts included spaces on a table for solutions and appropriate evaluations with a view of selecting the most viable solution(s). Each group was expected to present their findings to an audience comprising the remaining participants who were expected to evaluate the presentation (Appendix B). Time was allowed for reflection and offering suggestions for improvement.

Some relevant PBL literature from a previous faculty training workshop was circulated to provide readily available additional information. Students were allowed to do self-directed study as required. The PBL exercise terminated with a homework assignment

requiring an approximately 12 page report in the SPE technical paper format using the same Petroleum Engineering problem presented earlier. Reinforcement and reflection of the day's activities would inevitably reap rich dividends in a homework assignment of this nature that was meant to last for approximately one month. That time period allowed for internalization of concepts at each student's developmental level. Finally, a one pager requesting information about the day's proceedings: '*Three things I grasped*', '*Three things I need help with*' and '*Three things I will do differently*', followed with a brain exercise allowed for relaxation and savouring of pleasant memories of the entire PBL experience.

Results

The first PBL problem (Appendix A) presented to the groups revealed startling results of persons who were at both ends of the continuum regarding strictness and one group who appeared to maintain a balance. The group at the upper end of the strictness continuum were not at all willing to have students make excuses for their actions and expect to be accommodated. In particular, that group was hard and fast indicating that the student knew in advance about the PBL exercise and he should have organized himself to be there like they had done. That group reckoned that Joe had activities like theirs and since they were able to surmount their individual challenges and present themselves prepared for a novel experience in like manner Joe could have done the same. Their sentiments echoed were a reflection of the following quotes:

'...What does Joe have to do that we do not have to do?...

'...Well Joe needs to organize himself and do what is important to him....'

'... Joe is free to make his own choices but he must be prepared for the consequences of his choices...'

Another group at the lower end of the strictness continuum felt that some form of consideration should be given to Joe since there were numerous individual differences that may have accounted for his perception of his situation. That particular group appeared to empathise with Joe and arrived at what they considered a kind of ‘sympathy clause’ that befitted human interactions in order to accommodate Joe. Here are a few salient sentiments:

‘...I could well understand being in a situation like that ...’

‘...Here is an opportunity to display the human qualities ...’

‘..Place yourself in Joe’s situation and you could well see the kinds of challenges he has to face ...’

The third group that later turned out to have a few seasoned , experienced individuals who had tremendous industrial experience prior to taking the course presented a two sided argument that encompassed the views of the already mentioned groups and left the final decision to a panel of experts for consensus. Interestingly, this group presented first so it cannot be said that their findings were taken from the other two groups. Said some of the spokespersons for the group:

‘...let’s have a balance here....look at the first column...then look at the second column....’

‘...I have had situations pretty much like these before ...’

‘...Let the final word of consensus be the guide for arbitration....’

Flip chart pages of the groups deliberations and findings were displayed across the walls of the spacious room to give a storyboard effect. In summary, it was clear that students were

prepared to think through a given situation as a group, systematically arrive at consensus, present their corporate findings to an audience and be willing to be critiqued. With such a good start it was clear that the PBL exercise was going to be a success.

Most students responded to all statements (no responses columns, Table 1). At most 12.5% did not respond to any given statement. The table following also shows that student views did not change on issues like PBL being considered a fad, PBL being unsuitable for first year students, students need prior content knowledge and attitude towards PBL determining their success. It is noteworthy that 93.75% of students disagreed that PBL was just a fad. No one felt that PBL was unsuitable for first year students. Interestingly, 75% of the respondents felt that their attitude towards PBL could determine their success.

<Insert Table 1 here.>

On the other hand, there was an overall decrease in the number of students who felt that PBL was inappropriate for some disciplines. Prior to the PBL experience, 68.75% disagreed with the statement '*PBL is inappropriate for some disciplines*' whilst 81.25% disagreed with the same statement after the PBL experience. Regarding the teaching of sufficient content using PBL, whilst 56.2 % of respondents disagreed prior to the PBL experience, 81.25% disagreed after the PBL experience. In response to the statement '*I consider assessment in PBL to be a complicated activity*', half of the respondents disagreed prior to the PBL experience whilst 75% disagreed after the PBL experience. More than 20% of students felt more confident about PBL and no one felt that PBL was too time consuming after the PBL experience (Table 1).

From the focus group of 16 there were six females. The above analysis was done by gender to reveal the following tables (Tables 2, 3).

<Insert Table 2 here.>

Most females responded to all the given statements of the pretest except for statements 2, 8, 9, 10, 13, 14 and 15 where only 16.7% offered no response. For the post test, all females responded except for 16.7% towards statement 15 (Table 2). Among the females, no one agreed that PBL was just a fad, PBL does not allow for individual learning, PBL is inappropriate for some disciplines, PBL was unsuitable for first year students, given the course demands, using PBL would be too demanding, that they will not be embracing PBL and that PBL will make a difference to teaching and learning. Only 16.7 % of females thought that sufficient content is not taught using PBL, that PBL was too time consuming and that assessment in PBL was a complicated activity (Table 2). Half of the females reported that students needed prior content knowledge, that they were presently confident about PBL and that their attitude towards PBL could determine their success (Table 2). Over eighty three percent of females thought that PBL facilitated reflection necessary for reinforcement.

<Insert Table 3 here.>

Most males responded to all the given statements of the pretest except for statements 4, 10 and 15 where only 10 % offered no response. For the post test, all males responded except for 10% towards statements 3, 14 and 15 (Table 3). Among the males, no one agreed that PBL does not allow for individual learning, PBL is unsuitable for first year

students, given the course demands, using PBL would be too demanding and that they will not be embracing PBL. Only 10 % of males considered PBL to be just a fad and that PBL would make a difference to teaching and learning (Table 3). Half of the males reported that PBL was sufficient content is not taught using PBL. Sixty percent of males felt that they had little knowledge of PBL, that students needed prior content knowledge and that assessment in PBL was a complicated activity. Seventy percent of males declared that they were confident about PBL whilst 90% felt that PBL facilitated reflection necessary for reinforcement of concepts and that their attitude towards PBL could determine their success (Table 3). Over eighty three percent of females thought that PBL facilitated reflection necessary for reinforcement.

 <Insert Table 4 here.>

Comparing the responses of females and males (Table 4) it is apparent that no male or female thought that PBL does not allow for individual learning, that PBL was unsuitable for first years, that using PBL would be too demanding and that they will not be embracing PBL.

As the day progressed this researcher attempted to capture the mood and general feelings and attitudes of the participants by noting comments from participants. Participants attested to numerous benefits from their PBL experience. They generally claimed that they were exposed to new and diverse perspectives as evidenced from the following comment:

‘...I am appreciative of the fact that I can listen and learn from others and more so be exposed to new and diverse perspectives on natural reserves in the Petroleum Industry...’

While some students were exalting the value of interactions some were more protective and cautious as gauged from the following response:

'...I know I must work with others in the workplace but until then I do not mind going it alone as long as I can...'

Concerning the benefits of personal development, one particular participant was happy to have engaged with others in different groups:

'...I tend to be introverted...This is s good opportunity to get out of myself and engage with others especially when the main facilitator realised that I needed to be placed elsewhere for my own benefit...'

'...Now in this group I believe I can make a worthwhile contribution because I am surrounded by the top achievers...'

Most participants acknowledged the overall benefits of the PBL exercise as portrayed in the following comments:

'...I have learned a lot from actively listening to my colleagues as they share their experiences with passion...It makes you realize how much you have been missing by merely attending a lecture session and have a professor tell you as it is

without allowing you to personally grow, develop and self actualise...'

...' I realize that the tasks are ensure interdependence and face-to-face interaction of participants whilst at the same time demanding individual accountability... '

'...There is a process as well as a product approach....you have to go through the entire process to appreciate what's happening but you also need to have a well thought-out group presentation at the end of it all...'

'...At last I have a voice ...I can be heard instead of being silenced without being given a chance ...'

'...Initially I was apprehensive about certain group members and how I thought they may dominate the group but my apprehension was short-lived as folks toned down and gave others a chance to express themselves without interruption...'

'...Without a doubt I was motivated to think outside the box...to think critically...to think in terms of utilitarian good rather than being insular...'

On the issue of feedback, participants were elated at the idea of timely responses that prevented misconceptions from being fostered to the detriment of a holistic understanding of content material. Facilitators were briefed not to allow any erroneous content material to

go by without timely correction and reinforcement through a variety of ways, examples, non examples, anecdotal accounts, personal experiences, group encounters, etc.

‘...It was good for me to have instant feedback as it prevented me from going ahead with misconceptions especially when it came to certain ideas about the formula in use...’

Notwithstanding their satisfaction with timely feedback some participants wondered about how the assessment process would affect them personally. There were a number of researcher-designed assessment instruments in use: self, peer, group, facilitator assessment whose ‘*face validity*’ appeared important to all participants. Clearly, concerns about the validity, reliability and weighting of the various instruments appeared legitimate as the following quotes indicate.

‘I do wonder what kind of grade I will get eventually with this style of learning....the atmosphere appears so congenial and everyone seems so friendly and cooperative that it is extremely difficult to gauge what kind of final grade I will earn...’

‘...How would the various instruments be weighted to give me a final grade?...’

‘...What would happen if all group members conspired to defraud the system by cheating for each other?...’

'I guess the experts know what they are doing because they have the PBL experience and they have worked with several groups in different environments and in different countries...'

Fifteen participants evaluated the entire PBL experience towards the end of the day. On a scale of 1 to 10 where 1 = Strongly Disagree and 10 = Strongly Agree, with 5 = Neutral, respondents were required to rate ten statements about the entire PBL experience. The quantitative results are summarized in Table 5 followed by qualitative results from the open ended comments regarding three specific areas that were particularly well handled and three specific areas for improvement together with any other suggestions or comments and recommendation the experience to someone else.

<Insert Table 5 here.>

With an average score of 9, it may be observed that in general students claimed that they gained knowledge from the PBL experience, the activities stimulated discussion, the break-out groups allowed them to experience PBL and the facilitators assisted them in experiencing PBL in practice. Followed by an average score of 8, students reported that the PBL experience prepared them mentally for learning more, the information provided summarized the main points, the presenters held their interest and finally the presentations were easy to follow. With an average score of 7, students reported that the PowerPoint slides helped them to focus on the important ideas. Students' overall score (100 is the maximum) ranged from 53 (Student # 14) to 99 (Student # 12) with the average score being 82 (Table 5). The results speak for themselves and indicate that the one day PBL

experience was a tremendous success. The standard deviations noted indicate that the scores were distributed close to the mean (lowest = 0.7 and highest = 2.7).

From the open-ended comments received, some of the specific areas that students found were particularly well handled included: '*...encouraging group participation*', '*...the presentation of the entire experience...*', '*...rewards for motivation...*', '*...everyone being given a chance...*', '*...enthusiasm of main facilitator...*', '*...delivery...*', '*...organisation...*', '*...getting the class involved...*', '*assessment...*', '*...problem solving...*', '*...open mindedness...*', '*...team work...*' and '*...exchanging ideas..*'.

From the open-ended comments received, *some of the specific areas that students found needed improvement included '...more computer facilities present in the classroom during the PBL experience...'*. A few students wished the PBL experience was extended for a few more days. All students (100%) indicated that they would recommend the PBL experience to someone else. No additional suggestions and comments were made except that the PBL experience was excellent and this was written in bold print, perhaps indicative of the strong feeling of participants.

Discussion and Conclusion

Any new educational institution introducing a preferred pedagogic style across the board would be presented with numerous teething challenges: uneasiness of novices; over enthusiasm of the experienced, indifference of many and the unwillingness of some to embrace change. Questions may be asked about the need for a difference and perhaps a retention of accustomed traditional ways of dealing with issues. As a four year old tertiary institution The University of Trinidad and Tobago has had to grapple with these and other

concerns. This is the first study of its kind emanating from the university and so results have to be guardedly interpreted in the light of an absence of internal benchmarks. Best practices have not been sufficiently established to allow for fair comparison and analysis of data.

Inherent in this present study are several assumptions and limitations. The study assumes that the focus group under study represents, to a reasonable extent, all other groups in the institution; groups that are open-minded and not afraid to explore new ground. There is also the assumption that the responses obtained accurately represented the views of the cohort and participants did not feel constrained to offer answers that placed them in a 'good' light with authority figures. Additionally, because the primary facilitator was not the normal faculty, students may have felt the need to cooperate in the interest of good public relations and not necessarily in the interest of their own persuasions about PBL. Clearly, the restricted sample would not allow for the kind of generalizations that one would normally have preferred. Biographical data was not factored in since the group had already bonded for more than a month prior to the PBL session. Hence, absence of information on issues like nature of first degree, years of industry experience, familiarity with pedagogical issues, etc. would naturally restrict the scope of the present study.

Faculty and other interested parties in attendance reported their satisfaction with the PBL exercise. They shared how much they personally benefited from the hands-on experience. Students were more than enthusiastic to experience the PBL process about which they had heard do much. Many had read about the process but had never had the opportunity to actually experience the process without being instructed about it. Without offering a preamble about PBL, students were presented with a relevant PBL problem of interest to all

(Appendix A). At a very early stage students realized that they were setting the pace and deciding the terms and conditions under which they were operating. Having established this quite apart from being empowered and emboldened students took ownership of the process and participated fully in all activities even those that at first appeared unrelated to Petroleum Engineering (their area of specialty). Activities like distribution and receipt of gifts, impromptu speeches, sharing thoughts about issues, listening to others, preferring others, etc. were well endorsed. Collaboration and cooperation were hallmarks of the PBL experience while at the same time in depth understanding of the real-life issues regarding natural gas reserves as it affected their own country and its inevitable implications to their present way of life were of grave concern to all.

The tying of the PBL classroom experience with the homework assignment that assumed a comprehensive understanding of the real-life issues of reserve-to-production (R/P) ratio for the proven reserves of natural gas reinforced in students' minds the importance of punctuality, class attendance, class attentiveness and active class participation. The random allocation of students into groups whose composition could have changed at any time during the day forced students to appreciate the need to get along with all class members. Clearly, the socio-cultural approach to learning was underscored during the PBL process. Peer assessment underscored this since students assessed their peers using agreed upon criteria on a six point Likert scale ranging from 0 = urgently needing attention to 5 = outstanding. The role of self assessment allowed each student to objectively appraise himself and benchmark his assessment with that of the group. Signing an attendance register that required the participant's arrival time was also an integral part of the assessment process.

Reflection and introspection played a significant role in the process that saw students beginning to manage their own issues and taking responsibility for their own learning and progress. Both females and males (Tables 2, 3, 4) felt that PBL facilitated reflection necessary for reinforcement of concepts. Oftentimes, honest reflection is inhibited when it is attached to formative or summative assessment. For this reason students were encouraged to reflect openly and honestly with the understanding that the process of introspection and reflection allowed for personal ventilation which was an integral part of the human cleansing, renewal and rejuvenation process. Examples of situations in Petroleum Engineering further conceptually reinforced a number of learning issues.

Students had the opportunity to fully express themselves in an audience that welcomed their participation. They attested to the fact that they felt like they had a voice in their own future. Anxieties about *'being wrong'* were allayed by a kind of facilitation that appreciated the value in all responses and used what may have initially being regarded as an inappropriate response to affirm an upcoming related issue. The value of skill development cannot go under estimated. Since all students actively participated in the group presentations those who were not as proficient as others in Microsoft Word and Microsoft PowerPoint skills had the opportunity to develop and learn new ideas in a caring and supportive environment.

The design and development of assessment instruments, despite being an unintended outcome allowed both faculty and students to realize that assessment could take numerous forms depending on the learning issues and outcomes being examined. Early signs of prescription soon changed to accommodation as all participants appreciated the value in being able to customize or remodel an existing instrument to suit immediate needs. In

particular, each group was required to evaluate the presentation of all the other groups which meant that an appropriate instrument had to be designed to suit the specific needs of the groups.

At carefully selected times of the day this researcher used opportune moments to draw from students the kind of feelings they were experiencing and the qualities on the uncaptioned spreadsheet that were being harnessed or refined in them. The donation of prizes for the best caption and the inclusion of the highest number of additional qualities encouraged participants to be alert, innovative and responsive. As students circled the discussed qualities like teamwork, flexibility, creativity, collaborative skills, etc. they were better able to appreciate the potential of PBL as a teaching/learning methodology of significant value. In particular, abundance mentality that was honed allowed students to realize that fierce competition was unwarranted in a collegial environment of collaborative sharing and social learning since there was a space for each participant to be an individual to displaying basic professional courtesies and self actualizing simultaneously. The varying levels of commitment that participants brought to the inclusive exercise reinforced by adequate scaffolding and iterative feedback allowed for participant buy-in to the PBL process.

Threaded discussions with evidence-based information that oftentimes veered into cultural issues enabled participants to become more aware of local findings of natural reserves. By noting the elimination of the top down directionist approach and the allowance for critical engagement of all participants it was clear that the think tank of the future was systematically being nurtured in this group of graduate students.

Further research for the long term effects of PBL training on participants using longitudinal studies could unearth qualities that this research would not be able to unfold. Additionally, generational exposure to PBL experience and its effects on the society would be well worth the while to consider. Perhaps the most significant kind of future research might be a cost-benefit analysis of the preparation time and resources needed for PBL exercise compared to the overall benefits inherent in the exposure. An appreciation of the trade-offs between the gains and the efforts expended would allow for a better understanding of real-life processes. Needless to say, society stands to benefit tremendously from any form of research that seeks to tie PBL to the making of a well-rounded, civic-minded, caring member of society.

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Appendix A The first PBL Problem



Joe, an enthusiastic MSc. Petroleum Engineering student attended three hours out of a total of eight hours at a one day UTT PBL Orientation Workshop. Joe reported that he had to attend to urgent business, submit an outstanding homework assignment, prepare for other classes and attend to pressing personal matters. Course marks for workshop were denied him. Joe insists that he should receive a grade, claiming that he has a *'feel'* for PBL, he will get all the handouts from friends and that the group was aware of his situation. As a group member you have been asked to arbitrate.

Table 1 Percentage (to 2 dec. pl.) for all student responses to the opinionnaire

#	STATEMENT	<i>BEFORE</i>			<i>AFTER</i>		
		A	D	NR	A	D	NR
1	I consider PBL to be just a fad.	6.25	93.75	0.00	6.25	93.75	0.00
2	I think PBL does not allow for individual learning.	0.00	93.75	6.25	12.50	87.50	0.00
3	I have little knowledge of PBL.	75.00	25.00	0.00	6.25	87.50	6.25
4	PBL facilitates reflection necessary for reinforcement of concepts.	87.50	6.25	6.25	75.00	25.00	0.00
5	PBL is inappropriate for some disciplines.	31.25	68.75	0.00	18.75	81.25	0.00
6	I believe PBL is unsuitable for first year students.	0.00	100.00	0.00	0.00	100.00	0.00
7	Students need prior content knowledge.	56.25	43.75	0.00	56.25	43.75	0.00
8	Sufficient content is not taught using PBL.	37.50	56.25	6.25	18.75	81.25	0.00
9	I think PBL is too time consuming.	25.00	68.75	6.25	0.00	100.00	0.00
10	Given the course demands, using PBL will be too demanding for me.	0.00	87.50	12.50	6.25	93.75	0.00
11	I am not willing to embrace PBL.	0.00	93.75	6.25	6.25	93.75	0.00
12	I do not think PBL will make a difference to teaching and learning.	6.25	93.75	0.00	0.00	100.00	0.00
13	I consider assessment in PBL to be a complicated activity.	43.75	50.00	6.25	25.00	75.00	0.00
14	I am presently confident about PBL.	62.50	31.25	6.25	87.50	6.25	6.25
15	My attitude towards PBL could determine my success.	75.00	12.50	12.50	75.00	12.50	12.50

Table 2 Percentage (to 2 dec. pl.) for **female** student responses to the opinionnaire

#	STATEMENT	<i>BEFORE</i>			<i>AFTER</i>		
		A	D	NR	A	D	NR
1	I consider PBL to be just a fad.	0.00	100.00	0.00	0.00	100.00	0.00
2	I think PBL does not allow for individual learning.	0.00	83.30	16.70	16.70	83.30	0.00
3	I have little knowledge of PBL.	100.00	0.00	0.00	16.70	83.30	0.00
4	PBL facilitates reflection necessary for reinforcement of concepts.	83.30	16.70	0.00	83.30	16.70	0.00
5	PBL is inappropriate for some disciplines.	0.00	100.00	0.00	0.00	100.00	0.00
6	I believe PBL is unsuitable for first year students.	0.00	100.00	0.00	0.00	100.00	0.00
7	Students need prior content knowledge.	50.00	50.00	0.00	33.30	66.70	0.00
8	Sufficient content is not taught using PBL.	16.70	66.70	16.70	16.70	83.30	0.00
9	I think PBL is too time consuming.	16.70	66.70	16.70	0.00	100.00	0.00
10	Given the course demands, using PBL will be too demanding for me.	0.00	83.30	16.70	0.00	100.00	0.00
11	I am not willing to embrace PBL.	0.00	100.00	0.00	0.00	100.00	0.00
12	I do not think PBL will make a difference to teaching and learning.	0.00	100.00	0.00	0.00	100.00	0.00
13	I consider assessment in PBL to be a complicated activity.	16.70	66.70	16.70	33.30	66.70	0.00
14	I am presently confident about PBL.	50.00	33.30	16.70	0.00	100.00	0.00
15	My attitude towards PBL could determine my success.	50.00	33.30	16.70	83.30	0.00	16.70

Table 3 Percentage (to 2 dec. pl.) for **male** student responses to the opinionnaire

#	STATEMENT	<i>BEFORE</i>			<i>AFTER</i>		
		A	D	NR	A	D	NR
1	I consider PBL to be just a fad.	10.00	90.00	0.00	10.00	90.00	0.00
2	I think PBL does not allow for individual learning.	0.00	100.00	0.00	10.00	90.00	0.00
3	I have little knowledge of PBL.	60.00	40.00	0.00	0.00	90.00	10.00
4	PBL facilitates reflection necessary for reinforcement of concepts.	90.00	0.00	10.00	70.00	30.00	0.00
5	PBL is inappropriate for some disciplines.	50.00	50.00	0.00	30.00	70.00	0.00
6	I believe PBL is unsuitable for first year students.	0.00	100.00	0.00	0.00	100.00	0.00
7	Students need prior content knowledge.	60.00	40.00	0.00	70.00	30.00	0.00
8	Sufficient content is not taught using PBL.	50.00	50.00	0.00	20.00	80.00	0.00
9	I think PBL is too time consuming.	30.00	70.00	0.00	0.00	100.00	0.00
10	Given the course demands, using PBL will be too demanding for me.	0.00	90.00	10.00	10.00	90.00	0.00
11	I am not willing to embrace PBL.	0.00	100.00	0.00	10.00	90.00	0.00
12	I do not think PBL will make a difference to teaching and learning.	10.00	90.00	0.00	0.00	100.00	0.00
13	I consider assessment in PBL to be a complicated activity.	60.00	40.00	0.00	20.00	80.00	0.00
14	I am presently confident about PBL.	70.00	30.00	0.00	80.00	10.00	10.00
15	My attitude towards PBL could determine my success.	90.00	0.00	10.00	70.00	20.00	10.00

Table 4 Percentage (to 2 dec. pl.) for comparison of male and female student responses to the opinionnaire

#	STATEMENT	<i>BEFORE</i>						<i>AFTER</i>					
		AGREE		DISAGREE		NR		AGREE		DISAGREE		NR	
		F	M	F	M	F	M	F	M	F	M	F	M
1	I consider PBL to be just a fad.	0.00	10.00	100.00	90.00	0.00	0.00	0.00	10.00	100.00	90.00	0.00	0.00
2	I think PBL does not allow for individual learning.	0.00	0.00	83.30	100.00	16.70	0.00	16.70	10.00	83.30	90.00	0.00	0.00
3	I have little knowledge of PBL.	100.00	60.00	0.00	40.00	0.00	0.00	16.70	0.00	83.30	90.00	0.00	10.00
4	PBL facilitates reflection necessary for reinforcement of concepts.	83.30	90.00	16.70	0.00	0.00	10.00	83.30	70.00	16.70	30.00	0.00	0.00
5	PBL is inappropriate for some disciplines.	0.00	50.00	100.00	50.00	0.00	0.00	0.00	30.00	100.00	70.00	0.00	0.00
6	I believe PBL is unsuitable for first year students.	0.00	0.00	100.00	100.00	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00
7	Students need prior content knowledge.	50.00	60.00	50.00	40.00	0.00	0.00	33.30	70.00	66.70	30.00	0.00	0.00
8	Sufficient content is not taught using PBL.	16.70	50.00	66.70	50.00	16.70	0.00	16.70	20.00	83.30	80.00	0.00	0.00
9	I think PBL is too time consuming.	16.70	30.00	66.70	70.00	16.70	0.00	0.00	0.00	100.00	100.00	0.00	0.00
10	Given the course demands, using PBL will be too demanding for me.	0.00	0.00	83.30	90.00	16.70	10.00	0.00	10.00	100.00	90.00	0.00	0.00
11	I am not willing to embrace PBL.	0.00	0.00	100.00	100.00	0.00	0.00	0.00	10.00	100.00	90.00	0.00	0.00
12	I do not think PBL will make a difference to teaching and learning.	0.00	10.00	100.00	90.00	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00
13	I consider assessment in PBL to be a complicated activity.	16.70	60.00	66.70	40.00	16.70	0.00	33.30	20.00	66.70	80.00	0.00	0.00
14	I am presently confident about PBL.	50.00	70.00	33.30	30.00	16.70	0.00	0.00	80.00	100.00	10.00	0.00	10.00
15	My attitude towards PBL could determine my success.	50.00	90.00	33.30	0.00	16.70	10.00	83.30	70.00	0.00	20.00	16.70	10.00

Table 5 Summary of student evaluation of the PBL experience

STUDENT #

#	STATEMENT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	AV	SD
1	The PBL workshop prepared me mentally for learning more.	8	8	7	6	10	8	9	8	8	6	8	10	10	5	10	8	1.6
2	The activities stimulated discussion.	9	10	10	7	9	10	8	10	8	8	8	10	10	10	10	9	0.7
3	The PowerPoint slides helped me to focus on the important ideas.	6	10	7	4	7	3	7	5	5	7	8	10	10	5	8	7	2.2
4	The information contained in the presentations was delivered clearly.	7	8	10	6	8	5	8	10	7	8	8	10	10	5	9	8	1.7
5	The break-out groups allowed me to <i>experience</i> PBL.	9	9	7	7	10	8	9	10	7	8	8	10	10	5	10	9	1.5
6	The presenters held my interest.	8	9	8	7	9	8	6	7	8	5	8	9	8	5	10	8	1.4
7	The presentations were easy for me to follow.	8	10	8	7	8	3	8	9	8	7	8	10	7	5	9	8	1.8
8	The facilitators assisted me in experiencing PBL in practice.	10	10	9	7	10	9	9	10	8	7	9	10	10	5	10	9	1.5
9	The information in my binder summarized the main points.	8	10	10	5	9	8	7	10	8	7	10	10	10	0	9	8	2.7
10	I gained knowledge from this PBL workshop.	9	10	10	8	10	9	9	10	7	7	10	10	10	8	10	9	1.1
TOTAL		82	94	86	64	90	71	80	89	74	70	85	99	95	53	95	8	