*ISATE 2014*
*International Symposium on Advances in Technology Education*
*24 – 26 September 2014, Nanyang Polytechnic, SINGAPORE*

# DIFFERENCES IN PERCEPTIONS OF INTERNSHIP PROGRAMS BY STUDENTS, SCHOOL AND INDUSTRY

C.S. Yap

Republic Polytechnic/ School of Engineering, Singapore

yap_choon_seng@rp.edu.sg

**Abstract**

**Internships are increasingly becoming common as part of a tertiary engineering curriculum. However there are not many empirical studies being conducted that compares the views on internship among the 3 groups of stakeholders: students, industry supervisors and school supervisors. This paper reports the results of a study conducted on these 3 stakeholder groups that participated in Republic Polytechnic School of Engineering's Industry Immersion Program. Data is collected via a survey on the participants' views of the goals and structure of internship. Results showed that students disagreed with both academic and industry supervisors on several points: 1. whether an internship program's goal is to allow students to earn money; 2. whether students who failed should be put on an internship program; 3. whether interns should be viewed no differently from a regular staff of the company; 4. whether to formulate a mutually-agreed work plan prior to the start of internship; 5. frequency of visit by academic supervisor to the company. These differences in opinions may be due to students having a different set of priorities and expectations from their supervisors. The differences partly explain the dissatisfaction that is frequently voiced by students, academics and industry on the internship program. This dissatisfaction often surfaces itself in the form of frequent absenteeism or reporting late for work, which in turn affects the partnership between the companies and the school. Such cases often end with the offending student being discharged from the company and having to repeat the internship program at a later time with a different company. Ways to minimize such incidents include matching student ability with job requirements and making sure a student demonstrate an adequate level of responsibility before putting him on an internship program.**

**Keywords:** *internship, engineering diploma, comparison of views on internship*

## Introduction

It is common for students enrolled in tertiary institutions to be required as part of their graduation criteria to spend a portion of their time in a company doing full-time work. The name and structure of such an arrangement varies from institution to institution, but they can all be considered to be internship programs. In the School of Engineering in Republic Polytechnic, the internship program is known as the Industry Immersion Program (IIP). Under this program, it is compulsory for all engineering students to be working full time in a company for a period ranging from 16 to 20 weeks. The stated goals of the IIP program are to allow students to have a "first-hand experience of the work environment" and to "to apply knowledge, skill sets and techniques gained from the classroom" ("Internship", 2014).

The benefits of incorporating an internship component into the curriculum have been widely studied and reported over the years in fields ranging from business to information technology (Knouse & Fontenot, 2008, Renganathan, Karim & Chong, 2012, Schambach & Dirks, 2002). The same can also be said of the criticisms.

A common cause of student dissatisfaction is their perception of the lack of academic content in their work with the company, especially when the assigned work is too biased towards the company's operational needs and less towards the student's learning needs. Being given unchallenging and unrewarding work are other common complaints received from students on internship. On the other hand, common grouses voiced by companies include the lack of motivation on the part of the student, and the mismatch of the student's profile with the job (Garcia & Puig, 2011).

Most of the reports on internship programs are descriptive and anecdotal, focusing on students' experiences with the internship program at their institution. The voices of the other 2 groups of stakeholders, namely the school supervisors and company supervisors of the students, are less often heard in such reports. There are even fewer empirical studies that compare the views of these 3 groups on how they feel an internship program should be.

There appears to be some discrepancies among the stakeholders in the interpretation of the goals of an internship program and how it should be structured. A study conducted on Bachelor of Marketing internship program at the University of Queensland (Alpert, Heaney & Kuhn, 2009) did indeed find differences between students and employers in terms of the goals and structure of internship and how interns should be assessed.

The present study is an attempt to replicate the study conducted by University of Queensland, with students from a different type of demographics. It would be interesting to find out if the results obtained by Alpert et al's study on its Marketing degree program can be generalized to engineering diploma programs. The findings will also help to identify possible conflicting views held by the stakeholder groups. This understanding can help to inform the modification of the existing internship program in the School of Engineering.

**Methods**

*Sample*

The sample for this study comes from 3 groups: 1. student interns from 4 engineering diplomas; 2. academic staff from the School of Engineering; and 3. staff from companies that took in these interns. A total of 46 students, 21 academic staff and 25 industry staff completed the survey. Participation was on a voluntary basis, and all participants completed the same set of survey questions.

*Instrument*

The survey instrument used in this study is adapted from the one used by the University of Queensland's study (Alpert, Heaney & Kuhn, 2009). There are 2 sections to this survey. The first section contains 11 items on the goals of internship, and the second section contains 5 items on the structure of internship. Items in the Goals section utilized a Likert-type scale with 7 ordered response level ranging from "Strongly Agree" to "Strongly Disagree". Items in the Structure section are multiple choice questions.

*Analysis*

A Kruskal-Wallis test, the nonparametric equivalent of a one-way ANOVA, was conducted to examine differences in each of the items in the Goals section of the questionnaire. Non-parametric test is used instead of parametric tests such as ANOVA because of the ordinal nature of the data collected.

**Results**

Tables 1 to 3 summarize the descriptive statistics obtained from the results of the survey. Results of the Kruskal-Wallis test revealed significant differences between the 3 stakeholder groups for the items "Interns should be treated as professional staff personnel" (H(2) = 6.213, $p < 0.05$) and "Internships should allow students to earn money" (H(2) = 30.00, $p < 0.001$). These 2 items received significantly higher ratings from students compared to academic or industry supervisors. This result echoes the findings of the University of Queensland study.

Table 1 Structure of internship: Mean rank score for ordinal-scaled items

| Item | Student (*n* =46) | Academic (*n* = 21) | Industry (*n* = 25) |
|---|---|---|---|
| 1. How many days per week should the student be at the company for a 20-modular credit point internship? | 39.82 | 51.98 | 54.20 |
| 2. How often should academic supervisor be on site to meet with company supervisors? | 30.80 | 64.21 | 60.50 |
| 3. How often should students check in with academic supervisors? | 37.45 | 42.24 | 66.74 |

Table 2. Structure of internship: Responses for nominal-scaled items

| Item | Student (*n* =46) | Academic (*n* = 21) | Industry (*n* = 26) |
|---|---|---|---|
| 1. Should an internship plan be completed and signed by all parties before the internship starts? | Yes (91.3%)<br>No (8.7%) | Yes (66.7%)<br>No (33.3%) | Yes (61.5%)<br>No (38.5%) |
| 2. What should be the minimum GPA for students to be allowed to take part in internship? | Pass (39.1%)<br>No matter (60.9%) | Pass (61.9%)<br>No matter (38.1%) | Pass (65.4%)<br>No matter (34.6%) |

Table 3. Goals of internship: Mean and standard deviation for the 3 stakeholder groups. Items are rated on a 7-point Likert scale.

| Item | Student (*n* =46) | Academic (*n* = 21) | Industry (*n* = 26) |
|---|---|---|---|
| 1. Internships should guide students in applying textbook theory and academic research directly to work experiences | 46.41 | 47.14 | 47.92 |
| 2. Internships should enhance employments opportunities of students after they graduate | 48.95 | 47.29 | 43.33 |
| 3. The internship program is an opportunity for companies to develop and maintain relationships with polytechnics. | 46.35 | 47.19 | 48.00 |
| 4. Internship is a way to provide companies with cheap staff for getting tasks done. | 52.14 | 47.45 | 37.54 |
| 5. Interns can do almost the same work as entry-level diploma graduates. | 51.16 | 37.95 | 46.94 |
| 6. Interns should be treated as professional staff personnel (e.g. participate in staff meetings). | 52.98 | 46.40 | 36.90 |
| 7. Internships should allow students to earn money. | 62.15 | 31.98 | 32.33 |
| 8. Internships should help companies in recruiting and selecting new full-time employees. | 48.48 | 46.57 | 44.73 |
| 9. Internships should benefit the company, students, and the polytechnic equally. | 48.42 | 46.57 | 46.73 |
| 10. Internships should be compulsory for engineering students. | 49.13 | 48.05 | 42.38 |
| 11. Before the intern arrives, the company should develop goals and objectives for the program and establish policies and procedures to address the needs and roles of all relevant parties. | 51.60 | 46.74 | 36.92 |

There is also a significant difference in the opinions of students versus that of academic and industry staff on how often their academic supervisor should meet up with their industry supervisor at the company that the students are working in ($H(2) = 38.30$, $p < 0.001$). Students on the average felt that a fortnightly visit would be appropriate, whereas academic and industry supervisors are less keen on meeting up and prefer the visits to be no more than once per month.

The groups also disagreed on whether an internship work plan should be drawn out prior to the commencement of the internship. While the majority of students surveyed (91.3%) are for the idea, less than 70% of academic and industry supervisors support the idea of a formal internship plan possibly because of the reduction in flexibility in task assignment that a formal plan might bring.

The final point of contention arises from the placement of students who do not meet the minimum passing criteria in school. Two-thirds of the students surveyed are of the view that GPA does not matter in such matters, whereas the same proportion of industry and academic staff are of the view that a minimum passing GPA is required to be attained before a student can be sent out to the industry as an intern.

**Discussion**

The results of the study revealed a difference in expectations with regards to internship, and this difference is likely to show up in the form of dissatisfaction with the program and complaints to the academic supervisor.

For example, students may be dissatisfied with the stipend that they are getting for the internship if they view “earning money” as one of the goals of internship. Students may also feel that the work that they are tasked to do in their internship is incidental and unplanned for, especially if their supervisor in the company feels that interns are different from regular employees and should be differentiated as such in terms of the responsibilities and tasks that interns are allowed to take on. Interns will be missing out on an important part of the internship experience if they are not being assigned time-critical or operation-critical tasks.

Even though the purpose of this study is not to explore the reasons for the differing opinions held over internship, the author would like to venture a guess as to why this is so. The students participating in this study were all born after 1990. In other words, they are of the generation commonly known as Generation Y. This generation of youth is characterized by a stronger sense of entitlement compared to their supervisors in the school and the company, and also have greater expectations in the outcome of their endeavours.

Academic supervisors, being the middle-man that brings the student and industry together, will often need to manage incidents that arise from the student's disenchantment with the internship program due to differences between their expectations and reality. Much too frequently such unhappy incidents end with the offending student being terminated from the internship program. Occasionally, this termination is accompanied by protests from the parents of the student.

With the insight gained from this study, there is a chance that incidents such as interns frequently reporting late for work and malingering can be reduced through proper communication between all groups prior to the start of the internship. The aim of this communication should be to arrive at a common understanding on the purpose of internship and how it will be conducted. School supervisors can also strive for a better match between a student's abilities and the job requirements of an internship posting. Students who have a record of poor attendance or punctuality should also be allowed to delay their internship until such time as they have demonstrated a sufficient level of responsibility and professionalism in their work.

The assessment section of the original survey used in the University of Queensland study was not adopted in this study. A new set of questions can be designed to explore the differences in views on how an intern should be assessed. This can be the subject of a future study.

## Conclusion

This study identified areas in the goals and structure of internship where opinions differ. Students prefer a well-structured internship with clearly laid-out plans and good monetary returns. There are significantly fewer academic and industry supervisors who share this view. There is also disagreement on how often the academic supervisor should go down to the company for a visit, with students preferring more frequent visits from their academic supervisors than what the supervisors themselves would prefer. Industry supervisors tend to see interns as interns, even though students would like to be treated as a regular staff member of the company.

In summary, it is the author's view that academic institutions that have an interest in designing or modifying their internship programs can benefit from first conducting a similar comparison study that reveals any underlying differences in opinions between the stakeholder groups, so as to pre-empt problems that are likely to arise during the course of internship.

## References

Internship. (2014). Retrieved March 24, 2014, from http://www.rp.edu.sg/Internship.aspx.

Alpert, F., Heaney, J.G. & Kuhn, K.A.L. (2009). Internships in marketing: Goals, structures and assessment – Student, company and academic perspectives. *Australasian Marketing Journal*, *17*, 36 – 45.

Garcia, R. & Puig, J. (2011). A model for improving the quality of student internship placements in engineering degrees. *International Journal of Advanced Corporate Learning*, *4(1)*, 4 – 11.

Knouse, S. B., & Fontenot, G. (2008). Benefits of the business college internship: A research review. *Journal of Employment Counseling*, *45*(2), 61-66

Renganathan, S., Karim, Z. A. B. A., & Chong, S. L. (2012). Students' perception of industrial internship programme. *Education+ Training*, *54*(2/3), 180 – 191.

Schambach, T. P., & Dirks, J. (2002). Student Perceptions of Internship Experiences. *Proceedings of the 17th International Conference on Informatics Education Research. Barcelona, Spain.* 2002.

# PROBLEM-BASED LEARNING IN A TECHNOLOGY MEDIATED CURRICULUM: A CASE STUDY

Padma Rao

Centre for Educational Development, Republic Polytechnic, Singapore

padma_rao@rp.edu.sg

**Abstract**

**The aim of the research reported in this paper is to identify and understand students' perspectives on how they make meaning of their learning through collaborative problem-solving in the technology mediated, problem-based learning curriculum of one polytechnic in Singapore. This approach to learning on an institution wide application is unique amongst polytechnics in Singapore and a new experience to students whose secondary education was typically in a teacher-centred direct instructional context. A qualitative case study within an interpretivist research framework was undertaken. Data were gathered primarily through reflection journals written by 75 students in the first year of their diploma programme at the polytechnic. These data were supported by group interviews with students. Data were analysed by following the Miles and Huberman (1994) inductive approach to qualitative data analysis. Theory in the form of ten propositions was developed. These propositions show that students perceived PBL as enhancing their learning and preparing them for their work life in their chosen discipline of study. Students believed that they are supported in their learning by the scaffolding provided in the instructional design of PBL. Additionally, collaborative learning enabled them to co-construct knowledge while the reflective practice carried out through the use of reflective journals had the potential to help them to gain insights into their strengths and weaknesses as learners, and in turn, chart areas for improvement. However, student practices often fell short of their verbal understanding on this issue. Students were used to traditional learning methods and adapting to this type of new learning environment was not always easy. Implications for PBL practices are included in the concluding section of the paper.**

**Keywords:** *PBL, Learning environment, Scaffolding, Technology, Collaboration, Reflection*

**Introduction**

Education in Singapore has evolved with changing national and global circumstances. The country has geared its education system toward nurturing an innovative society attuned to the demands and opportunities of the 21st century (Shanmugaratnam, 2008). The establishment of Singapore's first polytechnic in 1952 ushered in technical education, with the objective to train middle-level professionals to support Singapore's technological and economic development. Between the 1960s to the 1990s, three more polytechnics were set up to spearhead the training of skilled manpower and meet the needs of Singapore's growing economy. Polytechnic education has been the backbone of Singapore's industrialisation programme. The polytechnics' core mission is to train and produce technologists and middle level professionals to support the technological, economic and social development of Singapore. Polytechnic graduates of today are highly valued for being practice-oriented and knowledgeable (Chan, 2008). They are highly sought after in the shift to a knowledge-based economy propelled by accelerated technological change and rapid globalisation.

At the turn of the century, the need for creating student capacity in technical education was compounded by new challenges in the face of the changing economy impacted by rapid growth of information technology and the effects of globalisation. In order to meet these challenges and to create more polytechnic capacity, a fifth polytechnic, the Republic Polytechnic emerged on the Singapore tertiary education landscape. It adopted Problem-based learning (PBL) as its pedagogical approach. PBL was first implemented in a medical education curriculum by Toronto's McMaster University in the late 1960s. However, its introduction at the new polytechnic marked a major educational institution in Singapore undertaking a fully integrated PBL curriculum. This context, PBL curriculum in Singapore, is a worthwhile field for investigation.

An extensive review of relevant literature indicated that there is very little knowledge of how students respond to the application of PBL in "a systematic and pervasive way", (Teo in Lau, 2007, p. 16). Literature emphasises that voices and views of students are crucial to the successful implementation of any programme since the students are the primary focus of these reforms. It therefore becomes important to understand how students view these programmes. This paper reports findings drawn from my doctoral research (Rao, 2010) that focuses on the following key research question:

*What are students' perspectives on how they make meaning of their learning through collaborative problem-solving in the technology mediated problem-based learning curriculum of one polytechnic in Singapore*?

There will be a brief description of the Problem-based learning as it is carried out in the polytechnic followed by method, results and discussion, and conclusion.

**The PBL Curriculum**

*If I hear it, I may forget it,*
*If I see it, I shall remember,*
*If I do it, I will understand*
- *Confucius.*

Problem-based Learning or PBL, based on the notion of learning by doing, is an emerging teaching approach that marks a paradigm shift from traditional didactic teaching to an approach where the learner plays an active role in the knowledge acquisition process.

The PBL adapted at the polytechnic is rather unique; the specially designed learning environment at the polytechnic is wireless and paperless. Students solve problems, seek information, submit assignments and carry out all necessary transactions electronically through the wireless information technology infrastructure of the campus. The PBL cycle in the polytechnic where this research was conducted is based on the approach that requires students to work on one problem in a day. It takes place in a class setting consisting of 25 students and one facilitator. Each class is allocated 25 students and is attended to by an assigned facilitator who manages the proceedings for the day. The students work in teams of five on each learning day. The daily routine comprises three meetings with facilitator interaction separated by two periods of self-directed study or teamwork without facilitator involvement, and ends with a personal reflection for the day. Students, all of whom carry personal notebook computers when on campus, use the wireless environment on campus extensively during their daily work. A web-based online learning platform with fairly sophisticated capabilities enables students to engage academically in diverse ways, inclusive of accessing learning resources, making required submissions and receiving feedback from teaching faculty, on an 'anywhere anytime' basis.

All learning in the polytechnic's problem-based curriculum starts with a problem which in essence acts as a stimulus. The meaning of 'problem' in the study is synonymous with its use in cognitive psychology used 'to denote any situation that inspires a goal for which there is no clear path to reach it' (Kelson & Distlehorst, 2000, p.168). A problem is presented to post-secondary students, enrolled in a three-year diploma programme, for discussion in small groups, each group comprising five students, and five such groups in a class. Usually the students have to explain the phenomena or events presented to them in terms of their underlying mechanisms, principles or processes. The students come into the classroom equipped with their prior knowledge and work in groups. While discussing a problem, the groups employ a specific procedure that comprises three phases - *problem presentation, problem follow-up* and *in-class presentations*. The learning context requires the students to articulate and communicate to their team members about what they know and what they do not know in the context of the problem presented to them.

In order to present students with opportunities to engage in complex problem solving tasks that would otherwise be beyond their current abilities, the problem-based environment is supported by scaffolding. 'Scaffolding' (Wood, Bruner & Ross, 1974) is a key strategy in cognitive apprenticeship which enables students to learn by taking increasing responsibility and ownership for their role in complex problem solving with the structure and guidance of more knowledgeable mentors or teachers (Collins, Brown, & Newman, 1989).

According to Hmelo-Silver (2006), scaffolding supports students' learning of both how to do the task as well as why the task should be done that way. In the context of PBL curriculum at the polytechnic, the Problem Definition Template or the PDT (Appendix A) acts as scaffolding by allowing the team members to record their discussions on what they know, what they do not know or unsure of, and what they need to find out, in order for them to start working on their response to the problem. In essence, the PDT serves as a point of reference for negotiation and reflection and helps the students keep track of their problem solving. In addition to the PDT, an accompanying worksheet for each problem is provided electronically to the students. The worksheet serves as scaffolding using a series of questions that will prompt the learner to think more deeply into the underlying concepts of the problem (Lim, 2007). PBL at the polytechnic is IT assisted and according to Lajoie (2000), it is often used as a tool to scaffold higher-order thinking. Many higher education institutions have implemented a learning management system (LMS) to manage online learning (Weaver, Spratt & Nair, 2008). An example of a LMS in the PBL context discussed, is the Learning Environment Online (LEO) which delivers learning content and resources to the students of the polytechnic. From a constructivist perspective, modern technology is an important example of a cultural tool that can be used to support learning in both scaffolding and co-constructing relationships (De Lisi, 2006). It appears that the more successful uses of the online learning environment are linked to a constructivist approach to its deployment (Deepwell & Syson, 2006), and the LEO is an example of one such deployment.

**Method**

A qualitative case study method located within the interpretivist tradition was selected as an appropriate strategy to gain deeper insights into the ways in which students believe the PDT, worksheet, and technology aid their learning in the PBL classroom. The primary source of data for the study was documents in the students' reflection journals. Data that contributed to the findings were drawn from 352 student journal entries over a 13-week period and across 3 classes of 75 students, in their first year of study and facilitated by the researcher. These journals are commonly referred to as Reflection Journals or RJs by the polytechnic population. Additional to the data collected and analysed from the progressive reflection journals, data were collected through 3 group interviews after the completion of students' journal writing and preliminary analysis of those data. The 3 group interviews comprised 7, 6 and 7 students respectively from the three classes, all of who provided parental consent for the interviews. Students participating in the research were assured of anonymity and all individual data were de-identified in the data set for analysis. Ethics approval for the research was sought from, and granted by the polytechnic ethics review committee

The central research question was addressed through the following set of guiding questions that were used as prompts to trigger student responses for both the data sources, i.e., the journal entries as well as group interviews:

1. *In what ways do students believe that working in teams helps their learning?*
2. *What do students like or dislike about their problem-solving approach to learning as opposed to their past experiences of teacher-directed learning?*
3. *What do students understand as the meaning of 'reflection' and how do they see this as helping their learning?*
4. *What strategies do students use to help them learn?*
5. *In what ways do students transfer learning gained through addressing one problem to addressing later problems? What helps this process?*
6. *What part do students believe that the following play in their progressive construction of meaning through their learning experiences:*
   a) *Prior knowledge; and*
   b) *Communication within and between groups?*
7. *What do students see as facilitators and inhibitors of their learning? How might these be addressed?*
8. *How do students see their use of time in the PBL classroom?*

In this research, the end product goes beyond description to theory construction through use of the Miles and Huberman (1994) approach to inductive data analysis. The Miles and Huberman (1994) framework has four main components which are data collection, data display, drawing and verifying conclusions and data reduction. This framework catered to the use of descriptive codes to summarise the data, followed by two levels of inductive coding, with memos drawing together first order inductive codes into higher order (umbrella) inductive codes. This method of data analysis offered a systematic approach to collecting, organising and analysing data.

**Results and Discussion**

Analysis of data from student journals and from interviews resulted in the emergence of theoretical findings in the form of ten propositions. The findings reported in this paper are organised into the four over-arching fields, viz., scaffolding learning, learning in teams, reflective practice in learning, and adapting to the new learning environment as discussed in the following section.

**Field One: Scaffolding Learning**

**Proposition One**
*Scaffolding, in the form of worksheets, not only provides students with valuable guidance to processes in their problem solving efforts but also contributes to intangibles such as team bonding. Students believe that questions in the worksheets act as clues or probes that permit an in-depth exploration of the problem through team discussions and collaboration.*

**Proposition Two**
*Students understand the value of the problem definition template (PDT) as a tool to support their learning. While students acknowledge the value of the PDT in problem solving, many of them admit that they find it useful only in some modules and the practice of using it for every lesson as being mundane.*

**Proposition Three**
*Students recognise the first step in problem solving as the activation of their existing knowledge. Students participating in this research believed that it was essential to examine their prior knowledge as a knowledge source which in turn provided an intellectual scaffold. This enabled the harnessing of additional information that was considered necessary for problem solving.*

**Proposition Four**

*Students believe that Information Technology (IT) is crucial to their problem solving efforts. Students admit using IT in problem solving is not always a smooth process. Nevertheless as an electronic scaffold, it enables rapid access to information, permits a deeper engagement with the given problem and aids in the presentation of possible solutions.*

**Field Two: Learning in Teams**

**Proposition Five**

*Students believe that collaboration in teams enables them to co-construct knowledge and that teamwork enhances their learning. However, team collaboration is not a smooth process as students have to contend with issues such as 'free riders' and tensions or conflicts between team members. These cause impediments to their learning journey. Such issues are perceived by students to be detrimental to the team and individual performances.*

**Proposition Six**

*Most students seek to enhance teamwork by managing differing perspectives through role assignment and distribution of workload based on the competencies of individual team members. However, students lack sufficient knowledge to ensure the efficacy of teamwork.*

**Proposition Seven**

*Students believe that communication within and between teams plays an important role in the joint construction of knowledge. Communication in the technology mediated problem-solving approach to learning, in turn, is affected by two key issues. The first concerns the types of communication platforms used and the balance between face-to-face communication and virtual online communication assisted by technology. The second issue concerns the competency of the predominantly Asian students, in the research undertaken for this thesis, to communicate in English. Both influence the interaction and the quality of discussions in the course of problem solving.*

**Field Three: Reflective Practice in Learning**

**Proposition Eight**

*Students believe that reflection is an effective way to think and review what has been done and learnt in the PBL classroom. Additionally, reflection allows them to gain insights into their strengths and weaknesses as learners, and helps them to chart areas for improvement. However, there appears to be a need for deeper reflection by students in order for them to construct a more coherent understanding of their learning. Applying a framework for reflection is essential to the gaining of deeper understanding.*

**Proposition Nine**

*The process of students recording their reflections in online journals which are then read by staff facilitators, who in turn use these journals as part of the process of grading students, is problematic. Students have different viewpoints on the value of the journals. While the shy and the less articulate students view the reflection journal as a communication channel with the facilitators, most others alternate their opinions on the writing of reflection journals as being essential for better grades or as a meaningless exercise that is attempted after solving a given problem. An implication is the need for students to understand the purpose of the reflection process as an aid to improved learning and not as a component of assessment. Assessment of reflection seems to undermine its value as a learning process.*

**Field Four: Adapting to the New Learning Environment**

**Proposition Ten**

*Students believe that learning in a fully integrated PBL curriculum is very different from their past teacher-directed learning experiences. They perceive the PBL approach to be a unique one, enabling them to become self-directed learners by equipping them with skills relevant to both academic and future life. However, students feel a sole PBL method across all units poses certain challenges and adapting to this new learning environment is not easy. A particular issue is the effective use of time.*

**An Overview of Propositions and the Central Research Question**

Students believe that they are assisted in their learning through the use of scaffolds such as the worksheet, the problem-definition template (PDT), prior knowledge and Information Technology (IT). Of the four scaffolds, the worksheet was one that offers the most assistance and provides a direction to their problem solving efforts. IT as an electronic scaffold and prior knowledge as an intellectual scaffold, also support students in harnessing additional information necessary for problem solving. In comparison, the PDT is a less-favoured scaffold as students find its use across all their PBL units of study both limited and monotonous.

Students believe that collaboration and communication amongst team members play important roles in the joint construction of knowledge and in turn enhancing their learning in the PBL classroom. However, students lack sufficient knowledge and skills to ensure efficacy of both these processes. Students face impediments in their learning because of issues such as 'free-riders' and tensions between team members which affect teamwork, and the interaction and the quality of discussions amongst team members in the course of problem solving is affected by students' varying levels of competency to communicate in English in the predominantly Asian PBL classroom.

Students admit that reflecting on their learning is a new experience for them. They believe that reflection is a way to review their learning and this helps them to chart areas for improvement. However, maintaining reflection journals across all units of their PBL study on a daily basis for the purpose of assessment is perceived as a tedious process. Very often, students stop short of deeper reflections that would have the capacity to offer a more coherent understanding of their learning.

**Conclusion**

In conclusion, while students value the PBL method of study in their institution and believe that it will equip them with relevant skills for the future, they also admit that adapting to this new method of learning is not easy as it is very different from their prior learning experiences in predominantly teacher-directed classrooms.

Although this study was conducted on a single site, it explored and investigated in-depth the perspectives of a group of 75 students engaged in the unique problem-based learning implemented at the polytechnic through qualitative analysis of data from 352 journal entries gathered over a 13 week period and three focus group interviews. The findings of this research can serve as supporting evidence for curriculum managers in their catering to learners' needs and course designers in their planning and designing of PBL to support institutional goals. Additionally, the findings have the potential to provide a frame of reference for educational providers with PBL on their agenda.

**References**

Chan, L.M. (2008). Polytechnic education. In Lee Sing Kong, Goh Chor Boon, Briger Fredriksen & Tan Jee Peng (Eds.), *Toward a Better Future: Education and Training for Economic Development in Singapore since 1965* (pp. 135-148). National Institute of Education, Singapore & The International Bank for Reconstruction and Development/World Bank, Washington D.C.

Collins, A., Brown, 1. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics. In L B. Resnick (Ed.), *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum Associates.

De Lisi, R. (2006). A developmental perspective on virtual scaffolding for learning in home and school contexts. In A. O'Donnell, C. E. Hmelo-Silver, & G. Erkens (Eds), *Collaborative Learning, Reasoning and Technology* (pp. 15-35). Marwah: Lawrence Erlbaum Associates.

Deepwell, F., & Syson, A. (2006). Institutional perspectives: making PBL online possible and sustainable. In M. Savin-Baden, & K. Wilkie (Eds.), *Problem-based Learning Online* (pp. 24-36). London: Open University Press, McGraw-Hill.

Hmelo-Silver, C. E. (2006). Design principles for scaffolding technology-based inquiry. In A.M. O'Donnell, C. E. Hmelo-Silver, & G. Erkens (Eds.) Collaborative reasoning, learning and technology). Mahwah, NJ: Erlbaum. p147-170.

Kelson, A., & Distlehorst, L. (2000). Groups in problem-based learning (PBL): Essential elements in theory and practice. In D. Evensen & C. Hmelo (Eds.), *Problem-based Learning: A Research Perspective on Learning Interactions* (pp. 167—184). Mahwah, NJ: Lawrence Erlbaum Assoc.

Lajoie, S.P. (2000). Breaking camp to find new summits. In S.P. Lajoie (Ed.), *Computers as Cognitive Tools (Vol. 2): No More Walls* (Vol. 5, pp. 15–32). Mahwah, NJ: Erlbaum.

Lim, F. S. (2007). Scaffolding using worksheets. Paper presented at the *International Society for the Scholarship of Teaching and Learning Conference*, July 2-5, 2007, Sydney, Australia.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis- An Expanded Sourcebook* ($2^{nd}$ ed.). Thousand Oaks, CA: Sage Publications, Inc.

Rao, B. P. (2010). *Problem-Based Learning in Polytechnic Education in Singapore.* Unpublished doctoral dissertation, The University of Western Australia, Crawley, WA.

Shanmugaratnam, T. (2008). Foreword. In Lee Sing Kong, Goh Chor Boon, Briger Fredriksen & Tan Jee Peng. (Eds.), *Toward a Better Future: Education and Training for Economic Development in Singapore since 1965* (pp. ix-x). National Institute of Education, Singapore & The International Bank for Reconstruction and Development/World Bank, Washington D.C.

Teo, Chee Han (2007). Reflections on the evolving technical education landscape. In Aileen T. Lau (Ed.), *Gateway Passage of a Learning Environment: Republic Polytechnic 2001-2007* (pp. 16-17). Singapore: Suntree Media Pte Ltd.

Weaver, D., Spratt, C., & Nair, C. S. (2008). Academic and student use of a learning management system: Implications for quality. *Australasian Journal of Educational Technology*, *24*(1), 30-41.

Wood, D. J., Bruner, J.S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89-100.

## APPENDIX A: Problem Definition Template

| *What we know* | *What we don't know* | *What we need to find out* |
|---|---|---|
| | | |

# UNIQUENESS OF MATHEMATICS AND COMPUTING IN EDUCATION

W. A. M. Alwis

School of Engineering, Republic Polytechnic, Singapore

Email: alwis@rp.edu.sg

## Abstract

**From the point of view of the conventional lecture-tutorial methods, regular mathematics and computing course units may not appear to be unduly different in nature to deserve any special attention. However, these two subjects tend to get invariably noticed as problematic by educators engaged in student-centred pedagogies that promote self-directed learning through guided problem solving. In any case, when compared to others, these two subjects are unique in that they are the only ones that deal with purely logical generic procedures for manipulation of abstract artefacts. The availability of diverse practical applications is supposed to make it easier to construct a learning activity for any chosen issue, but the 'many things to learn' nature of the curriculum makes it harder. Whether any prior knowledge would be activated or self-directed learning gets triggered by the context posed in the activity is another issue. Many students find it hard to draw useful appropriate abstractions from a given context for the purpose of mathematical and computing work. One cannot overlook the need to provide students with various formulae, schemes and structures that cannot be expected to be figured out by students on their own. These problems get interpreted as due to an incompatibility between the student-centred approach and the abstract subjects. The author herein argues that the problems are due to compounded effects of various issues on the ground. Students hold misunderstood notions from their previous schooling experiences and also tend to be weak in linking abstractions to reality. There are widespread deep seated notions that mind is a metaphorical container of knowledge and that learning is the same as becoming capable of recalling memorised matter to provide the expected answers to examination questions. These affect how the curriculum gets laid out, what form the test questions take, and what students take as their immediate purpose in school. Within the constraints at educational institutions a solution lies in detecting and addressing students' misconceptions directly during regular face-to-face encounters in classrooms with the expressed intention of developing students to acquire practical capabilities and cultivating practitioners' ethos and orientations in them.**

**Keywords:** *computing, container metaphor, ecological model, mathematics, student-centred, understanding.*

## Introduction

It is widely known that a neat definition of mathematics, or a clear identification of its specific scope, is hardly viable (Tobies and Helmut, 2012; Mura, 1993). Whether mathematics is a science, an art or something that should be classified under humanities had never been settled. Possibly based on the experiences with the material taught as mathematics at educational institutions, many would associate mathematics as a collection of abstractions, logical deductions and procedures for symbolic manipulation. These had been discovered, establishing a collection of logically exact formations regarding matters such as quantities, spaces, patterns and changes. However, such philosophical views hardly matter to the majority of science, technology and industry experts who have little doubt about the benefits of mathematics as a whole.

The classroom subject identified as 'computing' at institutions of technology education seldom appear at early levels of the education ladder, although any goal oriented activity that involves algorithmic schemes, such as the method of long division taught at primary schools, qualify as computing. Computing work that involves processing by hand methods are usually dealt with under arithmetic or mathematics in early schooling. When the use of electronic machines for computing is involved, the matter gets recognised as a subject that is different from mathematics and also from mechanical engineering, the specialisation that deals mainly with machines. The subject of computing today engulfs the issues of organising and managing information, extending to communications and entertainment, designing and building computing hardware and software systems, and attempts to make such systems behave in ways that appear to be intelligent.

Despite the vast reach of mathematics and computing as important endeavours of the human civilisation, the formal courses of these subjects in technology education are unavoidably compact and tend to be limited to simpler logical schemes and initiation to programming. Various practical applications of the contents of these two subjects are typically packaged separately under diverse practical terms such as AC circuit theory, digital electronics, and game design.

**Curriculum and Examinations**

At their respective bases, mathematics and computing share the common feature of logical consequences, although mathematics is about viable deductions from specified premises whereas computing is about logical processes that would produce desired outcomes. Typical difficulties with abstractions naturally affect the learners of both mathematics and computing. However, during the processes of curriculum development this difficulty does not receive any special attention. Mathematics and computing get treated just like any other regular subject taught at the institution. Any effect associated with teaching methods is only felt at the delivery end in classrooms.

In the metaphysical model of ideal forms and truths of Aristotle and Plato, the development of the young by formal education is seen as advancement towards an ideal, or a complete state, through an orderly process. Similar thinking is evident in the current curriculum development processes, which can be traced back to Bobbit (1918). He proposed activity analysis for planning the teaching actions for achieving human performance outcomes as per needs of the individuals and the industrial society. The underlying thinking therein is that for best results, teaching should be a well-planned and executed prescriptive production process, leading to completion of a clearly defined final product. This manufacturing notion of education is so deeply permeated now at all levels, that 'school is a manufacturing facility' hinted by common refrains like 'production of graduates' hardly gets noticed.

The belief that mind is a metaphorical container, in which knowledge can be stored and from which knowledge can be retrieved at will, is widespread and can be recognised as the basis of many practices at educational institutions, regardless of the pedagogical approach adopted. Bereiter (2002) had pointed out that the container metaphor is quite explicit in the document wherein the well-known Bloom's taxonomy appears (Bloom, 1956) wherein it has been stated: "It may be helpful in this case to think of knowledge as something filed or stored in the mind. The task for the individual in each knowledge test situation is to find the appropriate signals and cues in the problem which will most effectively bring out whatever knowledge is filed or stored." In Bloom's taxonomy, classification of Comprehension, Application, Analysis, Synthesis and Evaluation as higher order intellectual skills that operate on the lower level entity called Knowledge, leaves no room for accounting for what is known as 'understanding' of physical objects as well as abstract knowledge (Bereiter, 2002). Nevertheless, this metaphorical container dominates the thinking of most teachers, and therefore most teaching work, regardless of the pedagogical philosophy that is adopted at the institution. When someone says, for example, that "differentiation is covered in the secondary school, so we should not address differentiation here" it exposes the underlying belief of that individual, that 'mind is a container'.

The purpose of schooling gets implicitly defined by the modes of success within the schooling system, regardless of the pedagogical approach adopted, as would happen with any other system. Students learn very early that they would get treated as being successful if they score well in examinations. They also learn that important tests seldom contain questions that require procedurally different approaches from those addressed in the coaching processes in schools. Experience teaches those who had tried to understand the subject matter out of personal curiosity, that responding to such pattern-based questions on the strength of one's understanding of the subject matter is slower and inefficient when compared to regurgitation of memorised facts and mechanical application of memorised procedures. The low decay time of the kind of memory adopted in the latter approach gets readily addressed by just-in-time 'studying' prior to tests.

Research studies have confirmed what had been anecdotally evident to some educators for a long time, that testing in schools has failed to reveal serious widespread misconceptions (or, alternative conceptions to scientifically established ones) held by students (Kaiser, Profitt, & McCloskey, 1985; Wandersee, Mintzes & Novak, 1994). Shortcomings of education systems have been getting recognised better over the decades. The need for 'teaching for understanding' has gained some attention in the recent years, although action had been muted. Unfortunately, publications and discussions at education forums reveal that the teaching community still does not even have shared common interpretations for 'teaching' and 'learning'. Reforms in education had mostly been limited to changes in teaching methods and pedagogical strategies. Among such strategies, what is known as 'student-centred' approaches have gained increasing acceptance in the recent years.

**Mind and Learning**

At the core of any educational debate are ways in which individuals think and learn. The 'folk theory' had been that human beings are endowed with a general set of reasoning abilities which they bring to bear on any cognitive task. As had been pointed out by Hirschfeld and Gelman (1994) and numerous others, many cognitive abilities are indeed specialised to handle specific types of information. In other words, much of human cognition is domain-specific and therefore, the context in which learning takes place is critical. This makes questionable the belief of the 'transferability' of learned abilities to other domains. From the view point of situated learning (Lave & Wenger, 1991), the context of learning in a school is really the classroom, and not the context described in the posed problem trigger. Yet learning about a practical situation by engagement in a school can still be considered as a better initiation to learning of relevance to reality when compared with other limited alternatives at a school.

The mind is said to construct small scale models of reality and uses them to reason, to support explanations and to anticipate events (Khella, 1994). When reading and interpreting a given context to address a challenge or solve a problem, the learner is expected to perceive, imagine, and collaboratively interpret to construct some form of a model in mind. A mental model, being drawn and reinforced from what is identifiable, visible and noted, represents explicitly what is perceived to be true or known from the contexts encountered. Excluded from the mental model are what is false and those that are usually unknown or unnoticed. The deliberate omission is quite similar to the case of the Newtonian law about forces that is commonly phrased as "every action has an equal and opposite reaction", in which the location of the reaction is not stated, although many who memorised the law probably would not have noticed it.

**Student-Centred Pedagogical Approaches**

Sometimes characterised also as constructivist, problem-based, or inquiry-based pedagogies, the learner-centred schemes are based on the conviction that people learn best when engrossed in a topic. An expectation therein is that when triggered by a challenge or a problem, the learners would be naturally motivated to seek out the new knowledge and skills perceived to be needed to address the matter. The goal is to generate active exploration leading to knowledge construction. This is typically held in contrast to what is believed to be passivity of lecture attendance and textbook reading. In short, the idea is to focus education around a set of intrinsically-motivating problems or challenges which are realistic and of practical value

It is broadly recognised today that information may become more a source of confusion than coherence (Postman, 1993). Theories are based on simplifications of reality, or at least lead to simplification. The power of theories is in assisting to organise, weigh and include/exclude information from any given context of interest. This advantage of simplification can become a disadvantage when the theories and their bases are not understood to a sufficient level. In this regard, creating opportunities for teachers to converse with students and for students to converse with each other, with reference to information, concepts, and theories would be a vital need in the classrooms. Accordingly, it is important to design learning activities such that they permit and promote discussion and deliberation.

Entwistle (1998) has noted that the difference between the traditional approach and certain recent alternatives is in viewing the purpose of education "narrowly as training" for a specific functional purpose in the former and inclusively "as a preparation for life" in the latter. In the present work the purpose of education is taken as the latter with an emphasis on "enabling students to understand their world better" Bereiter (2002). The latter purpose makes sense even in the cases of technical education where economic utility is the central purpose, as the unfolding knowledge economy presents a compelling situation that anyone who is able to interpret their world better is more likely to function within and serve such an economy better.

What can be called 'successful teaching' depends on what is expected of education, making education a contested domain. Diverse views about knowledge, learning, achievement testing, and other related issues are quite evident. Differences exist even among individuals who subscribe to a single philosophy such as constructivism (Bereiter, 2002). The power of labels in educational thought obstruct the view while overused phrases such as 'collaborative learning', 'learning by doing' and 'project based learning' get interpreted in diverse ways and implemented for various purposes on the basis of inadequate models people have in their minds. Regardless of the purpose of education adopted, one can readily recognise that there would be different ways of being successful in teaching. Education being a complex process due to the diversity of interactions, interacting agents and influences, it would be impossible to accurately identify any of the 'active ingredients' of any known successful way of teaching. Even 'teaching causes learning' is a claim that is difficult to sustain (Davis, 2004).

Education is viewed herein as an effort directed at creating new perceptions of realities in learners, as had been elaborated in different ways by various researchers (e.g. Davis, 2004; Marton and Booth, 1997). Such new perceptions of realities, to be promoted with deliberate intent by the teachers, are needed to be progressive improvements over the previously held perceptions, if education is to serve a sensible purpose. For a learner, the natural creation of a simplified mental model makes it easier to work on a given context, interpret outcomes, and predict possibilities. To be taken note of is that development of mental models through collaborative effort in teams, and becoming familiar with them takes time. Accordingly, the time allocated for each learning activity in student-centred schemes tends to be longer, and may extend from a full day to several weeks.

The pedagogical models of information processing, cognitive psychology, situated cognition, constructivism, social constructivism and connectionism tend to dominate today's research on knowledge, mind, and learning. They also tend to resonate well with student-centred schemes of education. Student-centred settings can be more accurately described as learning eco-systems rather than as learning environments. Each learning ecosystem is a coevolving collective in which each learner affects and is affected by the system. Such collectives may be seen in various sizes and levels in reality, for example, in family units, groups of friends, whole schools and extending to cultural groups. Among the corresponding educational attitudes of teaching are mindful-participation, conversing, caring, pedagogical thoughtfulness, eco-justice, hermeneutic listening and minding (Davis, 2004) which are typically promoted as desirable characteristics of classroom teachers.

Despite the vast difference in the thinking and attitudes of what is considered as a good teacher in different pedagogical approaches such as the lecture-tutorial schemes and the student-centred ones, the curricular arrangement of content tends to be similar across those practices. This is due to aforementioned adoption of activity analysis directed at achieving a spelt out objective, which defines an implicit ideal end state. Such curricula pose challenges when designing learning activities for student centred learning due to lack of consideration for the special nature of the kind of scheme adopted. Fortunately, for most types of course units, this is an issue that can reasonably be addressed by staff development programmes on learning activity design,

**Mathematics and Computing**

However, mathematics and computing emerge here as significantly different from others in terms of the scale of the challenge. The curricular content of each course unit is typically laid out in a logical sequence under main topics and subtopics, in a very similar way to the content laid out in textbooks. The way the subject was originally developed by the community through a collective effort and long struggles seems to get less respect here than it deserves. The logical connections evident with the benefit of the hindsight, available only to those who had understood the subject well, instead, get a definite priority. The belief of linear content accumulation in the metaphorical mental container of each student thereby becomes quite evident in the curricula. In this case, teacher training programmes with an ecological narrative prove ineffective and largely irrelevant.

The fact that there exist diverse practical applications for any topic in mathematics and computing does not turn into an advantage when designing learning activities. The number of learning activities that can be addressed within the timeframe of a teaching semester is finite and far smaller than the numerous variations of abstract arrangements that need to be addressed within the course unit. Moreover, whether any prior knowledge would be activated or self-directed learning gets triggered by each context posed in the learning activities remains unanswered. Many students find it hard to draw useful and appropriate abstractions from a given context for the purpose of mathematical and computing work. One cannot overlook the need to provide students with various formulae, schemes and structures that cannot be expected to be figured out by students on their own.

One of the things that disturb mathematics and computing educators, as well as those enagaged in teaching other subjects, is that most students seem to be unable to form mental models. This gets readily noticed by the educator in-attendance during interactions with students in student-centred classrooms. As a result of this difficulty, especially in the case of mathematics and computing, students do not seem to be able to effectively self-learn or engage in knowledge-building in groups. This happens regularly despite that the classrooms are facilitated in the normal manner and additional help is provided in the form of information on relevant formulae, schemes and procedures. Out of desperation, in order to address the perceived shortcomings, some teachers are known to resort to delivering mini-lectures contrived within the student-centred setup with the hope that it would help. Overlooked here is that learning is a complex emergent process and teaching is not a matter of orchestrating. A complex emergence cannot be managed into existence (Davis, 2004). Those mini-lectures may look like that they help, but that is only for doing the tests, not for developing understanding.

What is known as a misconception, or an alternative conception to one of those that can be considered as correct, primarily arises from not looking for understanding in the first place. There are multiple ways of getting to know something and understanding it. Instead, most students look for memorising the content and the patterns by repeated practice. As a result each pattern that gets recognised has a specific nomenclature. A student may know that when $y = 2x$, then $dy/dx = 2$. If that student is given $z = 2f$, and asked to determine $dz/df$, at least there would be a moment of hesitation before the answer comes up. If the question was $z = 2f^2$, where $z$ and $f$ are functions of $x$, and asked to find $dz/dx$ the correct answer would be given by only a few. Only some among those would have a sensible understanding to back it up.

Taking a computing example, it would be hard to find a student who had understood sufficiently to tell the difference between the following two functions written in Python, given that `L` is a list of numbers.

```
def Numbers1(L):
     for num in L:
          if num % 2 == 0 :
               L.remove(num)
     return L

def Numbers2(L):
    K = []
    for num in L:
        if num % 2 != 0:
              K.append(num)
    return K
```

Very few, if any, would guess that these two functions would produce different outcomes. The first one looks like removing even numbers from the given list, but it operates on the given list itself, therefore skips the number just after any even number without checking it. The second one works well because it builds a new list from scratch. In programming terms, the first one illustrates a poor/dangerous practice and the least a class facilitator can do is to explicitly point this out.

When examinations do not test any of such different levels of understandings the students may have, these underlying inadequacies in students would get overlooked as noted before. This effect is compounded by a syllabus written with the inadequate notion that mind is a metaphorical container which needs to filled according to a pre-set plan. That also means, excluding what is supposed to be already in the container, so anything not adequately understood goes unnoticed too. This compounded effect needs attention of all teachers.

The only right thing a class teacher can do, without changing the curriculum and the examinations, is to work more on understanding. Here, we need a better clarification of understanding. An appropriate strategy for making sense of understanding has been suggested by Bereiter (2002). One has to start by considering something real. Consider someone who understands, say, welding. This understanding depends on whether that person is a welder, or a user of welded products, i.e. the relationship the person has with welding. Someone who does not have that kind of a relationship with welding has no chance of understanding welding, at least the way those welders have, or, the way the users of welded products have.

The same idea can be extended to conceptual objects, say, differentiation in mathematics, or, lists in Python. First of all one has have a need to use such conceptual objects to have a chance of building a relationship with the object. Note that this relationship depends on the specific use. Then one needs personal help from someone who used that object before, preferably in different ways, and knows; in the case of the welding example, say, how a left-handed welder would weld when compared to a right-handed one. There are values and ethical practices of practitioners that need to be introduced here. For example, in the case of computing, the program must deliver, guarding the user from typical mistakes and wrong inputs, within the shortest possible time, and requiring the least amount of resources. In case of mathematics, logically valid and simplest solutions that make use of the standard notation is highly valued. Quite obviously, this has a better chance of getting done sensibly in student-centred settings with small class sizes, with a reasonably experienced teacher.

## Concluding Remarks

Diverse problematic issues that affect learning mathematics and computing have been identified in this paper. These are shown to be present in both traditional and more recent systems, but tend to get noticed by teachers in the student-centred classrooms. As a result the problems are likely to get interpreted as due to a fundamental incompatibility between student-centred systems and these two subjects.

These issues originate from diverse sources. Most students are prone to memorisation of whatever done in schools, supposedly in preparation for tests. Curriculum writers and test setters are waylaid by the metaphor of mind as a container. These sources are also common at that practice all pedagogical systems.

Teachers have to necessarily work within the constraints put in place by those responsible for their system. In this regard, the teachers in student-centred systems can be said to be in a better position than those in the traditional systems. Learning activity designers have a chance of addressing the need for students to build a relationship with the target concepts laid out in the curriculum, by crafting activities that would make the students want to work using those concepts. The educators in the classrooms can use their personal experience with applications of the subject to scaffold the learning. Most importantly, they can attend to students on a personal basis as well as whole class basis.

## References

Bereiter, C. (2002). *Education and mind in the knowledge age.* London: Lawrence Erlbaum Associates, Publishers.

Bloom, B. S. (Ed.) (1956). *Taxonomy of educational objectives: Handbook 1. Cognitive domain.* New York: McKay.

Bobbitt, F. (1918). *The Curriculum: A summary of the development concerning the theory of the curriculum,* Boston, MA: Houghton Mifflin.

Davis, B. (2004). *Inventions of Teaching: A genealogy.* London: Lawrence Erlbaum Associates, Publishers.

Entwistle, N. (1998). *Styles of Learning and Teaching* (p. 226). London: David Fulton Publishers.

Hirschfeld L. A. and Gelman, S. A. (1994). Toward a topography of mind, and introduction to domain specificity. In Hirschfeld L.A. and Gelman, S. A. (Eds.), *Mapping the mind: Domain specificity in cognition and culture.* Cambridge: Cambridge University Press.

Kaiser, M. K., Profitt, D. R., and McCloskey, M. (1985). The development of beliefs about falling objects. *Perception & Psychophysics, 38,* 533-539.

Khella, A. (2002) *Mental Models in HCI, Theories in Human Computer Interaction.* Retrieved from http://www.cs.umd.edu/class/fall2002/cmsc838s/tichi/knowledge.html.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Mura, R. (1993). Images of mathematics held by university teachers of mathematical sciences. *Educational Studies in Mathematics,* 25(4).

Postman, N. (1993). *Technopolis: The surrender of culture to technology.* New York: Vintage Books.

Tobies, R and Helmut, N. (2012). *Iris Runge: A life at the crossroads of mathematics, science and industry.* Springer.

Wandersee, J., Mintzes, J., and Novak, J. (1994). Research on alternative conceptions in science. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 177-210). New York: Macmillan.

# TUTOR BEHAVIOURS AND THEIR INFLUENCE ON THE LEARNING PROCESS WITHIN A PBL CLASSROOM

E. Chng[*,a], E.H.J. Yew[a] and H.G. Schmidt[b]

[a] Republic Polytechnic, Singapore

[b] Erasmus University, The Netherlands

*esther_chng@rp.edu.sg

## Abstract

**Tutors in a Problem-Based Learning (PBL) classroom facilitate the learning process and promote collaborative learning by encouraging students to actively participate in classroom activities. This suggests that effective PBL tutors should not only be experts in their subject-matter but have the ability to facilitate the learning process. Hence, the purpose of this study was to examine how the behaviours of PBL tutors, namely, use of expertise, social congruence and cognitive congruence, influence the students' learning process and outcome. A concept recall test was used to estimate the extent of students' learning at each PBL phase while student achievement was based on students' ability to describe and elaborate upon the relationship between relevant concepts. Analysis of Covariance (ANCOVA) was used to analyse the data and the results suggested that all three tutor-related behaviours are determinants of learning in a PBL curriculum, with social congruence having a greater influence on each of the learning phases. Following from this study, a further investigation indicated that the academic abilities of students may affect the extent to which a PBL tutor influences learning. Results indicated that the tutor behaviours had a greater influence on average students as compared to the academically stronger and weaker students. These studies have shown that PBL tutors play important roles in the classroom and that their behaviours may influence the learning process and achievement of curricular outcomes. Findings from these studies provide useful input for the development of training courses that aim to develop effective PBL tutors.**

**Keywords:** *problem-based learning, tutor, social congruence, use of expertise, cognitive congruence*

## Introduction

In a Problem-Based Learning (PBL) classroom, students work in small collaborative groups and learn through the experience of solving problems. The PBL process typically consists of three phases, namely, a problem analysis, a self-directed learning, and a reporting phase (Barrows, 1988; Hmelo-Silver, 2004). During problem analysis, students work in groups to examine the problem, make inferences based on their prior knowledge and identify questions that aid in the problem-solving process. A period of self-directed study follows whereby students utilize a range of resources to search for relevant information and it forms the basis of brainstorming for possible solutions. In the reporting phase, students share their findings, refining their original ideas and hypotheses in the process.

Although learning through PBL is student-centric, a PBL tutor is present to facilitate and guide students' learning in the problem analysis and reporting phase. They play active roles in the scaffolding of student learning by assisting them in developing a framework that can be used to construct knowledge on their own which allows students to foster the skills of critical thinking and habits of life-long learning (Das, Mpofu, Hasan & Stewart, 2002). Rather than a question and answer session, the tutor would need to follow the discussions amongst students and to decide when to contribute (Wetzel, 1996). Therefore, in order to be effective, it is believed that the PBL tutor should possess the necessary subject-matter expertise and be skilled in facilitating discussions within the classroom (Maudsley, 1999). Schmidt, Van Der Arend, Kokx and Boon (1994), for instance, compared between faculty and student tutors and the results indicated that faculty tutors used their subject-matter knowledge more extensively while student tutors were better able to identify with the difficulties students experience. This difference could be attributed to what was termed as 'cognitively congruent behaviour' that is exhibited more significantly by student tutors (Dolmans, Gijselaers, Moust, De Grave, Wolfhagen, Van Der Vleuten, 2002).

Cognitive congruence can be defined as 'the ability to express oneself in the language of the students, using the concepts they use and explaining things in ways easily grasped by students' (Schmidt & Moust, 1995, p.709). It can be viewed as a combination of subject-matter expertise and social congruence as proposed by Schmidt & Moust (1995) whereby social congruence refers to the interpersonal qualities of the tutor such as the ability to communicate informally and empathically with students. Tutors with high social congruence are believed to be able to create a learning environment that encourages open exchange of ideas that in turn allows students to construct new knowledge (Schmidt & Moust, 1995).

As tutors appear to play critical roles in the PBL process, it can be assumed that their behaviours would affect student performance. Hence, this study aims to not only explore how the behaviours of tutors in a PBL environment can affect achievement but to also examine how they affect the learning process. In addition, this paper would also share some insights on how the effect of tutor-related behaviours on student achievement may be dependent on the students' academic abilities.

## Study 1

### Materials and Methods

A total of 223 participants under the tutelage of 7 tutors took part in this study. To assess the amount of learning taking place in each of the PBL phases, a concept recall test was used and the same test was administered at the end of each learning phase (Yew, Chng & Schmidt, 2011). The concept recall test was designed based on the assumption that students would begin to master more specific terminologies to articulate the newly acquired knowledge as learning progresses. Hence, measuring the number of relevant keywords that can be recalled at any point in time can be considered an indication of the quality and progress of students' learning. Besides the concept recall test, an essay test was used to measure students' achievement at the end of the PBL process. The essay test was used to estimate the depth of students' scientific knowledge by examining their ability to describe and elaborate upon the relationship between relevant concepts (Alao & Guthrie, 1999).

Tutor behaviours were assessed by asking students to complete a questionnaire consisting of 10 statements that were adapted from a questionnaire used by Schmidt & Moust (1995). The questions were crafted with the intention of gauging the tutor's level of social congruence, use of expertise and cognitive congruence. The total score for each of the behaviours were computed for each tutor.

Analysis of Covariance (ANCOVA) was used to analyze the effect of the tutor-related behaviours on students' learning and achievement as measured by the concept recall tests and essay test. The covariate used in the analysis was the students' pre-existing grade point averages (GPA), which serves as an indication of the students' level of prior knowledge.

### Results and Discussion

The results from the ANCOVA revealed that the social congruence of tutors had the most influence on the learning process relative to cognitive congruence and subject expertise. Social congruence was found to have a significant effect on the total number of concepts recalled at the end of the problem analysis phase, $F(2, 219) = 10.38$, $p < 0.01$; self-directed learning phase, $F(2, 219) = 9.83$, $p < 0.01$; and reporting phase, $F(2, 219) = 6.51$, $p < 0.01$. No significant effects were found of subject expertise and cognitive congruence of the tutor on each of the learning phases in the PBL process. This implies that the willingness of a tutor to establish an informal relationship with the students and display an attitude of genuine interest has the greatest impact on the progress made by students during the PBL process (Chng, Yew & Schmidt, 2011).

During the process of constructing new knowledge and solving the problem, students would challenge and analyze possible solutions that are raised by peers while the tutor observes student interactions and encourage various kinds of cognitive activities (Dolmans *et al.*, 2002). In addition, tutors should allow students to propose their own hypotheses regardless of whether they are inaccurate or superficial. In order to create a learning environment where there is a free flow exchange of ideas, it is vital for students to feel comfortable in expressing their opinions openly. Therefore, the social congruence of the tutor can be anticipated to influence the learning process as a more socially congruent tutor would possess the interpersonal qualities to relate informally with students (Schmidt & Moust, 1995).

Besides having a significant impact on the PBL process, social congruence had a significant effect on student achievement as measured by the essay test, $F(2, 219) = 4.914$, $p < 0.01$. This effect was observed as learning in a PBL environment is believed to be cumulative whereby knowledge is built upon that which was gained in the previous learning phase (Yew *et al.*, 2011). Therefore, the amount of knowledge acquired during the learning process would in turn have an effect on students' achievement. Similar effects on student achievement were also found for the use of expertise, $F(2, 219) = 7.74$, $p < 0.01$, and cognitive congruence, $F(2, 219) = 7.74$, $p < 0.01$.

A possible reason that a statistically significant effect on the PBL process was not observed for cognitive congruence and the use of expertise could be due to the sensitivity of the measurement tools. Another possible explanation could be due to the use of natural variations as the study was conducted in a real school setting.

## Study 2

### Materials and Methods

Following from the findings in study 1, another study was conducted to further investigate if this effect of tutor-related behaviours on student learning was influenced by other factors such as the students' academic abilities.

A total of 637 students under the tutelage of 11 tutors were involved in this study. The tutors were split into two groups whereby one group consist of six tutors who exhibited low levels of social congruence, cognitive congruence and use of expertise while the other group exhibited high levels of these behaviours.

Student achievement was measured by the module grade, which consists of the overall scores obtained from continuous assessments and examinations conducted as part of the assessment requirements for the module. The GPA score for each student was used as an indication of the students' academic abilities whereby it was assumed that students with a higher GPA were academically stronger. Based on the GPA, which had a maximum score of 4.0, the students were grouped into three categories. The first group consisted of students who were academically stronger and they had a GPA score that was greater than 3.0. The next group was made up of students who had a GPA score of greater than 1.0 but less than or equal to 3.0 and they represented the average students. The final group of students were academically weaker as they had a GPA score of less than or equal to 1.0.

Similar to Study 1, ANCOVA was used to determine the effect of the tutor-related behaviours on student achievement and after grouping the students into the three groups as described above.

**Results and Discussion**

The results from the ANCOVA revealed that there was a significant effect of all three tutor-related behaviours on student achievement. However, the effect differed for different groups of students. No significant effect of the use of expertise, social congruence, and cognitive congruence, on student achievement was found for students in the academically stronger and academically weaker groups. However, there was a significant effect of the use of subject-matter expertise, $F(1, 452) = 7.225$, $p < 0.01$; social congruence, $F(1, 452) = 8.730$, $p < 0.01$; and cognitive congruence, $F(1, 452) = 4.320$, $p < 0.05$ on the average students. These results support previous findings that all three tutor-related behaviours do influence student achievement (Schmidt & Moust, 1995; Chng *et al.*, 2011) and that the extent to which the tutor-related behaviours affect student achievement is influenced by the students' academic abilities.

To account for the differences seen with different groups of students, it is important to recognize that there are other factors besides the PBL tutor that may have helped students scaffold their learning. One such factor could be the peer group discussions that students are expected to engage in, which may increase students' interest in the subject and indirectly lead to an increase in motivation to learn (Dolmans and Schmidt, 2006). Therefore, for academically stronger students, they are probably more likely to engage in small group discussions and more willing to participate in peer teaching as they tend to be highly motivated and have the cognitive skills to tackle the tasks (Hmelo-Silver, 2004). By doing so, these students appear to be less dependent on the tutor as they would work collaboratively with their peers to achieve the learning objectives. Hence, this may account for the insignificant effect of the tutor-related behaviours for the academically stronger students.

The finding that average students are most influenced by tutor behaviours is an important one. These students make up the majority of the student population and it is significant that students' perceptions of the tutor's behaviour are demonstrated to impact students' learning outcomes. As compared to academically stronger students who tend to be highly motivated, average students may be less motivated and may not possess the cognitive skills to tackle complex problems, which may influence student learning (Hmelo-Silver, 2004). A study by De Grave, Dolmans and van der Vleuten (2002) explored students' perceptions of factors that may influence the tutorial group function and they found that a lack of motivation was an important inhibitor of the learning process. De Grave *et al.* (2002) also reported that students expected the tutor to do something about the lack of motivation in a tutorial group, which implies that students may be relying on the tutor to stimulate the learning process. Therefore, the students in the academically average group may be relying more on the tutor to guide their thought processes and to motivate them, which is indicated by the greater influence of the tutor-related behaviours on student achievement as observed for the average students.

Although the tutor behaviours were found to influence student achievement for the group of average students, the results did not find any significant effect for the academically weaker students. This suggests that other factors within the PBL environment may have affected their learning such as the difficulty of the problem or ability to interact with their peers during collaborative learning. In addition, the lack of effort and low level of motivation of the students may have affected the students' performance (Chng, Yew & Schmidt, 2014).

**Conclusion**

The results from the first study indicated that social congruence had a significant influence on the learning process while all three tutor-related behaviours had significant effects on student achievement (Chng *et al.*, 2011). These findings are supportive of the work previously done by Schmidt & Moust (1995) that advocate the positive influence of tutor-related behaviours on student achievement and it emphasizes the importance of possessing good facilitative skills in order to be an effective tutor. Furthermore, the findings provide new insights on the effects of tutor-related behaviours on the PBL learning process.

Besides this, the academic abilities of the students have also been found to influence the effect of the tutor behaviours on student learning. The results from the second study suggest that tutors do not necessarily exert the same influence on all students and seem to have a greater influence on average students, which suggests that they may rely more on the tutor (Chng *et al.*, 2014). For these students, the exact role played by the tutor and which behaviour has a greater influence on learning remains to be established. Nonetheless, this finding suggests that these students require tutors, who are able to provide more guidance, generate interest in the subject and deliver the subject matter in a way that is easily understood.

As PBL is more student-centred rather than teacher-centred, tutors avoid dispensing information, choosing to become a coach and focusing on guiding the learning process of the students instead, which suggests the need for tutors to possess good facilitative skills (Maudsley, 1999). Furthermore, in order to follow and contribute actively in the discussions, the tutor would need to have the necessary content knowledge. Therefore, together with the results from this study, it is reasonable to conclude that cognitive congruence, social congruence and subject-matter expertise of a PBL tutor are all determinants for learning, with social congruence having a greater influence on students' learning during the PBL process. In addition, these behaviours seem to be even more important when the tutor is facilitating the learning of academically average students.

**References**

Alao, S., & Guthrie, J. T. (1999). Predicting Conceptual Understanding with Cognitive and Motivational Variables. *The Journal of Educational Research*, 92 (4), 243-254.

Barrows, H. S. (1988). *The Tutorial Process*. Springfield, Illinois: Southern Illinois University School of Medicine.

Chng, E., Yew, E. H. J., & Schmidt, H. G. (2011) Effects of tutor-related behaviours on the process of problem-based learning. *Advances in Health Sciences Education*, 16 (4), pp. 491-503.

Chng, E., Yew, E. H. J., & Schmidt, H. G. (2014) To what extent do tutor-related behaviours influence student learning in PBL? *Advances in Health Sciences Education*, DOI 10.1007/s10459-014-9503-y.

Das, M., Mpofu, D. J. S., Hasan, M. Y., & Stewart, T. S. (2002). Student perceptions of tutor skills in problem-based learning tutorials. *Medical Education*, 36, pp. 272-278.

De Grave, W.S., Dolmans, D.H.J.M & van der Vleuten, C.P.M. (2002). Student perspectives on critical incidents in the tutorial group. *Advances in Health Sciences Education*, 7, pp. 201 – 209.

Dolmans, D.H.J.M., Gijselaers, W.H., Moust, J.H.C., De Grave, W.S., Wolfhagen, I.H.A.P., & Van Der Vleuten, C.P.M. (2002). Trends in research on the tutor in problem-based learning: conclusions and implications for education practice and research. *Medical Teacher*, 24 (2), 173-180.

Dolmans, D. H. J. M., & Schmidt, H. G. (2006). What do we know about cognitive and motivational effects of small group tutorials in problem-based learning? *Advances in Health Sciences Education*, 11(4), pp. 321–336.

Hmelo-Silver, C.E. (2004). Problem-Based Learning: What and how do students learn? *Educational Psychology Review*, 16 (3), 235-266.

Maudsley, G. (1999). Roles and responsibilities of the problem based learning tutor in the undergraduate medical curriculum. *British Medical Journal*, 318, 657-660.

Schmidt, H.G., Van Der Arend, A., Kokx, I. & Boon, L. (1994). Peer versus staff tutoring in problem-based learning. *Instructional Science*, 22, 279-284.

Schmidt, H.G., & Moust, J.H.C. (1995). What makes a tutor effective? A structural equations modeling approach to learning in problem-based curricula. *Academic Medicine*, 70, 708-714.

Wetzel, M.S. (1996). Developing the role of the tutor/facilitator. *Postgraduate Medical Journal*, 72, 474-477.

Yew, E. H. J., Chng, E., & Schmidt, H.G. (2011). Is learning in problem-based learning cumulative? *Advances in Health Sciences Education*, 16, pp. 449-464.

# "IT CONNECTS YOU & ME" - DEVELOPING STUDENTS THROUGH TECHNICAL COMMUNITY PROJECTS

Jason Lim*, Seeneth d/o Kamila Hanifa*, Li Yan* and Sharmila Kanna*

*School of Infocomm, Republic Polytechnic, Singapore

*jason_lim@rp.edu.sg, seeneth_hanifa@rp.edu.sg, li_yan@rp.edu.sg, sharmila_kanna@rp.edu.sg

**Abstract**

**This paper aims to share the efforts the authors had made in building a common platform for our students in Republic Polytechnic (RP), School of Infocomm (SOI), to apply their information technology (IT) knowledge gained from the classroom to serving the needs of communities.**

**Through these specially designed projects, the students had the opportunity to serve communities which required them to creatively apply their knowledge in practical ways. The planning process will be shared in this paper together with the experience during the planning and execution of the projects.**

**Keywords:** *Service Learning, Problem-Based Learning (PBL), Experiential Learning, Information Technology, Tertiary Institutions*

## Introduction

Republic Polytechnic's (RP) unique Problem-Based Learning (PBL) Approach - One Day One Problem (Li Yan, 2012 and O'Grady 2002) equips students with the necessary knowledge through daily problem solving. Through this classroom based learning, the students were exposed to various problems and solving them by utilising various e problem solving strategies, which was the focal point of their studies.

The Singapore Ministry of Education (MOE) has identified the following four attributes as the Desired Outcomes of Education (DOE), under the Singapore Education System

a. To be confident, critical and independent in thinking
b. To be self-directed, inquiring and reflective in learning
c. To be proactive and effective team player with initiatives
d. To be civic conscious and concerned about serving the community

RP, through its One Day One Problem has strived to prepare our students to achieve the DOE (Li Yan, 2012). However, to ensure our students are also developed holistically, this paper will share some co-curriculum activities that the school has implemented.

## Motivation

It is a common belief that academia involves more than theories and facts, especially on information beyond the four walls of a classroom. Many will agree that active learning would provide more tangible benefits to the students compared to passive learning. Through active learning, the students learning experience will be more comprehensive and relevant as the information gained is likely to be more internalized and linked to the knowledge gained in the classrooms.

In active learning, the students are directly in touch with the realities being studied. It involves a direct encounter with the phenomenon being studied rather than merely thinking about the encounter or only considering the possibility of doing something with it (Keeton, 1978).

With the intention of exposing the students to information tangibly attached to life outside of a classroom, carefully planned co-curriculum activities were developed and implemented to complement the PBL that takes place every day for a RP student. The objective of these activities is to have a series of continual engagements outside of classroom to enable the students to apply what they have learnt in class and to discover things beyond the usual learning zones.

## A common platform for applying IT knowledge

Kolb (1984) has discussed quite extensively on experiential learning and provided a conceptual framework based on a four phase learning cycle: (i) concrete experience; (ii) reflective observation; (iii) abstract conceptualization; and (iv) active experimentation.

We believe that learning is a lifelong process. Effective learning experience is usually drawn from continual exposure and repetitive reflection which will result in new discoveries. Through repetitive involvement of such activities, we believe that the students would be able to gain more insights and better understanding on what they have learnt in a classroom.

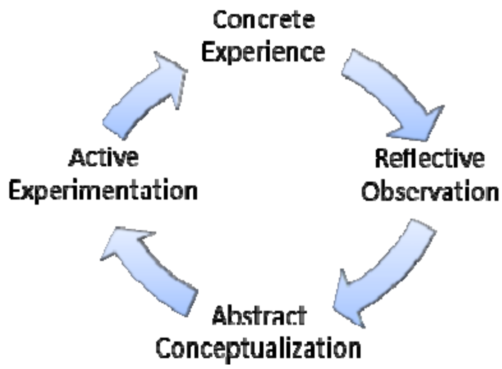



Figure 1: Kolb's Model of Experiential Learning

Students learn a broad spectrum of IT knowledge in SOI. Some of the learning that takes place involves our students getting their hands "dirty" by taking on several, hands-on practical exercises or assessments, while some deal with abstract concepts best learned with user interactions. Therefore, we have designed a series of co-curriculum activities that will take the students through various settings to ensure a holistic exposure. At the same time, we want our students to develop a greater sense of involvement in the community in tandem with character and citizenship education.

*Service Learning*

Participation in service learning has been demonstrated to improve academic performance, writing skills, critical thinking skills and values (Astin, et.al , 2000; Hou, 2009).

Service Learning generally places students at the frontline of fulfilling the needs in a community. This involves students solving carefully scoped real life problems in an environment where it is not their comfort zone. Through this setting, students would learn to apply what they have learnt in the classrooms while immersing into the local community.

Service Learning generally gets students out of their comfort zone to adapt to a new environment, to be resilient yet humble, to learn with the community. Through this exposure, students often get to be exposed to other important aspects such as developing social skills, community awareness, understanding ethical and economic issues, especially pertaining to the community they serve.

**Project design process**

The project design process consists of the following stages:

a. Pre-planning
b. Preparation
c. Re-planning
d. Implementation
e. Reflection
f. Closing

Stage (c) to (e) may be repeated a few times before it reaches stage (f). This is normally observed for projects that would take time to be completed, over an extended period.

*Pre-planning*

The theme for the overall design of the project is determined during the pre-planning stage. We will initially identify and connect to the community through a partner who is currently serving that community. From the partner, we gather all the necessary information that we would need in our planning and conceptualization for the actual activities, targeted specifically at meeting the infrastructural and community needs.

A project timeline, with milestones and a tentative date for completion, will be drawn up. This will aid all parties involved, to work towards a common dateline to ensure a successful completion of the project.

After gathering the necessary information, the staff in charge of the project would identify suitable groups of students, by understanding the requirements against the academic curriculum of the students.

A recruitment drive will take place to recruit interested students for the project. Students will be further shortlisted through a selection exercise which requires the students to undergo a series of activities. This selection process will help to ascertain the students commitment level and also, to identify students to assume the role of student leaders.

As part of the grooming process, the selected student leaders would be empowered to be "project managers" of these projects. These student leaders would be responsible to lead the planning and execution of the project. The staff would then be an advisor or a facilitator, supervising the team and providing necessary guidance, when approached or deemed necessary, with the subsequent planning and follow up for the project.

*Preparation*

With the student leaders (the core team) driving the project, the staff plays a facilitator role in this preparation stage.

The staff will facilitate a discussion with the core team on the following,

- Project duration and important timelines
- Actual day plan and backup plan
- Logistics requirement
- Manpower allocation
- Boundaries and limitations of the project

As many students would not have prior experience on such community project before, it is essential for them to go through a preparation workshop. This preparation workshop will help them to understand the community needs and understand how best to serve the community in the most comfortable and efficient manner.

For certain projects that require students to serve in an unfamiliar environment or community, these students would need to undertake additional workshops to prepare them emotionally, mentally and physically to carry out the project.

These preparation activities help the students to determine appropriate levels of expectations for the project. At the same time, the team will foster a closer working relationship and bond, when enduring hardship in the preparation stage. A bonded team will also be more likely to work in a more effective and efficient manner.

*Re-planning*

Before the actual day of implementation of the planned activities, it is important for the core team to meet with the community partner to clarify certain outstanding issues. It will normally be scheduled at the partner’s site which is close to or in the community that the team will be working with.

During this meeting, the team could possibly experience the actual environment that the project will be executed at. In addition to this, the team would be able to observe and ascertain necessary or unforeseen boundaries and limitations during the visit. The team will also be able to confirm on any additional or necessary logistics and resource (manpower).

After the visit, the core team may need to re-visit the initial planning details, as they may have gathered new or updated information during the visit. This is good practise and is usually required as part of the reconciliation process between the pre-trip assumptions and situation on the ground. The team may need to fine tune the plan and ensure that it’s more feasible to be carried out.

In addition to the visit, a series of simulations would be helpful in identifying potential loopholes during the planning and preparation stage. The reconciliation process and simulations would help the team to self-reflect and improvise their plan.

*Implementation*

The core team will drive the implementation of the project. The staff advisor or facilitator will closely monitor this implementation process. There will be occasions where the advisor or facilitator would need to intervene to help the team out when unforeseen technical glitches arise, which the students may not be familiar with.

During the monitoring of the implementation, the advisor would be able to chance upon a few teachable moments for the students. The project aims to serve the community, as well as provide learning opportunities for the students. It’s important to seize a teachable moment for the students to learn and reflect upon the experience.

Along the way, the advisor would also intervene, should he / she observe that the team is not on track to delivering the project. The team may need reminders to ensure that the project is executed or delivered in a timely manner.

Most importantly, for projects that may take place in a harsher environment, such as an overseas rural area, the advisor will need to be fully aware of possible hazards or dangers nearby and be mindful to always put the students’ safety as priority than the delivery or completion of the project.

*Reflection*

The students’ learning does not just end when the project is implemented. In fact, we find that the students learn the most during whilst they are reflecting upon their experience at the end of the project.

It’s more effective to host the sharing session right after the project has been implemented or executed. Though the team could be physically tired, this would be the best opportunity to have the sharing session as the students are able to recollect their experience faster and it’s fresh. The atmosphere of the sharing should not be fearful fault-finding, but rather encouraging and nurturing.

Open sharing will help the team to see the project from various perspectives, as individually they could be assuming specific roles during the implementation of the project. The advisor will facilitate the sharing session and highlight certain issues observed during the planning and implementation process. With the issues identified, the team could then work on them and brainstorm on possible solutions or enhancements.

At the end of the sharing session, the staff will summarize the learning points and re-affirm the team of their teamwork.

The Re-planning –> Implementation –> Reflection cycle may repeat itself a few times if the project stretches more than one session, which is normally a full day. Each time it repeats, we can observe the project being executed in a smooth manner.

*Closing*

It's important to document the project throughout the various phases and share with their peers, who may be keen in embarking on a similar project later on. Students are usually encouraged to write a daily journal to record down their experience and learning, as each day may bring about a different experience. .

The team of students and staff could provide a post-sharing session with the entire department or school. This would be a good platform for the team to collaborate again and share their learning experiences – both emotionally and academically. This post-sharing session would serve to celebrate their success in working together as team and a positive closure to a successfully completed project. To add on, social events, such as having a meal together will be a good way to put everyone in a celebration mood. Hopefully with this, the students would look forward to a new phase of learning..

**Service Learning Experiences at RP-SOI - Thailand**

Ecotrail 7 was in its seventh iteration, and also the longest running series of Service Learning projects in RP (2013). The project, which lasted for 2 weeks, was based in Chiang Rai, Thailand. The objective of this service learning project was to improve the livelihood of the local community in helping to promote the tourism industry.

Students were recruited and briefed on the project goal. The project involved, creating a website, developing video footages / clips, and promotional materials as well as putting up signboards in the local community. As such, our students were able to apply the IT skillsets they have learnt in class to help the local community.

To prepare our students for the environment in Chiang Rai, as it was very different from Singapore, the students went through an overnight camp in Pulau Ubin. This camp prepared and managed the expectations of the students of the environment that they could potentially be exposed to, during their stay in Chiang Rai. During this camp, potential student leaders were identified and empowered to lead the project.

Upon reaching Chiang Rai, the students experienced an environment which was very foreign to them. The amenities were basic and students who were very used to a modern lifestyle, started to find themselves in need to adapt. These students had to leave their comfort zone and were placed in a "stretched zone" in their learning experience. Culture shocks were inevitable and acted as important learning moments for the team to reflect on and appreciate what they have in Singapore.

The project required the students to explore and map the area while photographing and video recording the point of interests in the community. In addition to this, students were documenting the uniqueness in the area to bring about the unique selling points of the area. Again, our students were able to apply the skills which they have acquired in class during these activities.

For the period of execution, students were travelling to various villages, to explore and interact with the community. The interaction included mingling with the local community to understand how they could help to refine the efforts to improve the livelihood of the community. Changes were made to the team's originally planned activities. This was inevitable and common as this was part of the learning process to react to new discoveries or information gathered

The students applied their technical when they were designing a website, depicting the information gathered during the exploration. Graphics designing, mapping the area with Global Positioning System (GPS) information, photo shooting, video recording and editing were among the tasks to be performed throughout the trip.

While the students were engaged in providing service to the community, the students were learning from what they were experiencing in the entire period. The students learnt cultural elements of the local community but most importantly, about appreciation and gratitude for the basic things in life. The journey opened their eyes on life and to let them rediscover themselves from a newly gained perspective.

The deliverables were handed to the local partner and currently can be found online at http://www.cbtphuchifa.com.

Generally, students found the experience to be fruitful as they became more confident, responsible and forthcoming, demonstrating volunteerism. The project provided an avenue for the students to practice their skills and most importantly, an opportunity to "grow up" - to look beyond who they were previously.

**Service Learning Experiences at RP-SOI – Sri Lanka**

SL@Colombo was a 2-week service learning project to Sri Lanka in 2012. The project focused on refurbishing and troubleshooting issues in their personal computers and to teach programming.

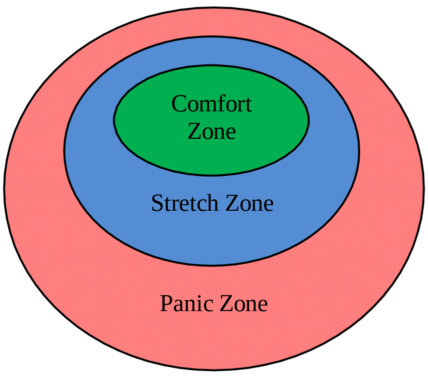
The project, which was partnered with the Royal College, involved providing assistance to repair and refurbish the computer labs. The students were involved in the entire planning, diagnosing, sourcing and repairing the computers. The students interacted with various parties to achieve the goal as well applying their knowledge to the various situations they were involved in.

The other focus was to teach programming in the Python language and AppInventor to two groups of local students. The students were involved from the planning of the lessons to the delivery of the content. In the process, the students were able share and reinforce their knowledge at the same time

The experiences gained by these students were unique as they were exposed to the colonial era as Royal College was rather colonial with a tinge of modernization. The students were culturally enriched by appreciating the country's history. Appreciation of history and culture took root as such an experience helped students to appreciate the rich historical assets in Singapore.

**Reflection on the Service Learning Trips**

For the students, it was an exhilarating experience to immerse into new cultures. Aside from getting the opportunity to hone what they have learnt in school, the students developed themselves to become more versatile. It would be viewed as part of a character building process where the students were placed in their "stretch zone", where they learnt the most.




Zones of learning

At the same time, having the ownership of the project, students are facing the challenges by choice and would learn the most from the experience (Rohnke, 1989). However, staff would need to ensure that the experience and challenges are within acceptable limits, which are within the stretch zone to maximize the learning but not crossing over to panic zone where the learning gets inefficient (Panicucci, 2007).

Regular reflections by the individual students are crucial to take stock on personalized learning. Reflections often coupled with emotions and experience (Moon, 1999) and thus, the teachable moments during projects are crucial too for better impact on learning. These experiences would then be shared to every team member as means to inspire, to get reaffirmation and to reinforce the lasting effects of the learning moments.

From experiences on the projects, the students developed themselves in areas that were not obvious before the trip. The SL@Colombo project taken place in 2012 while Chiang Rai project was implemented in 2013. Some students participated in both projects and assumed the role of leaders in the second project. The prior project has helped to develop the leadership qualities in the students and they were willing to step up to take on new challenges.

**Students Reflection**

"This is a fruitful and meaningful trip. During this trip, I learnt many things such as how to handle situations unexpectedly and also most importantly being an instructor was never easy. " ~ Joanne

"I think for most of us it served as a self-reflection and made us think whether we have such respect and obedience." ~ Josiah

"This trip has made me learn about the importance of decision making, respecting people's culture and also voicing out opinions." ~ Amanina

"I actually realized that every time after my reflections, I actually had more to say but just that I'm a person who does not really like to share my thoughts and just keep to myself. I would have to say that now I actually open up more compared to last time." ~ Faiz

"More or less in this trip, I have become more independent, learning to count my own finances without my parents around to help me out, learning how to live & tolerate with one another & what matters most is that I had impacted the S.L students' life with the art of python programming, something valuable that they had gained which it would be indeed useful to them in the future!" ~ Daniel

**Conclusions**

The service learning projects challenged the students to step out of their comfort zones. The choice of project holds particular importance in the outcome. For projects that focused more on the technical aspects, the challenges on identifying a project would be on the availability of infrastructure and the readiness of the partner to work with.

The planning process was rigorous. More often than not, the planning process was the key to the students learning in executing a project. With ownership on the project, students would be getting a first-hand experience and play an active role in learning.

Exposure to foreign environment is the first challenge to the students. Insecurity will usually surface out soon, but would be fuelling the team to work closely with one another if the emotional needs were handled well. Accompanying staff as an advisor or facilitator, plays a crucial role to ensure that the wellbeing of the students is within the acceptable threshold of the team.

The experiences on the projects were positive where students gained the opportunity to enhance communication, technical and life skills. In all cases, students gained some insights that will go a long way in their own character development.

**References**

Astin, A.W., Vogelgesang, L.J., Ikeda, E.K. & Yee, J.A. (2000). How Service Learning Affects Students. Los Angeles: University of California Los Angeles, Higher Education Research Institute

Glen O'Grady & W.A.M Alwis (2002). One Day, One Problem: PBL at the Republic Polytechnic. *4th Asia Pacific Conference in PBL. Hatyai, Thailand*

Hou, S.-I. (2009). Service Learning + New Master of Public Health = Changes for the Professor. International Journal of Teaching and Learning in Higher Education, 20(2), 292-297.

Keeton, M. and Tate, P. (1978). Learning by Experience – What, Why, How. San Francisco: Jossey-Bass

Kolb, David. (1984). Experiential learning: experience as the source of learning and development. Englewood Cliffs, New Jersey: Prentice-Hall

Li Yan & Ivan Wee (2012) PBL in Information and Communication Technology Modules – A Reflection From "Linux Server Administration and Virtualisation" Module, Proceedings ISATE 2012, pp. 232-236

Moon, J. (1999) Reflection in Learning and Professional Development. London: Kogan Page

Panicucci, J. (2007). Cornerstones of adventure education. In D. Prouty, J. Panicucci & R. Collinson (Eds.), Adventure education: Theory and applications (pp. 33-48). Champaign, IL: Human Kinetics.

Rohnke, K. (1989) Cowstails and cobras II: a guide to games, initiatives, ropes courses & adventure curriculum. Dubuque, Iowa: Kendall/Hunt Publishing Company.

*ISATE 2014*
*International Symposium on Advances in Technology Education*
*24 – 26 September 2014,Nanyang Polytechnic, SINGAPORE*

# Use of Simulation and Virtual Reality for Learning

A. Schlag and C.P. Tan

Centre for Educational Development, Republic Polytechnic, Singapore

alexander_schlag@rp.edu.sg

**Abstract**

**The use of simulation and virtual reality for learning can only be as effective as the pedagogical intentions and skills driving them. This study will examine the statement by describing how learning is facilitated using different types of simulation in an engineering module -- Aircraft Systems – in a problem-based learning environment. The authors will elaborate on the potential of such lesson designs to promote self- directedness in students.**

**Keywords:** *simulations, virtual reality, facilitation, self-directed learning, engineering*

## Introduction

Virtual Reality and Simulation have become tools frequently used in engineering education. The Republic Polytechnic has commissioned a number of laboratories with simulators or virtual reality tools (e.g. Airbus A320 Flight Simulator, Virtual Aerodrome Laboratory etc.) in order to enrich the students' learning experience and to provide for industry relevant content without having to have the full industry type installations. In addition, online simulation is available for many contents of the various engineering syllabi. Currently, in the said module, the most prominently used online tool is the NASA wind tunnel simulator.

Over the last 24 months, the first author made various attempts to enrich the problem packages of the modules Aerodynamics and Propulsion, Aircraft Systems, as well as Aviation Safety and Security through the use of Virtual Reality and Simulation. The initial objective was to increase the motivation of the students and to cater for their individual learning preferences. Not surprisingly, from observations by the facilitator and feedback given by the students, active use of simulation was found to be motivating for students to engage in the problem solving process. Students with visual and kinesthetic learning preferences reported that their learning process was easier with the use of simulation and that their understanding of the module content was improved.

Purpose

The purpose of this study is to examine how the use of the simulation and virtual reality tools, used during the lessons in the module Aircraft Systems, can contribute to the students' learning. Two theoretical frameworks will be used to anchor the discussion.

The first is Moust's theory of facilitation for learning. The theory consists of three constructs: Social congruence, cognitive congruence and use of subject matter expertise (Schmidt & Moust, 1995).

Social congruence is the interpersonal dimension which focuses on the teacher-student rapport. This is believed to be fundamental for creating and nurturing openness in students to engage in the learning and motivating them to put in effort to persist in the learning. The aim is for students to be actively engaged in the learning process, and not passively absorb the information from the lecturer. Cognitive congruence is the focus on effective communication for teaching. It can be defined as "the ability to express oneself in the language of the students, using the concepts they use, and explaining things in ways easily grasped by students' (Schmidt and Moust 1995, p. 709). The use of subject matter expertise refers to the teacher's ability to use his knowledge to help students learn. All three constructs address the process of teaching through facilitation, which is a learner-centered method of instruction, contributing to students' efforts and achievement.

The second theoretical framework is Stockdale and Brockett's personal responsibility orientation to self-direction in learning scale (PRO-SDLS). The four dimensions in the scale are initiative, control, self-efficacy and motivation. The first factor, initiative refers to the proactive nature of self-directedness (Stockdale & Brockett, 2011). The control factor is based on Brockett and Hiemstra's notion that "it is the ability and/or willingness of individuals to take control of their own learning that determines their potential for self-direction" (p. 26). Self-efficacy is "concerned with judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982, p. 122). Finally, motivation for self-directedness in learning is related to how well students identify with the learning and if they enjoyed the learning activity for itself and not for extrinsic rewards, such as good grades (Stockdale & Brockett, 2011).

The two theoretical frameworks were chosen because they are validated constructs. Moust's theory is a validated construct for learner centered teaching. Stockdale and Brockett's personal responsibility orientation to self-direction in learning scale (PRO-SDLS) is a validated construct, for self-directed learning. The authors have found them useful for understanding how learning can be facilitated using simulation and virtual reality tools.

Educational context

The Republic Polytechnic leverages PBL for students' learning. The module from which data was collected used PBL in all the lessons. The PBL structure implemented is a one-day, one-problem approach where students actively engage in gaining knowledge and skills through collaboratively solving a problem within the course of a day (Yew & O'Grady, 2012). Each class consists of twenty-five students, typically divided into five teams. The lessons for each module take place once a week over a fifteen-week semester. Both formative and summative assessments for the learning process and acquisition of knowledge are put in place at the polytechnic to provide adequate feedback for student learning.

Participants

Participants involved in the study were 50 second and third year students enrolled in the diploma program for Civil Aviation in the School of Engineering at the Republic Polytechnic. The module is Aircraft Systems.

Procedure

Please refer to Annex A for the list of online tools, laboratory simulators and smartphone apps used.

With the increased use of simulation tools, some problem statements in the lesson packages were adapted to maximize learning. Two examples will be illustrated here. Problem statements are introduced following a scenario or context, usually situated in some background story or real life problem. The first example is the lesson that presents gas turbine (i.e. jet) engines. The problem statement was changed from: "Your task today is to investigate how the different engines used by the aircraft (shown above) generate thrust. In line with this, you are also required to compare their major performance characteristics", to "Find out how a jet engine is started. Is it as easy as turning a key?"

A second example was the lesson about aircraft electrical systems. The original problem statement was: "Your task today is to find out how the various components described above (APU, GCU etc.) are related to one another and the implications of a failure in any of the components in the electrical system on the aircraft." The new problem statement first gave a description of an incident of an Easyjet flight across Europe, followed by the question: "Why does the Airbus electrical system have so many components? Is it considered normal that the failure of a single component, such as the Generator Control Unit (GCU), causes a serious degradation of the aircraft's performance as seen on that 15 September 2006 incident?" The fresh element here was that students had the opportunity to experience the situation of the Easyjet flight in the flight simulator and work on a viable solution.

**Discussion**

Facilitation for learning

Teaching at the Republic Polytechnic is mainly performed through facilitation of student learning: "Lecturers guide them [the students] through a range of resources, examples and questions. The lecturer is instrumental in facilitating the learning process and the students' metacognition." This philosophy is much in line with recent industry developments to incorporate experiential learning for improving competence of pilots to be able to judge appropriate decisions regarding flight controls (Learmount, Jan 2013).

Taking this premise into account, the trainer in a pilot's seat (with 25 students observing) would be a poor facilitator for two reasons. For one, as the pilot positions are forward looking, the person in a pilot seat occupies a disadvantaged position in terms of communication with the learners necessarily positioned behind him. For another, he would be deeply absorbed by the operation of the system. Together with the fact that he is the authority in class due to his skills and seniority, it is not possible for an atmosphere of self-directed learning to develop, i.e. no initiative, control, self-efficacy and motivation on the part of the students can be enacted.

Alternatively, in a class where the trainer takes a different position (i.e. not in the cockpit), he would be able to maintain an overview not only of the simulator and the students in the cockpit seats, but also of those students given additional roles as record takers, advisers, air traffic controllers and observers. Thus, he can engage more learners, observe and give more qualified and informed feedback.

The following are some excerpts from students when asked to reflect on their learning in the module:

*"…this module will equip you with knowledge that really benefits you about how the aircraft really works and will make you realize the importance of all components in the aircraft and how all the components work together to perform the flight." (Student A)*

*"Today, …it suddenly turned out to be quite stressful during the simulator session because we are required to think about and act on all the aircraft controls systems and translate the information on the flight displays and ECAM." (Student B)*

*"…I think the simulator part should be done at Problem 15! Where students can actually go and try to fly the plane given any problem and how to overcome it!…in this way, things will be better remembered and stayed in my mind... I could recall most of the things especially the flight instruments of the Altimeter and etc.!" (Student C)*

The Shivering Passenger

One of the concerns for active learning is that students may be overwhelmed by the task complexity (Van Merriênboer, Kirschner & Kester, 2003). Traditional teaching attempts to achieve a solid understanding of the subject matter in order to practice application as a next step. Students, therefore, are guided through theory lessons. Knowledge acquired here will be used in exercises and laboratory work. Following this approach it takes much studying beyond the one problem per day structure in order to fly the Airbus A320. The students may encounter misconceptions as a result of not having had hands-on experiences dealing what they had studied.

An alternative approach, where the students have not been expected to bring any specific knowledge to the simulator, has been tried out and found suitable for managing students' learning load. For example, during a lesson that introduces the cockpit layout and functionality, students are shown and explained various cockpit features and the most important controls and indications. They learn about the practical considerations for the design. The overhead panel is mentioned as the interface for systems control, while the ECAM display (i.e. a set of computer displays at the cockpit instrument panel) is shown as the place for system status indication.

After a general introduction, there is a small exercise for students to record the fuel on board. The ECAM fuel page needs to be dialed up by the students. The lecturer gives students specific instructions on how to do so.

After some time, the trainer takes the role of a cabin attendant, reporting that the aircraft is ready for ground movement. He also mentions that a passenger in the rear cabin has complained about the chilly temperatures in the aircraft. Typically, the facilitator can take a passive role now and leave the problem solving to the students where they call up the air conditions system page on the ECAM display, identify the (labeled) air condition control section on the overhead panel and adjust the temperature selector knobs. Students are generally able to recognize the problem and engage in its solving, constructing new knowledge from the experience just gained. The relatively younger students have lesser hesitation to engage in a playful collaborative working mode, while more mature participants or fellow teachers often show competitive behavior. With these experiences, the lecturer is now able to probe the students to think further about the use of the various controls and indications.

Needless to say, in traditional modes of didactic learning, the theory lesson would have been either so complex, that the information would easily have been forgotten by the time of application, or that the instruction would have been so rigid that it would be difficult for the students to construct knowledge beyond the content learned in the structured fashion.

Captains Announcement

Role play forms another entry point to self-directed learning. Students in the module were asked to take on the role of the captain in cruise flight to address the passengers with an announcement.

Working in teams, the students will put together a reasonable announcement, mimicking flight crew which they have experienced in their own air travelling, by looking up the necessary information in the cockpit, i.e. outside air temperature, speed, distance to destination and time to landing.

The most striking observation has been that some students would carry the status of that role, as gained in simulator work, into the class room and translate it into self-directedness for weeks after the actual practical exercise. Being called Captain again would activate their initiative and sense of responsibility in carrying out the role.

Punctuality

Treated as professionals in the described roles, the facilitator can confront students with the consequences of their decisions and actions. A permanent issue is punctuality. A school rule, a management demand, can now be discussed in the context of a future professional identity and responsibility and become more understandable and acceptable to students.

The authors also designed classroom documentation in an aviation fashion. Worksheets would appear as checklists or instructions as seen in aircraft maintenance manuals.

Self-Directed Learning

While motivation of the students is an important condition for self-directed learning, self-directedness does not automatically follow high motivation. Gray (2013) describes learning in the Sudbury Valley School (a radically alternative school in Massachusetts): "Even more important than specific skills are the attitudes that they learn. They learn to take responsibility for themselves and their community, and they learn that life is fun, even (maybe especially) when it involves doing things that are difficult."

Mynard and McLoughlin (2014) put the affective factors in the center of their observations, but fail to explain the mechanism which assures self-directedness. Gray lists this prime factor for self-directed learning: ".. what I see as the essential conditions for optimizing children's natural abilities to educate themselves ... the social expectation (and reality) that education is children's responsibility, not something that adults do to them, and ... provide unlimited freedom for children to play, explore, and pursue their own interests." To promote self-directedness in learning, elements of these need to be incorporated. Students need to be given ownership for their own learning and not be instructed all the time. They need to be given the space to engage in "play", and learn from their mistakes.

## Conclusions

We suggest that when using simulations and virtual reality, facilitation is a more effective means for helping students learn, because it promotes self-directed learning and its dimensions of initiative, control, self-efficacy and motivation. Conducting effective facilitation requires the facilitator to take a step back and to allow the students to engage in a more playful and creative learning mode. Playing, as much observed when adolescents learn to use modern communication gadgets, allows for a higher level of self-directedness. Such learning mode can be triggered by the use of adequate problem statements and "mini-problems" and the appointment of professional roles for students.

A cautionary note is that it is important for students to learn the responsibility of the role of the professional. While they may be "playful" in the process of constructing their understanding, they need to be aware of the implications of the decisions and actions using what they have learnt. This is where the design of role play assignments, the framing of the instructions and feedback given to the students can shape their perspective and attitudes in learning to become the professional.

**References**

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of personality and social psychology*, 41(3), 586.

Learmount, D. (2013, Jan). Future A350 pilots to "learn by doing". *Flight International.* Vol 4 (22-28. Jan. 2014., p.12.

Schmidt, H. G., & Moust, J. (1995). What makes a tutor effective? A structural-equations modeling approach to learning in problem-based curricula. *Academic Medicine*, 70(8), 708-714.

Stockdale, S. L., & Brockett, R. G. (2011). Development of the PRO-SDLS: A measure of self-direction in learning based on the personal responsibility orientation model. *Adult Education Quarterly*, 61(2), 161-180.

van Merriënboer, J. J., Kirschner, P. A., & Kester, L. (2003). Taking the load off a learner's mind: Instructional design for complex learning. Educational psychologist, 38(1), 5-13.

Mynard, J., McLoughlin, D. (2014). Affective Factors In Self-Directed Learning. Working Papers in Language Education and Research Vol. 2 No. 1. February 2014, 27-41

Gray, P (2013). The play deficit. Aeon Magazine (online), 18 September 2013. http://aeon.co

**Annex A**

List of online simulation tools used

• Simulation – aircraft simulator (Microsoft Flight Simulator 2009 and Project Magenta)
• Simulation – web-based wind tunnel (NASA - http://www.grc.nasa.gov/WWW/k-12/airplane/foil3.html)
• Aircraft Compass App (sensorworks.co.uk)
• Aircraft Attitude Indicator App (Rotation Vector)
• GPS essential App (Michael Schollmeyer)

List of laboratory simulators used

- Flight Simulation is used to visualize and understand the problems in three lessons
- Real wind tunnel in the laboratory is complemented by the use of the wind tunnel simulation e-tool in one lesson.
- Smartphone apps used to illustrate the work of the aircraft instruments and to visualize the problem in three lessons.
- Compass app was also introduced in one lesson to experiment and find limitations of the magnetic compass in real life applications.

# STUDENTS' PERCEPTIONS OF IMPACT OF SCAFFOLDS IN PROBLEM-BASED LEARNING

*Serene S.Y. Choo, *Elaine H. J. Yew, and **H. G Schmidt

*Republic Polytechnic, Singapore
**Erasmus University, The Netherlands

serene_choo@rp.edu.sg
elaine_yew@rp.edu.sg
schmidt@fsw.eur.nl

**Abstract**

**Problem-based learning or PBL in short, is an instructional approach that helps students to develop flexible understanding and lifelong learning skills. Throughout the PBL process, learning supports (i.e. scaffolds) may be provided to students as form of guidance and assistance to their understanding of the problem or task assigned. These scaffolds can be classified as either soft or hard scaffolds. Till date, there have been diverse opinions about how teaching resources should be used in a problem-based learning curriculum. Some suggest that PBL is less effective and efficient compared to instructional approaches that place a strong emphasis on guidance of the student learning process. On the contrary, there are advocates who do believe that PBL does provide an adequate level of scaffolding to facilitate and support student learning. The studies conducted aimed to investigate on the impact of different types of scaffolds on student learning in PBL. In this study, the students' perceptions of how various types of scaffolds were obtained via the mode of questionnaires. Qualitative and quantitative analyses were conducted to find out which types of scaffolds were perceived to have an impact on their learning. The findings suggested that scaffolds, especially soft scaffolds, do play a significant role in enhancing students' learning within the social constructivist framework of PBL. Furthermore, the importance of the role of tutor and collaborative small group learning which are key features of PBL, are again reinforced based on the outcome of this study.**

**Keywords:** *problem-based learning, scaffold, student perception, student learning, facilitate*

**Introduction**

Problem-based learning or PBL in short, is an instructional approach that helps students develop flexible understanding and lifelong learning skills (Hmelo-Silver, 2004; Schmidt, Loyens, Van Gog, & Paas, 2007; Simons & Klein, 2007). In general, the main instructional material used in the PBL curriculum is the problem, which is designed to trigger learning at the start of the lesson. In the course of the PBL tutorial process, students are trained to collect information, analyse data, develop hypothesis, and apply strong deductive reasoning to the problem at hand (Barrows & Tamblyn, 1980; Hmelo-Silver, 1998; Schmidt, van der Molen, te Winkel & Wijnen, 2009). Throughout this process, learning supports (i.e. scaffolds) may be provided to students as form of guidance and assistance to their understanding of the problem or task assigned.

Hard scaffolds are in general static supports that can be developed or provided based on learner difficulties prior to an assigned task (Saye & Brush, 2002). Such scaffolds can be provided once a task is assigned to the learner. Hard scaffolds can be in the form of computer or paper-based cognitive tools e.g. worksheets (Belland, Glazewski, & Richardson, 2008), reference books or other forms of text readings. On the other hand, soft scaffolds refer to the teacher's actions in response to the learner's efforts when the learner has a specific need (Saye & Brush, 2002). In the PBL context, instances of such scaffolds may refer to the guidance provided by the tutor or peer-teaching and learning within the small- groups.

As various institutions may employ various types of scaffolds in the curriculum to aid in student learning, scaffolds could be categorised differently into more distinct groups apart from 'hard' and 'soft'. In the instance of a worksheet, the tutor could utilise some of the questions to guide the student's metacognitive processes, in the event that the student expresses particular concerns or demonstrates difficulties understanding certain concepts in relation to the lesson curriculum. Therefore, the mode of how these types of scaffolds are administered in PBL could vary from that of a conventional non-PBL environment. To further distinguish between scaffolds of the above-mentioned nature, such examples of materials or scaffolding events may be referred to as 'semi-soft' scaffolds.

Various types of scaffolds could be deemed useful and even necessary in different situations in the PBL educational context. However, as there may be different forms of scaffolds provided for students in PBL, it would be useful if the value of each scaffold type is examined. In addition, there is a lack of studies providing an overview of the different types of hard and soft scaffolds. Therefore, one first step would be to find out the students' perspectives on which scaffolds they consider effective in contributing to their learning. This is because students are in the best position to assess the various scaffolds and their adequacy to support learning. Considering that they are exposed to problem-based learning throughout their course of study, it will be appropriate to use them as informants for this study.

The main focus of this study is about how scaffolds may be used to impact student learning in problem-based learning (PBL) environments. This study investigated the impact of different types of scaffolds on student learning in terms of student perceptions, and explored categorising various scaffolds into three different scaffolding nature – hard, soft and semi-soft scaffolds.

**Materials and Methods**

*Participants:* The sample consisted of 229 participants enrolled in courses at a polytechnic in Singapore, specifically in the respective areas of Biomedical Sciences, Biotechnology, Materials Science, Pharmaceutical Sciences and Environmental Science. The breakdown of the participants in terms of their years of study and frequencies of gender is shown in Table 1. Out of the total number students who were eligible for inclusion in this study (n=823), 28% of the students chose to participate.

Table 1: *Gender and age range of participants in respective year of study*

| *Year of study* | *Total number of participants (n)* | *Gender* | | *Age* | |
|---|---|---|---|---|---|
| | | *Male* | *Female* | *Mean* | *S.D.* |
| *Year One* | *95* | *43* | *52* | *16.54* | *0.97* |
| *Year Two* | *71* | *24* | *47* | *17.44* | *1.07* |
| *Year Three* | *63* | *31* | *32* | *18.73* | *1.30* |

*Educational Context:* In this particular institution, the instructional method is PBL for most of the courses it offers. In this approach, five students work together in one team under the guidance of a tutor or facilitator. Each class comprises four to five teams. A unique feature of the PBL approach used in this institution is that students work on one problem during the course of the day (Alwis & O'Grady, 2002). A typical day starts with the presentation of a problem. Next, students discuss in their teams, come up with tentative explanations for the problem, and formulate their own learning goals (Hmelo-Silver, 2004; Schmidt, 1983, 1993). During this process, students are provided with a template (referred to as Problem Definition Template), which they utilize to organize and scaffold the points brought up during team discussion. This Problem Definition Template (PDT) basically consists of three columns for students to fill in what they know, do not know, and need to find out in order to solve the problem.

The facilitator would then go through the PDT together with the students through discussions as a class. This is to allow the facilitator to guide or prompt the students' thinking towards understanding the learning objectives for the lesson. Subsequently, periods of self-study follow in which students individually and collaboratively try to find information to address the learning goals. At the end of the day, each team will come together to present, elaborate upon, and synthesize their findings. During the team presentations, there will be a series of class discussions generated by questions raised from either the students or facilitator, which encourage collaborative learning. By the end of the lesson, the facilitator will then provide a closure to the lesson by means of a concise presentation summarising the learning points generated throughout the day and relating them to the topic's objectives.

Apart from the problem statement, there are other forms of learning supports (e.g. worksheets) provided for the students to utilise throughout the lesson and scaffold the learning process. Resources are also provided for students to access and enhance their knowledge before
(e.g. recommended textbooks, pre- and post-lesson readings) and after (e.g. extracurricular talks, practice questions) lesson time.

*Questionnaire:* A Scaffold Impact Questionnaire was devised and administered to the participants to investigate what students perceive as important scaffolds that have an impact on their learning in a PBL environment. Students were asked to rate the level of impact different scaffolds have on their learning. They were also asked to provide written comments to justify the ratings for each item (i.e. scaffold). The list of 16 items (Table 2) that were measured for this study was based on the types of learning supports that are utilized in the polytechnic. Each item in the questionnaire was rated on a 5-point Likert scale: 0 (*not at all*), 1 (a little), 2 (*moderate*), 3 (much), and 4 (*very much*).

The participants were required to provide written comments to indicate why they perceive each scaffold listed in the Scaffold Impact Questionnaire to be useful or not. These written comments were then consolidated and analysed by the first author. As the comments provided by the participants for each type of scaffold are relatively similar, the statements listed were manually screened and themed under the common reasons that had the highest frequency.

*Categorization of scaffolds:* Although as mentioned in the Introduction section, scaffolds in general can be considered as either hard or soft, in this context of PBL, there are also scaffolds that can be regarded as a combination of both. For instance, due to the collaborative learning environment that students work in throughout the day, students tend to discuss and complete a worksheet together with their teammates, thus making the worksheet a form of flexible scaffolding instead of a hard scaffold. As mentioned in the Introduction section, the worksheet may also be a tool that facilitators utilize in different ways based on the learning needs of students during discussion time with the team or class. Likewise, the PDT is also used by the tutor to guide the students' cognitive processes by allowing them to organise their thoughts or inputs via team and class discussions. Hence, in this study, we aim to recognise the distinctiveness of such instances of learning supports which we classify as 'semi-soft' scaffolds (refer to *Educational Context*). Table 2 below shows the list of the 16 possible scaffolds used in the particular curriculum after classification into three categories of scaffolds – hard, soft and semi-soft.

Table 2
*Categorization of types of scaffolds used in PBL*

| **Type of scaffold or scaffolding event** | **Category of scaffold** |
|---|---|
| Pre-lesson readings | Hard |
| Recommended textbooks | |
| Extra-curricular talks or workshops related to the subject | |
| Post-lesson readings | |
| Practice questions provided after lesson | |
| Contributions of the facilitator (i.e. tutor) | Soft |
| Team contributions (involvement of a small group of 5 students with the learning of the individual) | |
| Class contributions (involvement of a larger group of about 25 students) | |
| Team presentations | |
| Worksheets | Semi-soft |
| Hands on activities (e.g. demonstrations or practical activities in class) | |
| Presentation by facilitator at the end of the lesson | |
| Computer animations or videos | |
| Internet resources | |
| Additional resources (e.g. text documents) embedded in worksheets | |
| Problem Definition Template | |

*Analyses:* Means and standard deviations for each of the items were computed. In addition, free responses to the question on why they found a particular scaffold useful or not useful were collected. In order to test the three-category theory of the scaffolds of this study, a confirmatory factor analysis was carried out to test for construct validity of hard, soft and semi-soft scaffolds.

ANOVA analyses were also performed to test for differences in the perceived usefulness of the three scaffold groups. As for the qualitative data i.e. the written comments, the data was consolidated and analysed. The statements provided by the respondents were manually screened by the first author and subsequently themed under the common reasons that were reflected at higher frequencies. These qualitative data, coupled with statistical analysis using the means obtained for the three scaffold groups, intends to provide insights to which types of scaffolds are perceived by students to be useful on their learning.

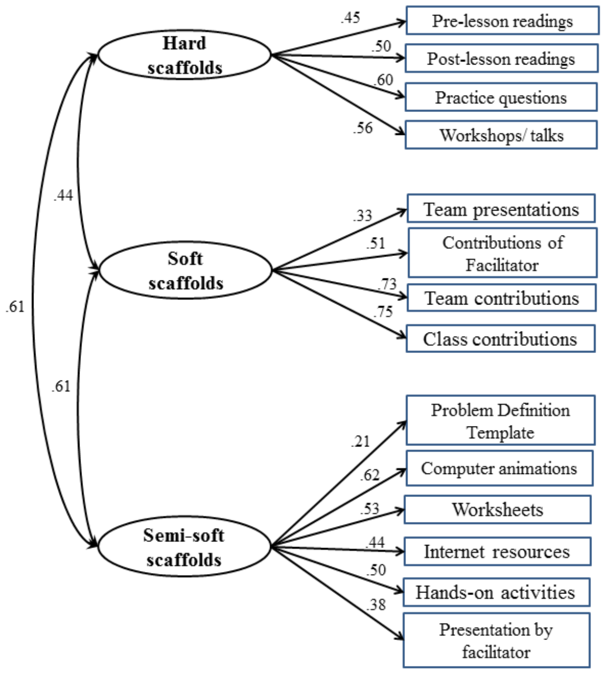
**Results and Discussion**

*Construct validity:* In order to assess the adequacy of the items under the three categories of scaffolds mentioned earlier under the Introduction section (i.e. hard, soft and semi-soft scaffolds); a confirmatory factor analysis was conducted to test for the validity of the model consisting of the 16 scaffold types.

A confirmatory factor model is assumed to fit the data well if the following criteria are met: (1) the chi-square divided by the degrees of freedom (CMIN/df) should be lower than 2 and have a p-value that differs from zero; (2) the root mean square error of approximation (RMSEA) should be lower than 0.05; and (3) the Comparative Factor (CFI) Index should be higher than 0.95. An inspection of the modification indices and the expected parameter statistics revealed that all 16 items fit appropriately in the model. For the model derived (Figure 1), the three conditions specified by Saris & Stronkhorst (1984) were met. A three factor model was found to be more specific compared to simpler models that resulted in lesser scaffold items omitted in order for the data to fit. The three-factor model constructed predicts possible directional influences amongst the various scaffold items, based on theory, and that these directional influences were confirmed through the confirmatory factor analysis.

The results for this model are: Chi-square = 123.4, df = 71, p = 0.029; RMSEA= 0.039; CFI = 0.95 indicating that this three-factor model fitted the data reasonably well. The model also suggests that the items within the three categories of scaffolds (hard, soft, semi-soft) do influence the impact of each item, hence showing validity of the three scaffold groups. For this final model that was constructed and validated, 14 out of 16 scaffolding items were retained. Figure 1 shows the relevant path coefficients. Only statistically significant path coefficients are displayed.

Figure 1
*Model illustrating types of hard, soft and semi-soft scaffolds (error terms are omitted for readability and only statistically significant path coefficients are displayed)*




After confirming the validity of the model obtained in Figure 1, further statistical analysis was conducted. The purpose was to find out if there are any significant differences between the three categories of scaffolds and students' perceptions of the impact of these scaffolds on their learning.

*Pervceived value of the 16 types of scaffolds:* The objective of the present study was to investigate the students' perceptions of the different scaffolds provided to them in a PBL setting, and how these scaffolds impact their learning. By comparing means of the 16 items in the Scaffold Impact Questionnaire (Table 3), it was found that that students perceived the following types of scaffolds to be of significant impact on their learning: team, class and facilitator contributions (soft scaffolds); worksheets (semi-soft scaffold); PDT (semi-soft scaffold) and practice questions (hard scaffolds).

Table 3
*Descriptive statistics of participant responses for individual scaffolds*

| **Item (Type of scaffold)** | **Mean** | **Std. Deviation** |
|---|---|---|
| Pre-lesson readings | 2.40 | 1.08 |
| Recommended textbooks | 1.77 | 1.27 |
| Problem Definition Template (PDT) | 2.52 | 1.14 |
| Worksheets | 3.28 | .77 |
| Computer animations or videos | 3.10 | .90 |
| Internet resources | 2.92 | .84 |
| Additional resources embedded in worksheets | 2.39 | 1.04 |
| Hands on activities (e.g. demonstrations or practical activities in class) | 2.84 | 1.09 |
| Team presentations | 2.66 | 1.01 |
| Presentation by facilitator at end of lesson | 3.00 | 1.02 |
| Post-lesson resources | 2.11 | 1.24 |
| Practice questions | 3.15 | 1.04 |
| Extra-curricular talks or workshops related to the subject | 2.61 | 1.11 |
| Contributions of the facilitator | 3.11 | .92 |
| Team contributions | 3.19 | .83 |
| Class contributions | 2.99 | .83 |
| **Average** | 2.75 | 1.10 |

With reference to previous studies, the findings for this study reinforced the view that tutor and small group learning are indeed perceived as important supports in the PBL environment. Tutors should have the relevant content knowledge to guide students throughout the process of solving the problem by asking open-ended questions to facilitate them (Hmelo-Silver, 2004; Hmelo-Silver & Barrows, 2008; Maudsley, 1999; Yee, Radhakrishnan, & Ponnudurai, 2006). The findings from this study also affirmed the role of a tutor or facilitator, as students rated the facilitator to have a relatively high impact on their learning. Through their written comments, they indicated that a facilitator provides guidance and encourages the students to think critically during the lesson.

Earlier studies have also showed that collaborative small group learning plays an important role in PBL. The formation of small problem-solving groups helps to distribute the cognitive load and allows students to learn in complex domains (Hmelo-Silver, 2004; Hmelo-Silver, et al., 2007; Schmidt, et al., 2007). For instance, students who attempted the problem or certain scaffolds (e.g. worksheet, PDT) in groups could have learnt more compared to those who work individually. This could have lead to a higher rating for team contributions (Table 3) in this study. Furthermore based on the comments made by the students in the Scaffold Impact Questionnaire, it showed that team contributions do help to promote sharing of opinions and increase efficiency in completing tasks at hand. In addition, class contributions also aid in prompting students to think further to promote deeper understanding.

With reference to the written comments given by the students in their questionnaire responses, worksheets were useful in terms of guiding them through the concepts required for solving the problem. Based on the justifications provided, scaffolds such as computer animations could serve as important visual aids especially for concepts that are more complex (e.g. process mechanisms). Students also commented that they are able to understand the concepts better if the processes are shown in the form of videos or animations, compared to reading plain text from resources. However, there are other studies demonstrating that there are no significant differences in student achievement between multimedia-enhanced PBL classes, compared to the traditional text-based PBL classes (Zumbach, Kumpf, & Koch, 2004). Therefore, it is still too early to conclude if the use of multimedia sources (e.g. computer animations, videos) does play significant roles in impacting student learning and achievement.

Another two scaffolds that students perceive to have an impact on their learning are worksheets and practice questions, which offer good cues on what to focus during self-study periods. Based on the student feedback, worksheets are perceived by students as guides for them to attempt the task or solve the problems. Practice questions are provided for the students to attempt after the day's lesson. According to majority of the responses collected, students felt that practice questions are good avenues of helping them understand the topic better, especially during revision before exams. The questions also help students to gauge their own understanding, so that they are able to identify the areas in which they are weaker. Therefore, such scaffolds that support active processing of information may be important in student learning.

*Comparison between hard, semi-soft and soft scaffolds:* Based on the descriptive statistics obtained for the three scaffold groups (Table 4), it shows that soft scaffolds were perceived to have a higher impact on student learning followed by semi-soft and hard scaffolds.

Table 4
*Means and standard deviations of hard, soft and semi-soft scaffolds*

| **Category of Scaffold** | **N** | **Mean** | **Std. Deviation** | **Std. Error** |
|---|---|---|---|---|
| Hard Scaffolds | 229 | 2.48 | .70 | .05 |
| Soft Scaffolds | 229 | 3.10 | .67 | .04 |
| Semi-soft Scaffolds | 229 | 2.81 | .53 | .04 |

To further investigate this, an ANOVA was performed. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that the perceived usefulness of the scaffolds differed statistically significantly between the three scaffold groups [$F(1.888, 430.507) = 82.336$, $p < 0.05$, partial $\eta^2=0.3$]. Post hoc tests using the Bonferroni correction revealed that students perceived the impact of learning derived from using hard scaffolds ($M = 2.48$, $SD = 0.70$) is significantly lower ($p < .001$) compared to semi-soft ($M = 2.81$, $SD = 0.53$) and soft scaffolds ($M = 3.10$, $SD = 0.67$). This result reflected that students deem soft and semi-soft scaffolds to be more useful or have a higher influence in their learning.

Since the ANOVA results indicated positive and significant differences between both soft and semi-soft scaffolds when compared to hard scaffolds, this thereby indicates that scaffolds are perceived to have certain advantages that students consider to be useful in their learning process. For example, students commented that the student team presentations (soft scaffold) are good ways of encouraging information sharing within the class. Through the team presentations, students tend to either gain additional knowledge or learn from each other's mistakes. This thus reflects the positive outcome of collaborative learning in a PBL classroom environment. In terms of semi-soft scaffolds, examples such as worksheets and PDTs are tools used as the subject of group discussions. Such scaffolds usually prompt further generation of ideas or information during the problem-solving process within the team or class. Despite the advantages of using soft and semi-soft scaffolds in PBL, there are certain hard scaffolds that aid in student learning too. In the case of hard scaffolds, students felt that practice questions that were provided as post-lesson material helped them in better understanding and preparation for tests.

On the other hand, recommended textbooks do not seem to contribute much to the learning process based on the average perceived impact (Table 3) as students tend to have reliance on other provided scaffolds. In addition, students also commented that there may be a lack of motivation to acquire the resources, which means borrowing of the textbooks. Hence the lower impact rating of recommended textbooks could have contributed to the outcome of how hard scaffolds are perceived in overall, by students to have a lower impact on their learning compared to the other two scaffold categories.

**Conclusions**

This study has shown that students do perceive different types of scaffolds to have varied levels of influence on their daily learning processes. Students generally perceived learning materials with elements of 'soft scaffolding' to impact their learning. Nevertheless, there are certain types of hard scaffolds (e.g. practice questions) that are deemed beneficial by students too. Hence, educators would have to consider the students' perception of these scaffolds when designing or incorporating them within the curriculum.

**Acknowledgements**

I would like to acknowledge Republic Polytechnic in providing the necessary resources and support required for completion of this study.

**References**

Alwis, W. A. M., & O'Grady, G. (2002). One day-one problem at Republic Polytechnic. Paper presented at the 4th Asia-Pacific Conference on PBL, Hatyai, Thailand

Barrows, H. S., & Tamblyn, R. M. (1980) Problem-based learning, an approach to medical education B2 - Problem-based learning, an approach to medical education. New York: Springer.

Belland, B., Glazewski, K., & Richardson, J. (2008). A scaffolding framework to support the construction of evidence-based arguments among middle school students. Educational Technology Research & Development, 56(4), 401(422).

Greening, T. (1998). Scaffolding for success in Problem-Based Learning. Medical Education Online, 3(4), 1-15.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16(3), 235-266.

Hmelo-Silver., C. E. (2004). Problem-Based Learning: What and How Do Students Learn? Educational Psychology Review, 16(3), 235-266.

Hmelo-Silver., C. E. (2009). Whare do we know about Problem-based learning?: Current status and future prospects. Paper presented at the 2nd International PBL Symposium 2009, Republic Polytechnic, Singapore.

Hmelo-Silver., C. E., & Barrows, H. S. (2008). Facilitating Collaborative Knowledge Building. Cognition and Instruction, 26(1), 48-94.

Maudsley, G. (1999). Roles and responsibilities of the problem based learning tutor in the undergraduate medical curriculum. BMJ, 318(7184), 657-661.

Saye, J. W., & Brush, T. (2002). Scaffolding Critical Reasoning about History and Social Issues in Multimedia-Supported Learning Environments. Educational Technology Research and Development, 50(3), 77-96.

Schmidt, H. G. (1983). Problem-based learning: Rationale and description. Medical Education, 17(1), 11-16.

Schmidt, H. G. (1993). Foundations of problem-based learning: Some explanatory notes. Medical Education, 27(5), 422-432.

Schmidt, H. G., Loyens, S. M. M., Van Gog, T., & Paas, F. (2007). Problem-Based Learning Is Compatible with Human Cognitive Architecture: Commentary on Kirschner, Sweller, and Clark (2006). Educational Psychologist, 42(2), 91-97.

Simons, K., & Klein, J. (2007). The Impact of Scaffolding and Student Achievement Levels in a Problem-based Learning Environment. Instructional Science, 35(1), 41(32).

Yee, H. Y., Radhakrishnan, A., & Ponnudurai, G. (2006). Improving PBLs in the International Medical University: defining the 'good' PBL facilitator. [Article]. Medical Teacher, 28(6), 558-560. doi: 10.1080/01421590600878226

Zumbach, J., Kumpf, D., & Koch, S. (2004). Using multimedia to enhance problem-based learning in elementary school. Inform. Technol. Child. Educ. Annu., 16(25-37).