CSCE Annual Conference
Growing with youth – Croître avec les jeunes

Laval (Greater Montreal)
June 12 - 15, 2019

PROBLEM BASED LEARNING FOR REINFORCING CIVIL ENGINEERING EDUCATION IN THE UNIVERSITIES OF TECHNOLOGIES IN SOUTH AFRICA

Das Dillip Kumar[1]
[1] Department of Civil Engineering, Central University of Technology, Free State, Bloemfontein, South Africa
ddas@cut.ac.za

Woyessa Y.E[1]
[1] Department of Civil Engineering, Central University of Technology, Free State, Bloemfontein, South Africa
ywoyessa@cut.ac.za

Abstract: The University of Technologies (UoT) of South Africa are in transition in terms of change in curricula. Although, Outcomes Based Education (OBE) is followed in engineering education in the UoTs, debates emerged whether students achieve the desired exit level outcomes or graduate attributes, become competent and become industry relevant by following this conventional form of education. In this context, Problem Based Learning (PBL) is argued to able to meet the challenges. Therefore, using the case study context of under graduate Civil Engineering education in an UoT if South Africa, this study examined the relevancy and implications of PBL and how it can be incorporated in to the curricula or modules so that it will reinforce Civil Engineering education in the UoTs. A research method that includes lessons from PBL workshops, a perception survey and focus group discussion was used for this purpose of the study. It is emanated from the findings that PBL will be highly relevant and will assist in attaining the exit level outcomes or graduate attributes as well as also help the students in acquiring relevant cognitive learning attributes. Although, it might face resistances and challenges, yet, it is argued that if it can be integrated to the curricula or modules through constructively aligning the student projects or assignments with industry or real life/ practical problems, it can reinforce Civil Engineering education at the UoTs of South Africa.

Keywords: Engineering Education; Industry problems; Outcomes Based Education; Problem Base Learning; Relevancy

1. INTRODUCTION

Universities of Technologies (UoT) in South Africa generally follow Outcomes Based Education (OBE) in which Work Integrated Learning (WIL) is an indispensable element. However, in the recent re-curriculation and adoption of the new under graduate qualifications both at the Diploma and Bachelors level in Engineering and Technology education, the WIL component is not anymore compulsory to obtain a qualification. So, the students may not have any work place training or experience during their study, which may put them at risk with regards to obtaining the requisite graduate attributes of problem solving, designing, working in groups and multidisciplinary environment, etc., and become industry relevant. Moreover, critics of OBE argued that contrary to the expectations it does not enable the students to learn the cognitive attributes (Lombard, and Grosser, 2008). Furthermore, although the under graduate students of UoTs are expected to deal with well defined and/ or broadly defined problems, most often they have to encounter complex problems in their world of work. Moreover, complex problems also constitute a set of well defined and broadly defined problems. Majority of the socio-economic and environmental problems, which the Civil Engineers often encounter in the real world to solve are complex and non-engineering problems and these problems need engineering solutions. Thus, the Civil Engineering students in UoTs while are required to be competent in solving well defined or broadly defined problems as the case may be depending on the requirement of competency level in exit level outcomes according to the level qualification, they need to be acquainted with the complex problems and have the ability to find engineering solutions to non- engineering socio-economic and environmental complex problems. In this context, Problem Based Learning (PBL) is argued to offer the opportunities for understanding the various types of problems, and hands on experience on practical problem solving within an academic environment, which could suffice to the needs of the students to become industry relevant, acquire exit level outcomes, learn cognitive attributes and more importantly gain ability to solve problems. Therefore, the objectives of this study were two fold. First, the study examined the relevancy and implications of the PBL in Civil Engineering education. Second, it explored how PBL can be integrated in under-graduate Civil Engineering programmes in the UoTs of South Africa. The study largely relied on the lessons learned from the industry based PBL workshops conducted by considering undergraduate engineering students including that of Civil Engineering and problems related to Sustainable Development Goals (SDG) of the United Nations. The SDGs considered were: Goal 6- Clean Water and Sanitation, Goal 9- Industry, Innovation and Infrastructure and Goal 11- Sustainable Cities and Communities. The problems related to these SDGs were chosen because most of the problems under these SDGs are largely complex and belong to socio-economic and environmental aspects of the society, and need engineering solutions, which the Civil Engineers usually encounter. A survey was conducted to collect data from the participants in the workshops. Further, a focus group discussion was conducted. Statistical analyses of data collected and qualitative narrative analysis of the perceptions of the focus group and content analyses of the student projects conducted during the workshops were conducted. Findings suggest that although it was contextualised in a controlled academic environment, PBL is relevant to engineering students as it provided them the opportunity to deal with practical problems with the assistance of both academicians and industry partners. It can also assist students to acquire the exit level outcomes or graduate attributes such as problem solving, design, multidisciplinary, entrepreneurship, etc. Further, this paper argues that PBL can reinforce the student learning if it can be integrated to the learning programmes through aligning the student projects or assignments with industry or real life socio-economic- environmental problems as well as aligning them constructively in terms of Intended Learning Outcomes, teaching and learning activities and assessment tasks.

2. PBL AND ENGINEERING EDUCATION: A THEORETICAL PERSPECTIVE

According to scholars in the education, PBL is simply a curricular design and pedagogical method that enables students to learn by using real-life problems and situations (Barrows, Tamblyn, 1980; Boud, Feletti, 1991; Schmidt, Moust, 1995). The philosophy behind this method of the learning is that the students play the active role in knowledge acquisition and the teachers play the role of the facilitator. The teacher's role is transformed from offering direct instruction to that of a facilitator who enables the students to be active in their learning. In other words, in PBL, the teacher is generally called a tutor or a facilitator and the student is the active learner who learns by doing (Barrows, Tamblyn, 1980; Boud, Feletti, 1991; Schmidt, Moust, 1995).

The teaching and learning in PBL generally conducted in small groups with specialised knowledge in which a group of students work on certain broadly defined or complex practical or real life problem and bring out innovative ideas, concepts, designs and/ or feasible solutions (Das and Mishra, 2018). The major attributes that are emphasized in this form of teaching and learning include but not limited to multi-disciplinarily, interdisciplinary, individual independence and communication and discussion skills among group members

(Chen, 2008; Das and Mishra, 2018; Duch, Groh, Allen, 2001). In other words, scholars argue that, it is learner driven in which students explore and try to solve open-ended problems in small and collaborative groups where lecturers take on the role as 'facilitators' of learning. However, this learning process demands that the students while working in small groups also contribute individually. More importantly, during the learning process, the students while are engaged in solving the problem, they present or communicate the outcomes of the different activities and tasks they conduct to the facilitators, peers, and other stakeholders for discussion, feedback and reflection (Barrett, 2005; Barrows, 1988; Hmelo-Silver, 2004; Hmelo-Silver, Barrows 2006; Schmidt, 1983). In other words, this learning process follows the constructivist theory of learning but it is different from the conventional classroom learning where the teacher is the provider of knowledge and the students are the passive recipients (Bennett, 1976; Williams, Paltridge, 2017). Moreover, the assessment of the student learning is purely formative and continuous. It measures the ability and competency of the students under a demanding situation instead of their knowledge as it is conducted through summative assessment (Servant-Miklos, 2018). Overall, it is argued that it assists the students to develop specific cognitive characteristics such as recognizing and updating knowledge deficits through self-directed learning (Biley and Smith, 1998), critically reflective (Williams, 2001), and being autonomous and unafraid to challenges (Biley and Smith, 1998; Moore, 2009).

PBL has mainly three primary requirements. They are: learning by doing, learning in the context, and focusing on the student (Chen, 2008). The students work on socio-economic and environmental problems in a systematic way to accomplish learning objectives that have been identified by them from the outset. However, each problem is overseen by the facilitators. Moreover, the assessment is based on the goals set by the students and the learning outcomes, which is one of the vital characteristics of the PBL (Alavi, 1995; Barrows, 1988; Rideout and Carpio, 2001; Wolf, 2007; Solomon, 2011). It allows the students the flexibility to learn according to the context and environment (Dattilo and Brewer, 2007; Özbıçakçı, Bilik, İntepeler, 2012). Further, it is also evidenced that such learning method can be linked with the Outcomes Based Education (OBE), which is usually practiced in professional education fields such as engineering (Das and Mishra, 2018). Moreover, it provides competence based education through critical thinking, problem solving, reflection, collaborative, self-directed as well as life-long learning (Schimdt, 1998; Mubuuke, Louw, Van Schalkwyk, 2017; Ward, Lee, 2002; Yeung, Au-Yeung, Chiu, et al., 2003).

Although, PBL has been practiced in health sciences education such as medicine and nursing, and incorporated in physical sciences such as Physics (Servant-Miklos, 2018), it was scarcely practiced in engineering education until recent years. However, certain universities in Europe including United Kingdom, and universities in Denmark and in North America have incorporated in their undergraduate education. In this regard, some UoTs in South Africa are engaged in exploring the possibilities to incorporate PBL in engineering education through pilot studies and workshops (Das and Mishra 2018), because of its benefits of allowing the students to learn actively in a multi-disciplinary environment dealing with practical or real life socio-economic and environmental problems and etch out engineering solutions to non-engineering societal problems.

3. **METHODS**

The study largely relied on the lessons learned from the industry based PBL workshops conducted by considering undergraduate engineering students including that of civil engineering and problems related to SDG of UN. Also, a survey was conducted to collect data from the participants in the workshop. Further, a focus group discussion was conducted.

Two PBL workshops were conducted during the year 2018 in the Central University of Technology (CUT), Free State, South Africa with 43 students and 11 facilitators. The first workshop constitutes 21 undergraduate students and 7 lecturers from the three engineering disciplines such as Civil Engineering, Electrical, Electronics and Computer Engineering and Mechanical Engineering. The second workshop was conducted with 22 undergraduate students and facilitators representing various sub disciplines from the Civil Engineering discipline. The purpose of the workshops was twofold, (1) to introduce philosophy, process and methodology of the PBL as well as educating the educators and (2) engage the students and familiars in the teaching and learning through PBL process. In other words, based on the understanding of

PBL and following the process and methods of the PBL the students were asked to bring out conceptual solutions to the complex problems and lecturers were asked as the facilitators. The students were divided into smaller groups and each group were asked to select a real-life or industry problem from a specific context and bring out engineering solutions to non-engineering socio-economic and environmental problems within a limited time frame of 3 days in case of first workshop and 4 days in case of second workshop. The challenges belonging to the United Nations Sustainable Development Goals (SDG) were considered to frame the PBL problems.

Further, a questionnaire survey was conducted among the students (43) and lecturers participated (11) in the workshops through purposive sampling. For this purpose, a pre-tested questionnaire was administered among the respondents. The questionnaire contained various aspects related to the relevancy, implication and challenges of the PBL in engineering education. Also, it contained open ended questions related to the various ways to integrate PBL into the current system of engineering education.

Furthermore, a focus group discussion was conducted to examine the opportunities, challenges and implications of PBL for engineering education as well as the ways to incorporate in to the learning programmes. The focus group constitutes academicians (lecturers, and facilitators), academic developers, academic leaders and professionals engaged in industry. The participants were selected based on their experience in teaching and learning, engagement with regards to academic development, leadership and engagement in PBL and engagement in industry. The researcher himself acted as the facilitator of the focus group discussion.

The survey data collected was analysed by use of quantitative statistical analyses such as percent analysis and descriptive statistics. The student outputs such as the student projects during the workshops were analysed by content analyses. The discussions among the focus group members and opinions of the participants were analysed by narrative analysis.

4. RESULTS AND DISCUSSIONS

The role of PBL in engineering education including that of civil engineering was analysed based on three aspects such as relevancy of the pedagogical method, its implications on the student learning and education, and challenges against its practice and implementation. For this purpose, the perceptions of the respondents from the survey, focus group discussions and lessons learned from the workshops. Followed by a discussion on the contextualisation of PBL was made to examine how the PBL can be integrated in to the learning programmes to reinforce the engineering education.

4.1 **Relevancy of PBL to Civil Engineering education**

Relevancy of PBL to engineering education was assessed premised upon different teaching and learning attributes such as whether it is related to exit level outcomes, has combination of both theoretical knowledge and practical application, deals with multidisciplinary and interdisciplinary problems, assists in independent learning, enables group work and apply engineering tools, techniques and models. According to the perception survey as shown in Table 1 more than 70% of the respondents agree PBL is highly relevant as the teaching and learning process practiced in PBL confirms to the almost all of the above attributes. Furthermore, the content analysis of the student projects revealed that although the problems given were mostly non-engineering and socio-economic or environmental based on the SDGs of UN, which demand engineering solutions, and require multi-disciplinary and interdisciplinary knowledge, skills and competency, the students could able to come up with feasible but conceptual engineering solutions or design within the limited time frame provided to them. They could achieve this by following a structured and systematic step wise process. In this process the various cognitive learnings they could able to obtain are understanding of the problem, application of the knowledge and skills, evaluation and design and creativity and problem solving. Moreover, the focus group discussion supported the perceptions of the respondents and the outcomes of the workshops. According to the focus group

"…students can use their cognitive knowledge to solve the complex problems belonging to practical or real life issues in a multi-disciplinary group environment through their direct active intellectual engagements and doing by themselves, which also refine and enhance their knowledge and skill".

Further, another member in the focus group argued that

"…. *the PBL process can enable student to learn how to deal with complex practical socio-economic-environmental (non-engineering wicked problems- having no specific solutions) problems, thereby making them to attain the exit level outcomes of undergraduate Civil Engineering education in some of the universities of South Africa because PBL demands both cognitive knowledge and follow systematic learning process to deal with real life challenges*."

Therefore, it is argued that PBL is highly relevant for engineering education and assist in offering the students the opportunities to attain critical exit level outs comes such as problem solving, design, applying of different engineering tools, techniques, theoretical knowledge, principles, working in a multi-disciplinary environment, working in groups while learning independently, etc.

Table 1: Perceptions on relevancy of PBL to Civil Engineering education

Relevancy of PBL to engineering education	Total Sample size	Frequency	Per cent
Related to exit level outcomes	52	33	67.35
Combination of both theoretical knowledge and practical application	52	42	80.77
Multidisciplinary and interdisciplinary problems	48	41	85.42
Independent learning	52	38	73.08
Group work	43	36	83.72
Application of engineering tools, techniques and models	52	37	71.15

4.2 Implications of PBL on Civil Engineering education

According to the majority of the respondents (more than 64%), PBL assists in learning of the students through hands on training (or by doing), improves their ability to apply the knowledge they have learned to solve practical problems, and enable them to link non-engineering (socio-economic and environmental) problems to engineering solutions. Moreover, it also enables them to learn how to evaluate different alternate and context specific solutions as well as acquire entrepreneurial attributes such as selling the product or design through short presentations, pitching and videos. Although to a lesser extent, it prompts students to think innovatively and assists it improving the industry academia inter-linkage. These implications were supported by the outcomes of the workshops. For example, according to the facilitators, even though the students were not exposed to such kind of challenges previously, the students were apparently, found to engage deeply to generate innovative ideas and bring out different alternate engineering solutions to the socio-economic-environmental problems they were working on. Moreover, the students also could able to engage with the stakeholders such as industry partners and academics involved in the projects to convince their ideas and solutions within a limited duration of time such as five minutes' pitch or a short video, which in fact assist them to acquire entrepreneurship attributes. In this context, the focus group observed that

"…. *usually Civil Engineering students remain aloof from the soft aspects of the projects such as selling their ideas and solutions and understanding the commercialisation prospects. The conventional education system does not really allow to learn those attributes. However, through PBL they can acquire those attributes*."

Also, the focus group unanimously agreed that

"*…. Civil Engineering students in normal circumstances do not link socio-economic- environmental problems to their engineering knowledge. However, PBL makes them think differently to find engineering solutions to the non- engineering problems at hand*."

Table 2: Implications of PBL on engineering education

Implications of PBL	Total Sample size	Frequency	Per cent
Assists in learning through hands on training	51	41	80.39
Improves application of knowledge to real life or practical problems	48	40	83.33
Instils innovative thinking	45	30	66.67
Enable students to learn to link non-engineering problems to engineering solutions	47	41	87.23
Enable the students to learn to evaluate different alternate and context specific solutions	42	33	78.57
Imbibing of entrepreneurial attributes	41	31	75.61
Better industry and academia inter-linkage	45	29	64.44

4.3 Challenges against PBL in Civil Engineering education

It was necessary to understand the challenges that may act as barriers against the implementation of PBL in engineering education in the wake of predominant practice of conventional mode of teaching and learning. It was evidenced from the survey that the major challenges include integration of PBL into the existing curriculum, formation of multidisciplinary groups, requirement of significant amount of financial resources and industry participation (Table 3). Followed by, it was also revealed that lack of adequate human resource adept in PBL method of pedagogy as well as motivating the students and lecturers unless it forms a part of the curriculum are the major challenges. These challenges were also corroborated in the focus group discussion. According to the focus group members,

"…*it is quite difficult and challenging to integrate PBL into the existing curriculum because of regulatory constraints and pedagogical method change point of view. Moreover, implementation of such learning methods require highly adept human resource, significant amount of financial resource and industry participation.*"

Besides, according to students and lecturers, unless it is a part of the curriculum, it will add extra load to the existing work-loads of the lecturers and students without much tangible benefits in terms of adding to the credit value. Furthermore, some academicians in the focus group showed their reservations indicating that PBL might not assist students in acquiring the conceptual, theoretical knowledge and principles which are fundamental to engineering education, although agreed that appropriate framing of the problems might able to meet such challenges. Thus, implementation PBL in engineering education under the prevailing conditions is appear to be quite challenging.

Table 3: Challenges against PBL in Civil Engineering education

Challenges	Total Sample size	Frequency	Per cent
Integrating with the existing curriculum	23	17	73.91
Industry participation	38	27	71.05
Motivation of the students*	42	25	59.52
Motivation of the lecturers*	11	7	63.63
Formation of multi-disciplinary groups	41	31	75.61

Financial resources	36	27	75.00
Human resource capacity of the universities	43	29	67.44

(* In the absence of part of the curriculum or syllabus)

4.4 Contextualising PBL to reinforce Civil Engineering education

It is evidenced from the perceptions of the respondents, lessons from the workshops and focus group discussion that PBL is relevant to engineering education and has beneficial implications for the engineering students and add new dimensions to their learning process. However, there are certain challenges that act as barriers against its sustainable implementation. Looking at the benefits it can bring and challenges it will face, there is a need to contextualise it within the prevailing conditions. In this context, although most of the focus group members unanimously agree that there is a need for paradigm shift to move away from the conventional form of teaching and learning to competency based multi-disciplinary and interdisciplinary form of teaching and learning, it remains a long shot and appears to be not realistic to attain in the near future. Under this premise, the few suggestions that have emerged from the focus group discussions are:

…*Perhaps identifying real life and practical problems in collaboration with industry partners and different social- solidarities (such as governance agencies and people) and assigning the students to solve these problems as part of their assignment and projects will assist integration of PBL into the current conventional form of teaching learning gradually*."

This will help in keeping the lecturers and students motivated as well as also can be accomplished without much additional requirements of both financial and human resources and with some modifications to what they are doing in the current system.

Alternatively, some focus group members believe in replicating the models with some modifications that is being used in some of the universities in Europe. For example, the model adopted by University College London, United Kingdom, which was found to be successful can be implemented with some modification and contextualising to the needs of UoTs. According to them,

"… *One compulsory module can be incorporated into the curriculum at the appropriate level which should be inter-and multi- disciplinary. The students should be assigned with practical/real life problems to solve within a specified duration of time by following the process of PBL. This might be possible without significant changes in the regulations and policies of the universities*."

Thus, it is apparent that although implementation of PBL could be difficult, yet if it is contextualised and implemented with some transformations, it will assist the students to attain competency in a number of exit level outcomes such as problem solving, design, application of engineering tools and techniques, independent learning and working in groups as well as acquiring entrepreneurship skills. Consequently, it is argued that PBL can reinforce engineering education in South Africa.

5. CONCLUSIONS

Acquiring higher cognitive learning attributes such as applying, analysing, evaluating, design, creativity, etc. and achieving exit level outcomes or graduate attributes such as problem solving, design, group work, multi-disciplinarity, entrepreneurship, etc., through conventional form of education are argued to be challenging. Although, OBE premised engineering and technology education are practiced in the UoTs of South Africa, arguments have emerged that in the absence of Work Integrated Learning (WIL), whether the graduates become industry relevant and competent by acquiring these cognitive learning attributes and exit level outcomes. Concurrently arguments have emerged that PBL as a pedagogical method can provide opportunities to the students to acquire these cognitive learning and graduate attributes through active leaning and hands on experience on dealing with the practical or real life problem within an academic environment, and become competent and industry relevant. However, literature suggests that explicit studies on relevancy and implication of PBL in engineering education- particularly in Civil Engineering and how it can be integrated in to the curriculum, specifically in the South African context are scarce. Therefore, the study examined the relevancy, implications and challenges of the PBL in Civil Engineering education and how it can be integrated in under-graduate engineering programmes in the UoTs of South Africa. The study largely relied on the lessons learned from the industry based PBL workshops conducted considering undergraduate engineering students at CUT, Free State, focus group discussion and a perception survey.

The findings revealed that that although PBL is contextualised in a controlled academic environment, it is perceived to be relevant to Civil Engineering students. It provides the students the opportunity to deal with or solve real life complex practical socio-economic and environmental or industry related problems by applying both theoretical and practical knowledge they have acquired earlier. It enables the students to learn to link non-engineering problems to engineering solutions and evaluate different alternate and context specific solutions. It also assists the students to acquire the cognitive attributes and the exit level outcomes or graduate attributes such as problem solving, design, multi-disciplinarity, entrepreneurship, innovative thinking, etc. It offers the students the opportunity to work in a multi-disciplinary environment in groups or teams.

On the other hand, PBL might face a number challenges including the challenge of incorporation of PBL into the existing curriculum, industry participation, demands for financial and human resource and perhaps the motivation of students and lecturers in case it is not an integral part of the curriculum. However, it is argued that incorporation of a special module in the curriculum to dealt by PBL, and / or creating assignments or projects to solve or deal with real life or industry based complex problems by the in collaboration with industries or social solidarities (components of the society such as municipalities, infrastructure development authorities, city development authorities, or communities, etc.,) may assist in the incorporation of PBL in the curriculum as well as enable participation of industries, increase the motivation of students and lecturers without much additional requirement of financial and human resources.

So, despite the challenges, this paper argued that if PBL is contextualised and integrated into the curriculum or modules and aligned it constructively in terms of Intended Learning Outcomes, teaching and learning activities and assessment tasks, then it can reinforce Civil Engineering education in the UoTS of South Africa.

REFERENCES

Alavi, C. 1995. *Problem-based Learning in a Health Science Curriculum*. Routledge, London, Great Britain.

Barrett, T. 2005. Understanding problem-based learning. In: Barrett T, Mac Labhrainn I, Fallon H, editors. *Handbook of Enquiry and Problem-Based Learning. Galway*: CELT, pp. 13–25.

Barrows, H.S. 1988. T*he Tutorial Process*. Southern Illinois University School of Medicine, Springfield, IL.

Barrows, H. S., Tamblyn, R. 1980. *Problem-Based Learning: An Approach to Medical Education*. New York: Springer.

Bennett N. N. 1976. *Teaching Styles and Pupils Progress*. London: Open Books Publishing.

Boud D, Feletti. G, 1991 (ed.). The Challenge of Problem Based Learning. London: Kogan Page.

Biley, F., Smith, K. 1998. Exploring the potential of problem based learning in nurse education. *Nurse Education Today*, **18**: 353–361.

Chen, Nan-Chieh. 2008. An Educational Approach to Problem-Based Learning. Kaohsiung. *J Med Sc*i, **24 (3 Suppl)**: S23–30.

Das, D. and Mishra, B. 2018. Exploring the Complementarity of Problem Based Learning with Outcomes Based Education in Engineering Education: A case study in South Africa, In Sunyu, W., Kolmos, A., Guerra, A., & Weifeng, Q. (Eds.) (2018). 7th International Research Symposium on PBL: Innovation, PBL and Competences in Engineering Education. Aalborg Universitetsforlag. International Research Symposium on PBL pp. 297-307. ISBN: 978-87-7210-002-9, ISSN: 2446-3833.

Dattilo, J., Brewer, K. 2007. *Historical influences in nursing curriculum.* In: Young, L.E.

Duch, B. J., Groh, S. E., Allen, D. E. 2001. Why Problem-Based Learning? A case study of institutional change in undergraduate education. *In Duch, B. J., Groh, S. E., Allen, D. E. (Eds.) The Power of Problem-Based Learning.* pp. 3-13. Stylus Publishing, 2001, Sterling, Virginia, USA.

Hmelo-Silver C. 2004. Problem-Based Learning: what and How do Students Learn? E*duc Psychol Rev*, **16(3)**: 235–266.

Hmelo-Silver C. E, Barrows H. S. 2006. Goals and strategies of a problem-based learning facilitator. *Interdiscip J Probl-based Learn*, **1(1)**: 21–39.
Lombard, K. and Grosser, M. 2008. Critical thinking: are the ideals of OBE failing us or are we failing the ideals of OBE?. *South African Journal of Education*, **28**: 561-579.
Moore, J. 2009. An exploration of lecturer as facilitator within the context of problem-based learning. *Nurse Education Toda*y, 29, 150–156.
Mubuuke, A. G., Louw, A. J.N., Van Schalkwyk, S. 2017. Cognitive and Social Factors Influencing Students' Response and Utilization of Facilitator Feedback in a Problem Based Learning Context. *Health Professions Education*, **3**: 85–98.
Özbıçakçı, Ş., Bilik, Ö., İntepeler, Ş.S. 2012. Assessment of goals in problem-based learning. Nurse Education Today, **32**: e79–e82.
Rideout, E., Carpio, B. 2001. The problem-based learning model of nursing education. In: Rideout, E. (Ed.), Transforming Nursing Education through Problem Based Learning. Jones and Bartlett, Sudbury, MA, pp. 21–50.
Schmidt HG 1983. Problem-based. learning: rationale and description. *Med Educ,* **17**: 11–16.
Schimdt, H. G. 1998. Problem-based learning: does it prepare medical students to become better doctors?. *Med J Aust*,168, 429–430.
Schmidt H. G., Moust, J.H.C. 1995. What makes a tutor effective? A structural equations modelling approach to learning in problem based learning. *Acad Med*, **70(8**): 708–714.
Servant-Miklos V.F.C. 2018. Fifty Years on: A Retrospective on the World's First Problem-based Learning Programme at McMaster University Medical School. *Health Professions Education*, https://doi.org/10.1016/j.hpe.2018.04.002
Solomon, P. 2011. Problem based learning. In: Bradshaw, M.J., Lownstein, A.J. (Eds.), Innovative teaching strategies in nursing and related health professions. Jones and Barlett Publishers, Boston, MA.
Ward, J. D, Lee, C. L. 2002. A review of problem-based learning. J *Fam Consum Sci Educ*, **20(1)**: 16–26.
Williams, J. C., Paltridge, D.J. 2017. *What We Think We Know About the Tutor in Problem-Based Learning*. *Health Professions Education*, **3**: 26–31.
Wolf, A. 2007. Tutoring PBL: a model for student centered teaching. In: Young, L.E., Paterson, B.L. (Eds.), Teaching Nursing. Lippincott, Philadelphia, PA.
Yeung, E., Au-Yeung, S., Chiu, T., et al., 2003. Problem design in problem-based learning: evaluating student's learning and self-directed learning practice. *Innovations in Education and Teaching International,* **40 (3)**: 237–244.