

Introduction

The qualities of successful PBL facilitators and of effective PBL facilitation have been extensively studied. Many researchers have identified the roles and responsibilities of tutors/facilitators in a PBL setting. Since the deployment of PBL in educational settings, it has been argued the role of teaching should be in facilitating students' learning rather than conveying knowledge (Barrows & Tamblyn, 1980). Instead of telling students what they should learn and in what sequence they should learn, tutors should help students to independently determine what they need to know and how to learn. By stating that 'a faculty person who is a good tutor can successfully tutor in any area', Barrow and Tamblyn (1980) highly weight the role of facilitation in teaching activities in PBL.

Since the effectiveness of facilitators is instrumental to the success of PBL (Maudsley, 1999), it is vital to identify the characteristics and skills of an effective PBL facilitator. To date, PBL researchers and experts have examined tutors' facilitation behaviour from multiple perspectives and this has led to a wealth of literature. However, at present little is known about the ways research methodologies for PBL facilitation studies have evolved over the past twenty years. The focus of this paper is to identify trends in the use of various research methodologies about effective PBL facilitation. The findings indicate that for the past decade, there has been a marked increase in the utilisation of qualitative and mixed methods investigations. Engineering education having contributed in a small way to these studies can be informed by what the trends are in the approaches used to better understand the way we teach our discipline. As we implement studies to better inform ourselves of the most effective approaches to teaching, we can learn from the current approaches used to gain this understanding.

What is Research Methodology

A research methodology is the strategy that determines the way in which research objectives are accomplished effectively (Goddard & Melville, 2004) and this will ultimately lead to an answer for the research question. All research is based on some underlying philosophical assumptions about what constitutes valid research and which research methods are appropriate for the development of knowledge in a given study. In order to conduct and evaluate any research, it is therefore important to know what these assumptions are. Philosophical assumptions are often referred to as paradigms of inquiry (Bettis & Gregson, 2001; Creswell, 2014).

A paradigm can be defined as the "basic belief system or world view that guides the investigation" (Guba & Lincoln, 1994, p. 105). Paradigms are often characterized by the ways their proponents respond to ontological, epistemological, and methodological questions and to a series of research issues such as inquiry aims, researcher values, voice, representation, and quality criteria (Guba & Lincoln, 1994). Ontology relates to the philosophy of reality; epistemology reflects how we come to know that reality while methodology describes the particular practices used to attain knowledge of it (Krauss, 2005). In practical terms, epistemology involves both ontology and methodology. Implicitly, making decisions about research design is fundamental to both the philosophy underpinning the research and the contributions that the research is likely to make.

Qualitative methodologies are underpinned by an interpretivist epistemology and constructionist ontology (Mack, 2010). Constructivist researchers assume that reality is socially constructed in the context of lived experiences, and therefore, must be studied through observation and participation (Krauss, 2005). The process of research involves emerging questions and procedures, data typically collected in participants' settings, data analysis inductively built from particular to general themes, and researchers interpreting the

meaning of the data (Creswell, 2014; Crotty, 1998). In general, qualitative research is based on a relativistic, constructivist ontology that posits that there is no objective reality. Rather, there are multiple realities constructed by human beings who experience a phenomenon of interest (Krauss, 2005).

A quantitative methodology is underpinned by a positivist paradigm where the research purpose is to prove or disprove a hypothesis. These approaches emphasise scientific methods, statistical analysis, and generalizable findings (Creswell, 2014). In the positivist paradigm, the object of study is independent of researchers; knowledge is discovered and verified through direct observations or measurements of phenomena; facts are established by taking apart a phenomenon to examine its component parts (Krauss, 2005). Quantitative researchers make assumptions about testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings (Creswell, 2014).

A mixed-methods methodology is underpinned by a realism paradigm, which has elements of both positivism and constructivism (Healy & Perry, 2000). Realism is also known as post-positivism (Guba & Lincoln, 1994). While positivism concerns a single, concrete reality and interpretivism multiple realities, realism concerns multiple perceptions about a single, mind-independent reality (Healy & Perry, 2000). Therefore, mixed methods research is an approach that involves collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks (Creswell, 2014). The purpose of mixed methods research is not to replace quantitative or qualitative research but to use each to enhance the strengths and reduce the weaknesses of both methodologies, both in single research studies and across studies (Johnson & Onwuegbuzie, 2004).

In short, different methods of research allow the means whereby we can understand different phenomena, through their application. The methodology employed must align with the particular phenomenon of interest. By focusing on the phenomenon under examination, researchers can select appropriate methodologies for their enquiries (Krauss, 2005).

Research Strategy and design

Published empirical studies that have investigated effective PBL facilitation and the role of PBL facilitators in all fields were considered. Using titles and descriptors, the following key words were searched for: Problem based learning, PBL facilitation, PBL tutor role, effective PBL facilitation. The period from which the studies were selected covers the last 20 years (1994-2014) and examines patterns in current practices in PBL facilitation studies. The selection criteria were that studies should relate to effective PBL facilitation, and reported in English. To extract the data, all articles were merged in the Mendeley, a web program for managing and sharing research papers, discovering research data and providing reference management tools. In the initial screening, duplicates were removed and all identified abstracts were manually reviewed for the applicability of the predetermined criteria. The full text manuscripts of relevant articles were obtained electronically for assessment. Information extracted from the full text manuscripts was recorded in a literature review matrix which included the following data: title, author, year, research objectives, methodology, results and conclusion.

Analysis of Results

The first-named author conducted a systematic review of relevant databases for articles about PBL facilitation. Fifty five articles were found relevant for this study. Three broad classifications were used for summarising the methodologies adopted within the papers as follows:

- (1) Quantitative –methods that were rooted in a positivist research paradigm.
- (2) Qualitative –methods that were rooted in an interpretative research paradigm.
- (3) Mixed methods – comprising a combination of both quantitative and qualitative research methods.

The results of the analysis are presented in Tables 1, Table 2 and Table 3.

Table 1: Broad classification of research methods reported for the past two decades.

| | Quantitative | Qualitative | Mixed Methods |
|--------------------------|--------------|-------------|---------------|
| No of papers (1994-2004) | 11 | 6 | 2 |
| No of papers (2005-2014) | 10 | 19 | 7 |
| Increase in % | (9%) | 68% | 71% |

Table 1 shows the number of papers using the methods embodied by the broad classifications listed above. This shows that of the 55 papers analysed, 21 used quantitative methods and 25 used qualitative methods exclusively. In addition, a further 9 papers used a mixed methods approach. It can be seen that in the past ten years, there has been a significant increase in the number of paper adopting qualitative and mixed methods approaches (68% and 75% respectively). On the other hand, the numbers of research papers based on quantitative methodologies has decreased by 9%.

Table 2: Classification of research methods reported in papers using qualitative methods

| | Interviews | Focus group interviews | Observation | Document or textual analysis | Video Analysis |
|---------------|--|------------------------|-------------|------------------------------|----------------|
| No. of papers | 14 (1: structured 13: semi-structured) | 5 | 4 | 7 | 3 |

Table 2 presents a breakdown of the types of research methods employed by those using qualitative methods and mixed methods approach. This table reflects the frequency this method was applied across the sample of papers. It is apparent from this table that the use of semi-structured interviews is significantly high.

Interviews may take several forms; they may be structured, semi-structured or unstructured (Woods, 2011). In a structured interview, researchers ask a predetermined set of questions, using the same wording and order of questions as specified in the interview schedule (Kumar, 2011). It is the most controlled interview with restrictive questioning which leads to restrictive answers (Woods, 2011). It can also be insensitive to participants' need to express themselves.

On the other hand, semi-structured interviews are less controlled, and are often used when researchers want to delve deeply into a topic and to understand thoroughly the answers provided (Harrell & Bradley, 2009). Here, an interview guide is used, with standardised questions and topics that must be covered. Researchers have flexibility to probe by asking further questions relevant to the purpose of the research and to ensure that appropriate material is covered. The main advantages of semi-structured interviews include standardisation of the questions, which increases data reliability, and the ability to ask some spontaneous questions whereby the participants feel the need to express themselves (Woods, 2011).

The use of thematic analysis of the interview data and written responses is quite high. Table 3 shows the breakdown of data analysis techniques used for qualitative research. Out of the 25 qualitative papers assessed, 11 employed thematic analysis, 8 employed content analysis whereas 5 papers did not provide details of the data analysis process applied.

Table 3: Qualitative Data Analysis Techniques

| | Content Analysis | Thematic Analysis | Others |
|--------------------------|------------------|-------------------|--------|
| Data Analysis Techniques | 9 | 11 | 5 |

Content analysis uses a descriptive approach in both coding of the data and its interpretation of quantitative counts of the codes. By using content analysis, it is possible to analyse data qualitatively and at the same time quantify the data (Vaismoradi, Turunen, & Bondas, 2013). On the other hand, thematic analysis moves beyond counting explicit words or phrases and focuses on identifying and describing both implicit and explicit ideas. Thematic analysis is flexible and provides a rich and detailed, yet complex, account of the data (Braun & Clarke, 2006).

Table 4 shows the classification of PBL facilitation studies according to disciplines. The majority of the studies originate from medical and health science which comprises 76% of the research. The remainder of the studies come from other disciplines such as engineering, education, business and statistics. This demonstrates that since its first introduction in 1969 (Barrows & Tamblyn, 1980), PBL is still an approach being used significantly in medical and health science disciplines.

Table 4: the classification of PBL facilitation studies according to disciplines

| | Health Science | Engineering | Others |
|------------------------------|----------------|-------------|--------|
| | 41 | 7 | 6 |
| (Percent within parenthesis) | 76% | (13%) | (11%) |

What is of significance is the results indicate important shift in research methodologies applied to the study of teaching approaches used to better understand PBL, in this case specifically to PBL facilitation. Researchers are increasingly employing qualitative and mixed research as the methodological approach to better understand PBL facilitation and possibly teaching approaches more generally. It is argued that qualitative research is able to address questions of relevance to teachers and students conceptions about PBL facilitation, which are difficult to answer satisfactorily using quantitative methods alone. In addition, qualitative approaches provide opportunities to be innovative and creative, and adopt a literary-style of writing that individuals may like to use (Creswell, 2014).

Overview of Significant articles

Over the past twenty years, a plethora of PBL literature has been published that specifically focuses on effective facilitation and the role of facilitators. Most of the early literature relates to PBL in undergraduate medical education and health science, however, the recent publications see an increase in PBL facilitation studies from other disciplines including engineering and education. This section describes the significant articles that utilised Quantitative, Qualitative and Mixed Method approaches in PBL facilitation studies.

Rating Scale (Quantitative)

Since the early 1990s, the studies of PBL facilitation typically utilised a quantitative methodology, relying on the use of rating tools to assess facilitator performance. Few studies have investigated actual tutor behaviors and processes. Most studies of PBL tutors focus on

what facilitators ought to do rather than on what they actually do or why they do it. This is clearly shown by the considerable number of published studies describing these rating tools and tutor evaluations.

For instance, Schmidt & Moust (1995) developed program evaluation survey questionnaires which contains ten items that measure three separate constructs: (1) social congruence - five items, (2) cognitive congruence – three items and (3) tutorial group functioning – two items. The items included for example: “The tutor showed interest in our personal lives”, “The tutor used his subject matter knowledge to guide the group” and “The tutor displayed an understanding of our problems with the subject matter”. This study proposed a theory of the characteristics of an effective tutor. Schmidt and Moust (1995) concluded that cognitive congruence, where facilitators communicated in a language that was understandable to students, and social congruence, based upon good interpersonal relationships were key factors in the PBL process.

De Grave et al., (1999) developed a Tutor Intervention Profile (TIP) that measures tutor interventions in stimulating elaboration, directing the learning process, stimulating integration, and stimulating interaction and individual accountability. First and second year undergraduate medical students were asked to rate facilitators according to 33 statements using a five point Likert scale. The results were then analysed and classified to provide profiles of poor, average and excellent tutors. The results show a tutor stressing the learning process was perceived as more effective than a tutor stressing content.

Similarly, Dolman et al., (2003) developed a questionnaire with 22 items. These items were derived from modern theories on student learning and emphasised the importance of creating a powerful learning environment. These theories imply that teachers should stimulate students towards constructive, self-directed, contextual and collaborative learning and should demonstrate adequate interpersonal behaviour. The questionnaire responses provide rich feedback indicating strong and weak aspects of a teacher’s performance in guiding small groups. This initially developed and validated questionnaire contained three-to-five items for each factor. Students’ complained about the length of the questionnaire. This prompted Dolmans & Ginns (2005) to review and shorten the questionnaire while retaining acceptable levels of reliability and validity. The original 22 items were reduced to 11. Based on the study findings, it can be concluded that this short instrument is valid and reliable and more convenient for students.

The development of the teaching style inventory (TSI) with 35-items questionnaire by Leung et al., (2003) was based on four types of teaching behaviours: the assertive, suggestive, collaborative and facilitative styles. Tutors in this study scored the highest in the collaborative domain and lowest in the assertive domain. This shows that the tutors fulfilled their role as effective PBL tutors. In the real world, a teacher may exhibit all four kinds of teaching behaviours. Teachers only differ in the extent of each domain or in using different teaching styles to in different teaching situations.

The questionnaire used in the study conducted by Budé et al., (2011) had 19 items consisting of statements that students used to rate various aspects of teaching and learning on a five point Likert-scale. The statements covered the course itself, the statistical problems used in meetings, tutorial meetings, the performance of tutors in stimulating understanding, and three more traditional aspects related to the general functioning of tutors, with respect to facilitation of groups and learning processes. Results showed that the subjective perceptions of the students with regard to the course, the tutor, and the discussions in the tutorial meetings were more positive in guided conditions. The quality of the problems used in the meetings and general tutor functioning were evaluated as equal in both conditions. Achievement was marginally higher in the guided condition. The study concluded that directed tutor guidance is an effective addition to when PBL was used in a Statistics Course.

Turan et al., (2009) developed an instrument (The Hacettepe Tutor Evaluation Scale) to determine students’ and tutors’ views of the tutor role. Items were rated on a five-point Likert

scale ranging from 1 “strongly disagree” to 5 “strongly agree”. The scale contained 22 items over 4 dimensions. Dimension 1 - Supporting the Learning Process and Metacognitive Knowledge (9 items), Dimension 2 - Conducting PBL (6 items), Dimension 3 - Communication and Supporting Students’ Autonomy (4 items) and Dimension 4 - Assessing and Giving Feedback (3 items). All the statements received high scores and the results demonstrated that the tutors required the skills and attitudes for “supporting the learning process and metacognitive knowledge” and “assessing and giving feedback”.

In summary, all the instruments described in this section have a common purpose which is to measure key aspects of the performance of a facilitator in PBL sessions by using quantitative approaches. Haith-Cooper (2003) criticises instruments that have been developed to evaluate effectiveness of facilitator behaviour in that they provide little detail about the specific interventions for specific situations. Moreover, Dolmans et al., (2002), in investigating trends of PBL facilitation research suggests that instead of focusing upon student test scores, future research should comprise qualitative studies to obtain detailed and in-depth knowledge concerning teachers’ conceptions of the tutor role and student learning and provide better insight into interpreting facilitator behaviour.

Qualitative

During the past decade, many researchers have conducted qualitative studies to investigate the effective facilitation of PBL (refer to Table 1). These studies range from what students expect from facilitators, studies on facilitators’ perspectives on effective facilitation as well as studies of both students’ and facilitators’ perspectives on effective PBL facilitation. Examples of such studies are described below.

Students’ perception

Steinert (2004), Ling & Jee (2007) and Mete & Yildirim Sari (2008) conducted qualitative studies to investigate students’ perception of effective PBL facilitators in medicine, polytechnic courses and nursing respectively. Steinert (2004) conducted focus group interviews and found that students identified tutor characteristics, a non-threatening group atmosphere, clinical relevance and integration, and pedagogical materials that encourage independent thinking and problem solving as the most important characteristics of effective small groups. Tutor characteristics included personal attributes and the ability to promote group interaction and problem solving. Small group teaching goals included opportunities to ask questions, to work as a team, and to learn to problem solve.

Ling & Jee (2007) collected data via 25 final year students’ self-reflections at the end of the first PBL problem scenario in the middle of the semester; a written questionnaire completed by students individually, and focus group interviews. These findings reveal students’ perceptions of good PBL facilitation and show that they appreciated more guided questions, more constructive feedback on research done and more affirmation and encouragement. It also appears that in the final year of their tertiary education, students required minimal help with group processes and self-reflection.

Focus group semi-structured interviews were also conducted in Mete & Yildirim (2008) study. Findings from this study reveal that individual tutor characteristics were classified under seven headings: individual characteristics, asking questions, expertise, giving information, group dynamics, giving feedback and evaluation. Students also clearly reported that tutors’ behaviour affected their motivation and success.

Facilitator’s perception

Some of the qualitative studies of teachers’ perceptions were conducted by Jung et al., (2005), (Hendry, 2009) and Aarnio & Lindblom-Ylänne (2014). In the study by Jung et al. (2005), thirteen novice tutors were interviewed in a qualitative, ethnographic study to identify their learning needs and culture at the entry phase of ‘becoming a tutor’. Ten tutor mentors

were also interviewed to provide additional information and perspectives regarding the data generated by the novice tutors. Categories that emerged were: (1) benefiting from the experience, (2) managing the challenges, (3) transitioning to a new role, (4) uncovering learning opportunities, (5) maintaining vigilance, and (6) explicating the implicit. The overarching framework that wove the categories together was that of the theme of storytelling in the teaching–learning process. Implications for practice for tutor training were addressed, including emphasis on meetings, dialoguing and sharing of stories between the novice tutor and tutor mentor in order to facilitate a positive and educational entry of the novice tutor into the culture of tutoring in a PBL programme; and access to resource materials that identify instrumental information such as ‘tips for tutoring’, and information on professional content and pedagogy.

Hendry (2009) had explored PBL tutors’ conceptions of their role and how they grow and develop as tutors. In this study, a range of conceptions of increasing complexity emerged. Tutors conceived of their role in the simplest way as enabling equal contribution of all students to the group’s discussion. Higher levels of conception involved steering the discussion in appropriate directions, and making learning easier for students by identifying key questions and issues. Hendry (2009) concluded that the most effective way to help teachers become better PBL tutors may be to require their participation in a systematic program of academic development.

Aarnio & Lindblom-Ylänne (2014) used video-taped sessions in a study that aimed at deepening the understanding of tutor facilitation during tutorial discussions. Tutor facilitation was examined in detail in videotaped tutorial sessions with subsequent qualitative interaction analyses. Their findings suggest that tutor training should focus on promoting tutors’ understanding on when to give direct explanations, and when and how to encourage students to collaboratively elaborate on conflicting ideas.

Students’ and Tutors’ Perceptions

The studies by Ates & Eryilmaz (2010) and Lekalakala-Mokgele (2010) adopted qualitative methods to investigate both students’ and tutors’ perceptions of effective facilitation in engineering and nursing respectively. Ates & Eryilmaz (2010) employed a case study design in order to identify and analyze factors affecting the performance of PBL facilitators. Four tutors and fourteen students were selected for the case study. The data were collected by means of observations and interviews. The findings of this study indicated that tutors’ level of adaptation of PBL and their content expertise were commonly mentioned as factors affecting their performance during PBL implementations.

In a study by Lekalakala-Mokgele (2010), using a non-experimental, exploratory, descriptive and contextual design, twelve (12) focus-group interviews were conducted. Data provided evidence that the control of teaching and learning which facilitators brought with them and were unable to relinquish, became a problem for the students. These traditionally trained facilitators experienced difficulties in allowing their students to take charge of their own learning and function in a self-directed manner.

Mixed method

Mohamad et al., (2009) evaluated facilitators’ skills in conducting PBL tutorials by reviewing questionnaires at the end of each PBL tutorial. The information gathered from questionnaires was triangulated through a structured interview with students’ PBL group leaders. The responses for each item were rated as strongly agree, agree or disagree. The results show that more than 99% of students’ perceived facilitators as having good knowledge about PBL processes and that 97% agreed and strongly agreed the facilitators showed interest in students’ learning. During the interviews, students described three categories of facilitators; (i) facilitators who were actively involved in the tutorial process, probing students across the breadth and depth of their knowledge; (ii) facilitators who were dominant and do not allow

free discussion among students and (iii) facilitators who appeared passive and did not provide any guidance to students.

Kassab et al., (2006) compared the self-rated with student-rated teaching styles of PBL tutors. They examined the relationships between the teaching styles of tutors' and students' evaluation of tutor effectiveness in tutorials. Tutors and students' were given a teaching style inventory with a five-point scale consisting of 21 items that comprise four domains of teaching styles (facilitative, collaborative, suggestive and assertive). In addition, quantitative and qualitative evaluations of tutor effectiveness by students were analyzed. PBL tutors perceived their teaching styles in the facilitative and collaborative domain, while students perceived the teaching styles of tutors to be less 'facilitative' and more 'assertive' than tutors' self-ratings. Students perceived the facilitative–collaborative style of tutors as necessary but not sufficient for being an effective tutor. Kassab et al (2006) concluded that there was a mismatch between students' and tutors' perceptions about teaching styles of tutors. Tutor attributes other than teaching styles are seen as important determinants of an effective tutor.

Limitation of this study

The present study has several limitations. Firstly, the examination of these 55 articles does not represent an exhaustive survey of the literature. There may be relevant papers that were not located, because of limitations in the search strings used. Secondly, papers may have been published in journals or conference proceedings not indexed in the databases the first-named author searched. Thirdly, the research papers assessed may not have contained adequate details of the data and methodology used. It may have been difficult to categorise, for example, what type of data analysis techniques was used, whether content-analysis or thematic analysis. Nevertheless, this paper has investigated a wide range of empirical work across PBL facilitation studies in all disciplines. Examination of the patterns identified provides insights into the possible future development of research methodologies in PBL facilitation.

Conclusion

The number of engineering education papers analysed in this study was very modest (13%), but as we grapple with the means of better informing our practice we need to be looking at the means by which we can better inform our practice. The analysis of PBL literature presented above highlights patterns in the methodologies employed in PBL facilitation studies. In the mid-1990s and early 2000s, PBL facilitation literature was primarily quantitative, which assumes the existence of an objective reality and waiting to be discovered. However, for the past decade, there has been a marked increase in the utilisation of qualitative and mixed methods investigations. One conclusion from the literature is that qualitative research is needed to inform PBL practitioners and researchers about different approaches. Qualitative research is able to provide detailed and in-depth knowledge on how different features of tutors' tasks and characteristics can be shaped, facilitated and how they constrain self-regulated learning. This will therefore provide an informative insight into interpreting facilitators' behaviours. In addition, the future development of PBL facilitation research will depend upon the willingness of its research community to see qualitative and quantitative research as complementary rather than competitive and/or mutually exclusive.

Engineering education with its rich history of quantitative research needs to, as with education generally, shift its methodological approach to studies which employ qualitative methods so as to better understand our practice. What is evident from the results reported in this paper is that there is a dearth of understanding of effective PBL facilitation within engineering education. As such the focus of research needs to consider approaches to gain

a better understanding of how we can be more effective facilitators of our students' learning in engineering education.

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