

The potential improvement of team-working skills in Biomedical and Natural Science students using a problem-based learning approach

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ABSTRACT

Teamwork has become an integral part of most organisations today, and it is clearly important in Science and other disciplines. In Science, research teams increase in size while the number of single-authored papers and patents decline. Team-work in laboratory sciences permits projects that are too big or complex for one individual to be tackled. This development requires that students gain experience of team-work before they start their professional career. Students working in teams this may increase productivity, confidence, innovative capacity and improvement of interpersonal skills. Problem-based learning (PBL) is an instructional approach focusing on real analytical problems as a means of training an analytical scientist. PBL may have a positive impact on team-work skills that are important for undergraduates and postgraduates to enable effective collaborative work. This survey of the current literature explores the development of the team-work skills in Biomedical Science students using PBL.

INTRODUCTION

Biomedical and Natural Science comprise many undergraduate degree programmes. They are partly a practical discipline covering a broad knowledge and practice within Science, and they encompass many technical skills which students will use during their education. The ability of the students to master the principles of analytical knowledge is of great importance in their progress within a chosen educational field.

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The term “team” in literature has been defined as a special group of people working interdependently to achieve a goal (Levi, 2010). Teams are a ubiquitous part of most organizations today. Students accordingly need to gain experience of working in teams before starting their professional career. Teamwork is increasingly important in Science and other disciplines. The numbers of single-authored papers and patents are declining and the size of research teams is increasing, particularly in Medical Science and other related educational fields. In these occupations it is common to have a project which is too big or complex for one individual. For these reasons, teaching methods which improves the students’ ability to work in teams are highly desirable.

A great number of university teachers, especially those in the laboratory sciences and related areas, have been using teams in different ways in their courses/classes such as short-and long-term projects and, in addition, it is common for students to work in the laboratory in teams of two people. Benefits of group projects include an increased understanding of group dynamics, an improvement of interpersonal skills and a potential exposure to diverse opinions (Alkaslassy, 2011; Mello, 1993). It accordingly increases productivity, confidence and innovation (Wuchty, Jones, & Uzzi, 2007).

Problem-based learning (PBL) represents a principal change in educational practice within higher education, and it is today an established method of education for medical, health care and analytical Science, world over (Dolmans, De Grave, Wolfhagen, & Van Der Vleuten, 2005). There are many variations on PBL, however the traditional definition emphasises on the learning which comes from the understanding of, or resolution of a problem. In fact, the problem is encountered first in the learning process (Barrows & Tamblyn, 1980). PBL can be very strictly defined as a purely student-centered approach with minimal teacher guidance or a more mixed approached where the teacher guides the process to a greater or lesser degree (Smith, 2005).

LEARNING THEORY UNDERLYING PBL

The learning theories behind successful PBL have been extensively reviewed and discussed for more than 20 years e.g., (Schmidt, et al, 2009; Thurley & Dennick, 2008; Springer, et al, 1999). Briefly, PBL is based on four learning principles. These are that learning is 1) a constructivist process 2) self-directed 3) social and collaborative; and 4) a contextual process (Dolmans, De Grave, Wolfhagen, & Van Der Vleuten, 2005).

Learning should be a constructive process; learning is an active process in which students actively construct or reconstruct their knowledge (Biggs & Tang 2007). The students’ competences will be developed through participating actively in discussion, note-taking or answering questions, and generally talking about a subject. This process plays an important

role in activating prior knowledge and then relating it to the new information. In other words, learners should be involved actively and should be stimulated towards activation of prior knowledge that may lead to deeper and richer understanding and better use of knowledge.

Learning should be a self-directed process; PBL is student centred and based on an active role of the group members. Students should actively participate in planning, monitoring and evaluation of the learning process (Ertmer & Newby, 1996). PBL requires students to take responsibility for their learning, and if they are not motivated to study in an independent way it will impact the progress of the PBL group. Thus motivation plays an essential role in promoting self-directed progress (Pintrich, 1999).

Learning should be a social and collaborative process; PBL is normally carried out within small groups in which two or more people interact with each other; students work together in a team to achieve a common task. However, collaboration is not always a matter of division of tasks among learners i.e. it may involve mutual interaction and a shared understanding of a problem. Thus, they talk, communicate, interact and collaborate (Reimann & Spada, 1996). The social nature is an important trait of PBL and it has been suggested that cooperation leads to more effective problem-solving skills than competitive learning (Qin, Johnson, & Johnson, 1995).

Learning should be a contextual process; Contextual learning theory also relates to constructivism. Learning in a context may support storage and recall of knowledge more easily. In other words, learning is situational and the situation in which knowledge is acquired determines the effective use of this knowledge (Billet, 1996).

Even though PBL may differ in various institutions, it will always be characterized by three features: a) problem as stimulus for learning, b) tutors or teachers as facilitators and c) group work as stimulus for interaction (Dolmans, De Grave, Wolfhagen, & Van Der Vleuten, 2005).

Problem as stimulus for learning; problem refers to a scientific case which should be explored during the course. Students first analyse the problem, decide what they already know about it and then what they need to figure out. Hence they determine what questions are relevant to their enquiry and what actions they need to take. The team members then work independently and research different aspects of the problem before bringing their finding back to the group and to the tutorial session in order to co-construct new knowledge.

Teachers as facilitators; the teacher's main role is to facilitate the tutorials in which they can evaluate student learning, develop students' problem-solving skills and promote critical thinking (Barrows, 1988). The teacher as facilitator role is not to transmit information but rather to facilitate self-directed learning.

Group work as stimulus for interactions; in PBL, problems are discussed in a small group in which students learn from each other by asking and answering questions and by discussing the case which should be explained. Thus the students learn to work together which may help them to become better collaborators (Hmelo-Silver, 2004).

It has been generally assumed that PBL has positive effects on team-working abilities i.e. it prepares students to work with colleagues from different occupations and enhances their knowledge of team work in different aspects. However, research into the impact of PBL on development of team-working skills is limited. The aim of this paper is to review the current literature and discuss the possibility that PBL has the potential to prepare students to work more effectively in teams than other teaching methods, particularly in the natural sciences.

TEAM-WORKING SKILLS AND PBL

PBL was begun in the medical schools and other related occupations as an alternative learning method many years ago, reviewed in (Allen, Donham, & Bernhardt, 2011; Seymour, 2011). It is an approach to learning which can be implemented over a complete program or applied to specific sections.

A problem arises however, in assessing the effect of using PBL compared to traditional, lecture based methods. As mentioned above, the implementation of PBL varies widely from course to course. For example, the case study approaches, although not traditionally a PBL approach does often include many of the features of PBL such as teamwork, problem solving and discussion. One must look carefully at individual reports to determine which variant of PBL is being studied. A second problem that arises is contextual. It is clear from the literature that skilled tutors or facilitators have better outcomes than unskilled tutors. Individual student groups also may have more or less success with the methodology. It has been argued that because a change to a PBL format changes so many variables, that simple comparisons to traditional methods will be ineffective (Dolmans & Gijbels, 2013; Norman & Schmidt, 2000).

Overall, however, positive outcomes for PBL are noted, firstly, with student satisfaction or interest, and to a lesser degree with long-term application of knowledge e.g., (Albanese & Mitchell, 1993). What is often also cited is that PBL increases the students' ability to work in teams. Although this is a commonly desired skill by employers, it is vaguely defined, therefore effort has been made to define it more precisely.

Skills which are essential for working within a team can be divided into two categories: task-directed skills which focus on to completing the final product, and socio-emotional- oriented skills which are involved in maintaining the team processes (Prichard & Stanton, 1999). The first category consists of the skills in searching for relevant information, resource investigation and planning. The second category comprises the skills such as the ability to

deal with conflict, support and encouragement of others and communication within team and between teams (Wheelan, 2005).

The importance of the team member personality on the team effectiveness has been debated (Driskell, Goodwin, Salas, & O'Shea, 2006), the matter is quite complex and its explanation depends on the definition of personality and effectiveness. However, many studies have attempted to define the relationship between team-member personality and team effectiveness. The following personality characteristics: emotional stability, extraversion, openness, agreeableness, and conscientiousness have been related to team success (Barrick, Stewart, Neubert, & Mount, 1998; Barry & Stewart, 1997; Hollenbeck et al., 2002; Neuman & Wright, 1999). Furthermore, Cannon-Bowers et.al. have integrated a great range of studies and have proposed that eight features are needed for effective team work, i.e. adaptability, team awareness, performance monitoring and feedback, team management, interpersonal relations, coordination, communication and decision making (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995). Within these dimensions lie many task-oriented and socio-emotional skills and behaviours. These complex skills however, do not develop by simply gathering students in groups to work on projects (Prichard & Stanton, 1999) but these skills are likely improved when students are practicing them in an appropriate learning program such as PBL.

Communication and negotiation are common social skills practiced within PBL. When you are working together as a team to reach the same goal it is really important that you can negotiate with each other, communicate what you can bring to the team and what others can bring to the team as well. To learn through PBL you need to be able to speak up otherwise you are not really contributing and you should also have an opinion and not be afraid to give it. The ability to make decisions and time management are task-orientated skills that often improve through PBL (Seymour, 2011).

Although it may seem obvious that giving the students the chance to practice working in a team in the more protective atmosphere of the university should have a positive effect on the students' ability to work in teams in the future, direct evidence for this is sparse. In large part this is likely because it is difficult to measure team-working skills. The few studies that have directly addressed the impact of PBL on team-work are generally positive however.

A qualitative study undertaken by Stern et al. (Stern, 1996) in therapy education that was based on group interviews, individual interviews and course evaluation questionnaires has shown that PBL enhanced the personal behaviours such as interpersonal communication and team work. The course was short (a seven-week course) and thereby probably not long enough to give an appropriate evaluation of PBL effects. Although, another report investigating a full PBL program suggested that PBL contributes to development of communication and team-building skills, information management, critical reasoning and

students are trained for an effectively collaboration with colleagues from different professional groups (Hammell et al., 1999).

Some studies have suggested that graduates of PBL medical schools have better interpersonal abilities, communication and the team-working abilities and also some task-specific talents such as planning and organisation and leadership (Prince, Van Eijs, Boshuizen, Van Der Vleuten, & Schuerpbier, 2005). Notably, non-hierarchical nature of PBL group is an important character that prepares an environment where group members feel safe to practice new team-working skills. Students' confidence and critical thinking will accordingly be improved (Seymour, 2011).

Several researchers have looked at self-reported outcomes of PBL-based medical education and saw significant effects on teamwork. Prince, et al (Prince, et al., 2005) surveyed a large number of graduates of medical schools in the Netherlands and found the young doctors reported significantly better preparation in the areas of profession-specific skills, communication and teamwork if they had attended a PBL programme. Watmough, et al (Watmough, Cherry, & O'Sullivan, 2012) reported that medical school graduates reported being significantly better prepared for teamwork than their traditional counterparts in a British study done 6 years after graduation. Similarly, a study by (Schlett et al., 2010) of graduates of medical schools (8-10 years after graduation) in Germany using PBL felt they were better prepared for several professional skills, such as teamwork, than did graduates of conventional medical schools.

FUTURE PERSPECTIVES

One area where the increase in teamwork in a PBL setting could be very useful and is generally underutilized is the laboratory. At our university, natural science and biomedical undergraduate and postgraduate students have a great deal of laboratory classes (as much as 20 hours/week). Students are usually organised in a team with 2-4 members, working together during the laboratory. According to the layout of the laboratory experiments the different tasks are distributed between the team members. Thus, the use of a learning method that improves the team-working skills would be very useful.

Often students complain that the laboratory programs are dull and it is difficult to connect the theoretical concepts to the laboratory experiences. Many of the experiments in our laboratory program are not experiments; they are determination of a question. Other laboratory exercises are demonstrations designed to simply illustrate some aspect of an analysis. Thus, the outcome of the laboratory work did not influence intellectual interest of students but only affected their grade.

One approach to address these concerns are inquiry based laboratories which are closely related to the PBL approach. Inquiry based laboratories start with the problem and require the students to think about the problem, design experimental approaches and then do the analysis. They are generally a more guided form of PBL due to practical limitations. Studies have shown that inquiry laboratories have increased student motivation and better student outcomes e.g., reviewed in (Wood, 2009). If one made an effort to include more PBL type group work structure in the inquiry based lab, one might be able to increase the students' ability to work in teams as well. One example of this approach is described in (Larive, 2004) where a business-like approach to hiring students into group roles was utilized. As mentioned in the introduction, team-work has become the standard in modern biomedical research and improving our students skills in this area would improve their future prospects.

CONCLUDING REMARKS

Data on the impact of PBL on the development of team-working abilities is limited. Most studies are qualitative and they do not give a comprehensive description of how these skills are developed (Norman & Schmidt, 2000). The difficulty with evaluating the effectiveness of PBL may be due to the fact that it is not only regarded as a teaching method but also as a philosophy of teaching thus it is practised differently in various institutions (Norman & Schmidt, 2000). Thus, it is difficult to compare data gathered from one program or course with another see e.g. (Dolmans & Gijbels, 2013) for a discussion of some of these issues). However, the studies that have been conducted indicate a generally favourable effect on team-working abilities when students are taught in a PBL environment.

In conclusion, this work focused on collecting data from current literatures regarding development of students' personality and professional team-working skills through using PBL. There was a great agreement that PBL enhances communication, negotiation, collaboration, independency, confidence, making decisions, management and organisation skills. Since these characters are prerequisites for the effectiveness of a team. PBL is accordingly an appropriate learning method especially in analytical educations in which the team working is fundamental.

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