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Project-based learning: A review of the literature

Dimitra Kokotsaki
Durham University, UK

Victoria Menzies
Durham University, UK

Andy Wiggins
Durham University, UK

Abstract

Project-based learning (PBL) is an active student-centred form of instruction which is characterised by students' autonomy, constructive investigations, goal-setting, collaboration, communication and reflection within real-world practices. It has been explored in various contexts and in different phases of schooling, from primary to higher education. The majority of the reviewed studies were based on a quasi-experimental pretest–posttest design with some baseline equivalence established but no random allocation of participants to control and experimental groups, and as a result, a causal link between PBL instruction and positive student outcomes cannot be established with certainty. Modern digital technology, group processes of high quality, teachers' ability to effectively scaffold students' learning and provide guidance and support, the balance between didactic instruction with in-depth inquiry methods and well-aligned assessment have been identified in the literature as facilitating factors in the implementation of PBL. The article concludes with six key recommendations considered to be essential for the successful adoption of a PBL approach in the mainstream school setting.

Keywords

Collaboration, communication, constructivism, goal-setting, inquiry-based learning, project-based learning, reflection

Defining characteristics of project-based learning

Project-based learning (PBL) is a student-centred form of instruction which is based on three constructivist principles: learning is context-specific, learners are involved actively in the learning process and they achieve their goals through social interactions and the sharing of knowledge and

Corresponding author:
Dimitra Kokotsaki, School of Education, Durham University, Leazes Road, Durham DH1 1TA, UK.
Email: dimitra.kokotsaki@durham.ac.uk

understanding (Cocco, 2006). It is considered to be a particular type of inquiry-based learning where the context of learning is provided through authentic questions and problems within real-world practices (Al-Balushi & Al-Aamri, 2014) that lead to meaningful learning experiences (Wurdinger, Haar, Hugg, & Bezon, 2007). Blumenfeld, Fishman, Krajcik, Marx, and Soloway (2000), for example, described the process of project-based science as follows:

> The presumption is that students need opportunities to construct knowledge by solving real problems through asking and refining questions, designing and conducting investigations, gathering, analysing, and interpreting information and data, drawing conclusions, and reporting findings. (p. 150)

PBL as a form of instruction has clear connections with other pedagogical approaches, such as problem-based learning among others (Helle, Tynjälä, & Olkinuora, 2006). The focus in both is for participants to achieve a shared goal through collaboration. In their engagement with a project, students can encounter problems which need to be addressed in order to construct and present the end product in response to the driving question. The main difference between the two is that whereas students in problem-based learning are primarily focused on the process of learning, PBL needs to culminate in an end product (see also Blumenfeld et al., 1991). PBL has also been compared with other pedagogical practices such as experiential or collaborative learning. As Helle et al. (2006) argue, project work is a collaborative form of learning as all participants need to contribute to the shared outcome and has elements of experiential learning with active reflection and conscious engagement rather than passive experiences being essential. This study focuses on a review of the relevant literature on PBL as defined above looking at relevant studies internationally that seek to evaluate benefits to learning. It concludes with six key recommendations considered to be essential for the successful adoption of a PBL approach in the mainstream school setting.

It has been argued that the freedom and challenge that students experience as a result of solving the problems that arise in designing and building their projects result in high levels of student engagement (Wurdinger et al., 2007) due to the cognitive challenge as well as the strong affective, ethical and aesthetic dimensions that form part of a well-designed project (Wrigley, 2007). Thomas (2000) identified five essential characteristics of projects: (1) Centrality, (2) Driving question, (3) Constructive investigations, (4) Autonomy and (5) Realism, with the importance of student collaboration, reflection, redrafting and presentations emphasised in other publications (Kwon, Wardrip & Gomez, 2014; Patton, 2012). The uniqueness of PBL is the construction of an end product, a ‘concrete artefact’ (Helle et al., 2006) which represents students’ new understandings, knowledge and attitudes regarding the issue under investigation often presented using videos, photographs, sketches, reports, models and other collected artefacts (Holubova, 2008).

It is argued that it can help foster self-regulated learning and can promote pupils’ conceptual knowledge within a systematic process of documenting and reflecting on learning (Barak, 2012). Students learn to be self-reliant through goal-setting, planning and organisation; they develop collaboration skills through social learning and become intrinsically motivated by being encouraged to exercise an element of choice while learning at their own level (Bell, 2010). PBL has been explored in various contexts and in different phases of schooling, ranging from the early stages of education through primary and secondary school to higher education.

Overview of the evidence for the effectiveness of PBL

Most of the reviewed studies did not involve random allocation of participants to control and experimental groups, and as a result, a causal link between PBL instruction and positive student outcomes cannot be established with certainty. The majority of these studies were based on a quasi-experimental pretest–posttest design with some baseline equivalence established for the outcomes measured at the classroom level. Some studies of weaker quality were based on observations of students' behaviour, attitudes and accomplishments in a PBL environment without the presence of a comparator group (e.g. Barak & Asad, 2012; ChanLin, 2008; Cuevas, Lee, Hart, & Deaktor, 2005; Morales, Bang, & Andre, 2013). Other studies have used state standardised test averages against which to compare the performance of seventh-/eighth-grade students (Geier et al., 2008) and 12th-grade students (Schneider, Krajcik, Marx, & Soloway, 2002).

Sweller, Kirschner, and Clark (2007) have emphasised the importance of randomised controlled experimental studies of different instructional procedures to provide stronger and more reliable evidence on the effectiveness of PBL.

Pre-school and primary school

Implementation of a project-based concept mapping developmental programme to facilitate children's experiential reasoning and comprehension of relations (Habok, 2015) reported positive results for the experimental group that attended one of the two kindergartens in Hungary. In particular, although the experimental group started with a disadvantage in achievement, there was a significant increase in this group's development compared to the control group. Habok concluded that the use of concept maps in school practice holds promise as a visual expression tool in promoting understanding of connections and causalities. Another study with pre-school science teachers in Sweden (Ljung-Djärf, Magnusson, & Peterson, 2014) argued that a learning study project model (a kind of action research that combines variation theory with the concept of lesson study) has the potential to promote pre-school science.

In their quasi-experimental study on the effectiveness of PBL in primary school in Greece, Kaldi, Filippatou, and Govaris (2011) argued that primary age pupils can develop content knowledge and group work skills in addition to motivation and positive attitudes towards peers from a different ethnic background through PBL instruction. Similarly, Karaçalli and Korur (2014) conducted a quasi-experimental study in Turkey with fourth-grade science students (equivalent to Year 5 in the United Kingdom) and found a statistically significant effect in terms of academic achievement and retention of knowledge for the PBL students. A US study that explored the effectiveness of a project-based approach in second-grade (equivalent to Year 1 in the United Kingdom) social studies and content area literacy (Halvorsen, Duke, Brugar, Berka, & Brown, 2012) reported positive outcomes for low socioeconomic status (SES) students and claimed that the PBL approach has the potential to help narrow the gap between low- and high-SES students in social studies and literacy for second-grade students. The study employed a 'design or formative experiment approach' (p. 10) where six teachers and a subset of their students participated in the study. Two teachers were from high-SES schools and four teachers from low-SES schools. The teachers in the low-SES schools implemented project-based units in their teaching which were developed by the researchers. In addition to student assessments, data were also collected through classroom observations and teacher interviews. The study had a number of limitations, such as a small sample size (N= 10–12 from each class with 43 children in low-SES and 20 children in high-SES classrooms), lack of a control group and researcher-designed assessment measures that may be less reliable and valid in comparison with other published standardised measures.

Secondary school

Al-Balushi and Al-Aamri (2014) conducted a quasi-experimental study with 62 11th-grade female students (equivalent to Year 12 in the United Kingdom) in Oman that explored the effect of environmental science projects on students' environmental knowledge and attitudes towards science. Two classes were randomly assigned into an experimental group and a control group. The findings were positive, with the experimental group significantly outperforming the control group in the Environmental Knowledge Test and the Science Attitudes Survey. The authors acknowledged, however, that a novelty effect could not be ruled out as students' enthusiasm in the experimental group in using new technology to design their products could have led to the more positive results in the posttests.

In history learning, Hernández-Ramos and De La Paz (2009) had eighth-grade students in the United States (equivalent to Year 9 in the United Kingdom) learn to create multimedia mini-documentaries in a 6-week history unit. Compared to students who received traditional instruction, students who engaged in the PBL curriculum demonstrated positive affective benefits and significant gains in content knowledge as well as historical thinking skills. This was a quasi-experimental study using a pretest–posttest design, and there was no random allocation of students or teachers to control and experimental conditions. Therefore, it cannot be inferred with certainty that the knowledge gains are necessarily the result of technology-enhanced PBL at the intervention school as other teaching and learning activities could have contributed to the positive results.

Another quasi-experimental study carried out in the United States (Hsu, Van Dyke, Chen, & Smith, 2015) explored seventh graders' (equivalent to Year 8 in the United Kingdom) development of argumentation skills and construction of science knowledge in a graph-oriented computer-assisted PBL environment. A significant difference in science knowledge, counterargument and rebuttal skills was found in favour of the treatment condition. In another US study, Geier et al. (2008) reported that seventh- and eighth-grade students who participated in project-based inquiry science units showed increased science content understanding, better process skills and significantly higher pass rates on the statewide test over the remainder of the district population.

Boaler (1998) conducted a longitudinal study of mathematics instruction comparing an open, project-based environment to a traditional approach, and it followed two cohorts of students in two British secondary schools from Year 9 to Year 11. Although this study did not involve the random allocation of participants, it employed a closely matched control group in terms of SES, prior mathematics instruction and attainment. A variety of instruments were used to measure students' skills, attitudes and attainment. The main finding was that the two groups developed different forms of knowledge. The students learning mathematics in the project-based environment developed conceptual understanding which often required creative and deeper thinking in contrast to the procedural knowledge acquired by the traditional instruction group which was mainly based on information recall. In addition, more students at the project-based school succeeded in passing the General Certificate of Secondary Education (GCSE) at the end of the 3-year study than those students receiving the traditional instruction.

Other studies have shown higher learner motivation in a PBL environment, with 14- and 15-year-old girls in Israel showing increased interest in learning scientific-technological subjects (Barak and Asad, 2012). PBL as related to STEM (science, technology, engineering and mathematics) curriculum design for female senior high school students in Taiwan led to gains in terms of enjoyment, engagement with the project and the ability to combine theory and practice effectively (Lou, Liu, Shih, & Tseng, 2011). This study was an in-depth investigation of 84 students' cognition, behavioural intentions and attitudes in the project-based STEM environment and involved text analysis and questionnaire survey as the main data collection tools.

The 10- to 11-year-old students in ChanLin's (2008) qualitative study in Taiwan developed skills in synthesising and elaborating knowledge and in engaging in scientific exploratory tasks with the use of technology. PBL has also been explored as a method of instruction with low-achieving students in Israel (Doppelt, 2003) and the United States (Cuevas et al., 2005) and with second chance school students in Greece (Koutrouba & Karageorgou, 2013) with positive outcomes. Doppelt (2003) found that scientific-technological PBL helped improve low-achieving students' motivation and self-image by allowing students to succeed early on in the process and led to more students achieving the college admittance requirements. Doppelt's study was a field research project that used qualitative and quantitative tools (portfolio analysis, observations, interviews, matriculation examination results and assessment of students' projects) with a sample of 54 10th- to 12th-grade students (15–18 years old).

Encouraging results were also reported with high school high achievers in Israel where 60 students from three experimental classes in comprehensive high schools exhibited a significant increase in formal technological knowledge and skills and more positive attitudes towards technology in comparison with the students in the three control classes which were drawn from technological high schools (Mioduser & Betzer, 2008). However, the different types of schools involved suggest differences in student take-up and characteristics and indicate an unequal student comparison which limits the strength of the findings. Some studies have shown mixed results. For example, in their quasi-experimental study with 13-year-old children (Grade 8) taking computer courses in Greece, Boubouka and Papanikolaou (2013) found no significant effect of PBL on student achievement but a statistically positive effect on self-perceived learning performances.

PBL studies in higher education and in pre-service teacher training

A number of studies have explored the effectiveness of PBL in higher education in different countries. Most of these studies have focused on engineering education. For example, Ruikar and Demian (2013) made links with industry engagement through multimedia podcasting in the United Kingdom; Hassan et al. (2008) adopted an integrated, multicourse, PBL methodology in electronic engineering in Spain; and Fernandes, Mesquita, Flores, and Lima (2014) followed the project-led education model developed by Powell and Weenk (2003, cited in Fernandes et al., 2014) to engage students in learning at a University in Portugal. In Australia, Stewart (2007) investigated the link between self-directed learning readiness and PBL outcomes in a postgraduate management course and found that self-directed learning readiness, such as having high self-management skills, was a key enabler for achievement learning outcomes from PBL. Another study (Gibbes & Carson, 2014) investigated project-based language learning using Activity Theory in a university language programme in Ireland. This study reported mixed results in learning outcomes for the study participants because of contradictions found in the activity system (e.g. inequitable divisions of labour, perceived lack of time due to community obligations or opposition to the rules governing the activity in the modules).

Some studies have applied the principles of PBL with pre-service teachers and claimed that student-teachers can become better problem-solvers (Mettas & Constantinou, 2008), can gain benefits from formative assessment (Frank & Barzilai, 2004) and become more aware of the object of learning which can then lead to enhanced learning among pre-school children (Ljung-Djärf et al., 2014).

The review of the literature indicated certain factors that can help facilitate the adoption of project-based teaching instruction in the classroom. These are summarised in the section that follows.

Facilitating factors in the implementation of PBL instruction

On the basis of their study and findings, Al-Balushi and Al-Aamri (2014) concluded that project-based instruction is not more demanding than traditional instruction in terms of resources and time and can be implemented with few resources, inside the school building and within the time allocated for the study of particular topics.

Modern digital technology is a major enabler for students to comfortably engage with the process of designing and developing their project as they can document the whole process and easily share their creations in a digital format (Patton, 2012). Effective use of technology as an integrated part of the pedagogical processes has been found to help both weakly and strongly performing students construct knowledge in the PBL environment (Erstad, 2002). However, Bell (2010) points out that children need to be guided and supported in using technology safely and effectively to gain the creativity affordances that technological involvement can offer.

Furthermore, group processes of high quality (conceptualised as group members showing positive interdependence, individual accountability, equal participation and social skills) have been found to play a pivotal role to the success of collaboration in PBL (Cheng, Lam, & Chan, 2008). High-quality group work becomes even more important when challenges associated with social class differences, gender and attainment hierarchies have been found to affect power relations among some students in the PBL group, leading to unequal learning possibilities with some pupils enjoying more agency than others (Crossouard, 2012). Crossouard argues that teachers need to be better supported, both within initial teacher education and continuing professional development, to develop more sensitivity towards the social and gendered hierarchies that can often be implicit in pupils' discourse, particularly in relation to peer assessment interactions. Issues of social equity can thus become part of the pedagogic focus and the language used in the classroom in order to explore social relations.

The successful implementation of PBL in the classroom lies on the teacher's ability to effectively scaffold students' learning, motivate, support and guide them along the way. Effective scaffolded instruction within high-quality experiences will help reduce students' 'cognitive load' (Hmelo-Silver, Duncan, & Chinn, 2007), will enable them to make small successful steps and ultimately achieve 'cognitive growth just beyond their reach' (Bell, 2010, p. 41). Leaving scope for learner control of the learning process is crucial with teachers and students having to work together to reflect upon the purpose of the project, set clear and realistic goals and make decisions regarding the pace, sequencing and content of learning (Helle et al., 2006). In scaffolding students' learning, teachers may need to give students insight into the content of the desired response in PBL in order to allow them to recognise and take up the learning opportunities afforded in the classroom (Gresalfi, Barnes, & Cross, 2012). Based on their case study findings in the United States, Grant and Branch (2005) concluded that the exploration of cross-disciplinary units and team teaching should be emphasised so that students can understand how their abilities can be used across domains and avoid the fragmentation of skills and knowledge.

The level of support that teachers get from the school's senior management (Erstad, 2002) and from other colleagues is of particular importance. Lam, Cheng, and Choy (2010) concluded that when teachers felt well supported by their schools in terms of their competence and autonomy, they were more motivated to implement and persist in using PBL.

The use of a two-phase project-based approach has been put forth in the literature as an effective approach to first help the students become sufficiently competent by developing the knowledge and skills needed to then be able to design and make products independently in the second phase (see, for example, Drain, 2010; Good & Jarvenin, 2007). Drain (2010) used the Cognitive Apprenticeship framework which, on the basis of situated cognition theory, claims that learning is maximised when it occurs in real-life contexts and students engage with authentic problems. This was a case study of a primary school class (Year 5) in New Zealand and their teacher during a technology unit. The first part of the unit aimed to help pupils develop knowledge of technological concepts and procedures through appropriate activities, while the second half enabled pupils to be creative and exercise initiative in designing and creating their projects. The importance of balancing didactic instruction with in-depth inquiry methods has also been emphasised by Grant and Branch (2005). Student assessment needs to be aligned to the unique features of the PBL process and outcomes, with teachers identifying suitable assessment moments where they can first generate 'teachable moments' (Lehman, George, Buchanan, & Rush, 2006) and then create formative scaffolds to guide and support their students along the project process (Hmelo-Silver et al., 2007). Assessment in PBL has been described as 'authentic' (Bell, 2010, p. 43) which, in addition to measuring a child's performance via rubrics, primarily focuses on reflection, self and peer evaluation. Self-assessment skills can help students learn to regulate their own learning and acquire ownership of the learning process (Ertmer & Simons, 2005).

How teachers can support PBL in the classroom – what the evidence shows

Mergendoller and Thomas (2005) interviewed 12 expert teachers in PBL in the United States to elicit the teachers' strategies for implementing and managing the project, and maximising its success. These teachers were recognised as experts within the national PBL community; they had trained other teachers and had made presentations on PBL at various professional conferences and workshops. A total of 43 questions formed part of the semi-structured interview schedule and covered aspects of overall planning and project planning, carrying out the project and the future of project work in the classroom. The interview transcripts were coded into narrative segments that led to themes about aspects of project implementation such as time management, getting started and managing student groups. This analysis revealed a number of successful techniques employed by expert teachers in PBL and were grouped around seven overarching themes and 18 sub-themes. Each sub-theme comprised a number of principles or guidelines which aim to provide practical advice to teachers and are summarised below under each theme:

1. *Time management* - This theme relates to scheduling projects effectively by coordinating project schedules with other teachers, for example, or using block scheduling to increase flexibility, and being able to hold to timelines by building in a 20 percent overrun when planning a project or learning when to enforce and when to extend a time line.
2. *Getting started* - This theme is about orienting students, that is, getting them think about the project well before they begin, giving them a rubric that clearly explains what they are expected to search for and try to accomplish and jointly agreeing on grading criteria before the start of the project. The 'getting started' theme is also about encouraging thoughtful work early on in the project in developing a research plan and a suitable research question while facilitating a sense of mission.
3. *Establishing a culture that stresses student self-management* - Here, responsibility is shifted from the teacher to students where they are involved in project design, they make decisions for themselves and they are encouraged to learn how to learn.
4. *Managing student groups* - The emphasis is on establishing the appropriate grouping pattern, promoting full participation and keeping track of each group's progress through discussion, monitoring and recording evidence of progress.
5. *Working with others outside the classroom*, such as other teachers, parents and people from the community, in order to work out the feasibility and nature of external partnerships.
6. *Getting the most out of technological resources*, such as judging the suitability of using technology for the project, making efficient use of the Internet by being encouraged to make informed choices in exploring relevant web sites and developing critical thinking skills.

7. *Assessing students and evaluating projects* - This final theme refers, first, to the importance of grading students by using a variety of assessment methods, including individual and group grades and giving emphasis to individual over group performance and, second, to adequately debriefing projects by demonstrating reflection strategies and collecting formative evaluation information from students about the project and how it might be improved.

Starting from the premise that project-based teaching assumes significant changes in classroom practices, Krajcik, Blumenfeld, Marx, and Soloway (1994) described how teachers can learn to address the new challenges presented through the dynamic interplay of three elements in middle school science teaching: teachers' *collaboration* with consultants and university personnel to share and critique ideas, plans and teaching activities; *classroom enactment* where teachers plan and carry out new practices in the classroom in an attempt to construct and generate understandings about what is possible in their classroom, modify their thinking and adopt the most appropriate teaching strategies; teachers' *reflection* on their teaching via journals, case reports or videotapes of classroom implementation to develop the knowledge that will help promote student learning.

Recommendations made on the basis of the evidence

On the basis of the literature review, the following six key recommendations can be made which are considered to be essential for the successful adoption of a PBL approach in the mainstream school setting:

1. *Student support*: Students need to be effectively guided and supported; emphasis should be given on effective time management and student self-management, including making safe and productive use of technological resources.
2. *Teacher support*: Regular support needs to be offered to teachers through regular networking and professional development opportunities. The support from the school senior management is crucial.
3. *Effective group work*: High-quality group work will help ensure that students share equal levels of agency and participation.
4. *Balancing didactic instruction with independent inquiry method* work will ensure that students develop a certain level of knowledge and skills before being comfortably engaged in independent work.
5. *Assessment emphasis on reflection, self and peer evaluation*. Evidence of progress needs to be regularly monitored and recorded.
6. An element of *student choice and autonomy* throughout the PBL process will help students develop a sense of ownership and control over their learning.

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