Web 2.0 Technologies Supporting Problem-Based Learning: A Systematic Literature Review

Erhan Ünal *

ABSTRACT

The purpose of this study was to investigate the study general trends with regards to Web 2.0 technologies supporting problem-based learning (PBL) environments. A systematic literature review was applied to analyse studies published in this area, with a total of 18 articles included in the review. The content analysis method was applied in the study. The results indicated that the emergence of studies in this area was in 2007. The studies were conducted in different research domains. The qualitative research paradigm was the most frequently used, and higher education students the most preferred study group in the articles. Wiki was the most integrated Web 2.0 tool in PBL environments. Interview was the most selected data collection tool, with qualitative analysis methods the most used in the articles. The variables investigated the most in the studies were perception about the effectiveness of PBL and achievement. The effectiveness of Web 2.0 technologies supporting PBL was the most frequently reported finding. Therefore, the current study was able to identify the recent trends in this research area. Based on the results, the study put forward suggested implications for future research.

Keywords: Web 2.0 technology, problem based learning, systematic review.

INTRODUCTION

Problem-based learning (PBL) first emerged in the 1970s at McMaster University in Canada. The need for PBL was that students at the university's medical faculty had become disinterested with the traditional methods of learning, and were experiencing difficulties in transferring their gained knowledge to the real world. Therefore, PBL was

* Erhan Ünal, Faculty of Education, Department of Computer Education and Instructional Technology, Afyon Kocatepe University, Afyonkarahisar, Turkey
  Email: eunal@aku.edu.tr

first implemented in the medical curriculum as a means to overcome those problems (Barrows, 1996). Since PBL first emerged, it has since been developed and implemented across different education contexts and from K-12 through to the institutions of higher education. However, with the advent of technology, computers and other related tools, known collectively as cognitive tools (Jonassen & Reeves, 1996), can all be utilised within the PBL environment. Therefore, researchers have integrated different technological tools such as virtual worlds (e.g., Beaumont, Savin-Baden, Conradi, & Poulton, 2014; Good, Howland, & Thackray, 2008), online chat applications (e.g., Donnelly, 2010; Hashim et al., 2017), 3-D technologies (e.g., Omale, Hung, Luetkehans, & Cooke-Plagwitz, 2009), online course management systems (e.g., Baturay & Bay, 2010; Delialioğlu, 2012), and dynamic web technologies (e.g., Huang, Huang, Wu, Chen, & Chang, 2016; Jaffar, 2012) into the PBL environment. According to literature based on technology-enhanced PBL environments, Web 2.0 technologies have been investigated in a number of studies. Therefore, the primary focus of the current study was to systematically review published studies that were conducted in the field of Web 2.0 technologies supporting PBL environments.

Problem-Based Learning

PBL is an instructional method based on experiential learning (Hmelo-Silver, 2004). 'PBL is the learning that results from the process of working toward the understanding or resolution of a problem' (Barrows & Tamblyn, 1980, p. 1). PBL is an instructional method in which students are confronted with authentic problems, and in which they learn knowledge through the problem-solving process (Hung, Jonassen, & Liu, 2008). According to the definitions of PBL, learning is a problem-solving process. In PBL, students should become active learners in order to solve problems. When students are presented with a problem, they work in groups, analyse the problem, determine what they know about the problem and which knowledge is needed to solve the problem, synthesise the knowledge, and then attempt to solve the problem (Hmelo-Silver, 2004; Jonassen, 1997). As a theoretical basis, PBL is grounded on constructivism. According to the learning principle of constructivism, knowledge is socially co-constructed based on the individual's interpretation of the external world (Jonassen, 1997), and students' construction of knowledge is an active process (Duffy & Cunningham, 1996). In this regard, students should participate in PBL activities such as problem analysis; communication and collaboration with students, teachers, and others; studying resources; and, actively generating discussion with other students.

Problem-Based Learning and Web 2.0 Technologies

In PBL activities, technology usage in the PBL environment is an important issue. In this regard, Web 2.0 technologies are considered a good option to support the PBL environment due to their various advantageous aspects (Thomas & Li, 2008) being consistent with the learning principles of PBL. Different Web 2.0 technologies such as collaborative tools, audio tools, video tools, and image-based tools can be used in support of learning in the PBL environment. Students can utilise Web 2.0 technologies in order to search for information, access resources, communicate and collaborate with their student peers and teachers, as well as generally interact with other students, resources, and teachers during the PBL activities.

In the literature, a number of studies have been conducted with regards to the use of Web 2.0 technologies in the PBL teaching and learning environment. Researchers have undertaken such studies based on different Web 2.0 technologies. For example, Robertson (2008) incorporated wiki technology to design a blended PBL environment, with wikis used in order to support problem-based and group-based learning and assessment. In another study, Lo (2009) used blogs, wikis, and instant messaging tools within the online PBL environment to accomplish various steps of PBL. Similar to Lo's study, Pardo and Kloos (2009) used a learning management system within a PBL environment, incorporating modules on discussion, wikis, and file storage. Students then applied these modules within the PBL process. Duncan (2009) used wiki technology within an online PBL environment, with students using wikis to facilitate the learning process in PBL. In another study, Tambouris et al. (2012) developed a platform for usage in a PBL environment that was based on the affordances of Web 2.0 such as collaboration, sharing, support, and discussion, in which the students evaluated the platform with respect to four courses. In a more recent study, Virtanen and Rasi (2017) integrated blogs, interactive online wall and board functionality, a chat tool, and a mind-mapping tool into the PBL process of a course on Moving Images in Teaching and Learning. The tools were used within the different steps of PBL for the storing, production, and sharing of the course content. Considering these various interrelated studies, it could be said that the features of Web 2.0 tools are in congruency with the principles of PBL, and that such studies tend to focus on the integration of these tools into the PBL teaching and learning environment. Therefore, researchers have conducted their studies on integrating Web 2.0 tools with PBL according to the context.

Although there have been several studies about using Web 2.0 technologies in the support of PBL, to the researcher's knowledge there has been no systematic review performed with regards to this topic area that has examined articles related in terms of their methodology, study group, and educational contributions. However, there are reviews about how web 2.0 technologies are used in education. For example, Conole and Alevizou

(2010) published a report reviewing studies from the perspective of Web 2.0 technologies' benefits and limitations in higher education. Liu, Kalk, Kinney, and Orr (2012) analysed conference papers published from 2007 to 2009 related to the use of Web 2.0 technologies in higher education, and a focus on the educational purposes of Web 2.0 technologies in higher education. Cheston, Flickinger, and Chisolm (2013) conducted a review about the use of social media in medical education, focussing their study on the methodologies, social media tools involved, and the educational output in that context. In another study, Hew and Cheung (2013) reviewed the literature about the use of Web 2.0 technologies for teaching and learning in both K-12 and higher education. The researchers examined published studies in terms of the Web 2.0 tools used, as well as research discipline, learning objectives, and pedagogical approach. In a study by Tsai and Chiang (2013), the researchers analysed empirical online PBL studies in SSCI-indexed journals published between 2004 and 2012.

Summarily, it can be seen that the literature has mostly focused on the educational contributions of Web 2.0 technologies in learning environments. Therefore, the researcher considers it would be useful to conduct a systematic review regarding the topic of Web 2.0 technologies supporting PBL environments as systematic review studies can provide vital information to researchers about the current direction and trends of research in the area (Kitchenham, 2004). Therefore, the current study aims to be of significance in helping researchers to understand the current situation, new trends, and potential future research areas with regards to Web 2.0 technologies supporting PBL. Additionally, policymakers could utilise this study's results to develop future plans for integrating Web 2.0 technologies into PBL environments.

Purpose of the Study
The purpose of the current study was to investigate the general trends in Web 2.0 technologies supporting PBL studies indexed in the Web of Science and ERIC databases between 2004 and 2018. The following research questions were addressed in the study:

1. What is the distribution of the studies by years?
2. What is the distribution of the studies by research domain?
3. What research paradigms and methods are most commonly used in the studies?
4. What Web 2.0 technologies are most commonly used in the studies?
5. What sample groups are most commonly preferred in the studies?
6. What data collection tools are most commonly preferred in the studies?
7. What analysis methods are most commonly preferred in the studies?
8. Which variables do the studies most commonly investigate?
9. What findings do the studies most commonly report?

METHOD

A systematic literature review was applied in order to analyse studies published on Web 2.0 technologies supporting PBL. Systematic literature review is 'a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest' (Kitchenham, 2004, p. 1). Therefore, the following review process was adopted from the literature (Kitchenham, 2004; Moher et al., 2015).

Search Strategy
1. The researcher identified the databases upon which the search for articles would be performed, and the types of articles that were being sought. The search was conducted based on the Web of Science database with journals indexed as SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, or ESCI and ERIC database. The reasoning behind the researcher's selection of these indexes was their known hosting capacity for high quality and relevant studies. Additionally, many reviews are known to have been published related to technology usage in educational settings (e.g., Hew & Cheung, 2013; Tsai & Chiang, 2013) based on similar database searches.

2. The article publication time period for the selected database searches was determined to be from February 2004 to February 2018 (performed as of 28 February, 2018). The reason for the search start being set as 2004 was the acknowledged emergence of Web 2.0 technologies having occurred in that year.

3. Keywords were identified and used within the advanced search function of each database. The primary keywords related to the topic were problem-based learning and Web 2.0 technologies. However, some authors had used different terms such as PBL instead of problem-based learning or social network instead of Web 2.0 technologies. Therefore, Boolean operators (And, Or) were applied in order to return more accurate results using the advanced search functionality. Searches were therefore performed using the aforementioned terms as (("problem based learning" OR "PBL" OR "problem-based learning" OR "problem-based" OR "problem based") AND ("web" OR "web 2.0" OR "dynamic web" "social media" OR "social network")).

Study Selection (Inclusion and Exclusion Criteria)
Once all the primary search results had been obtained from the selected databases, the inclusion and exclusion criteria were then determined by the researcher based on the research questions of the current study.

1. Articles were only included where they were based on the integration of at least one Web 2.0 tool into a PBL environment. According to this criterion, articles which only used PBL or Web 2.0 technologies in the learning environment, and not both, were excluded from the study.

2. Only published articles related to the topic were included in the review. Conference papers, editorials, reviews, or book chapters were excluded from the study in order to retain only high quality peer-reviewed published articles for the study.

3. Access was required to the full text of each article, and the article publication language was selected as English. Therefore, articles deemed to be published as 'abstract-only', were unable to be freely accessed, or where the publication language was other than English were excluded.

The first search yielded a total of 490 articles from the Web of Science database, plus a further 79 from the ERIC database. After scanning the titles and abstracts of each of the returned papers, a total of 222 papers from the Web of Science database and 46 from the ERIC database were initially selected to be included in the current study's review.

Next, the full text of each article (222 from Web of Science and 46 from ERIC) were examined in detail by the researcher. The reason for certain articles then being rejected included not having incorporated Web 2.0 technology integration in a PBL environment. Furthermore, as Boolean operators (And, Or) were applied to the search process, some of the articles included Web 2.0 technology integration in PBL environments, whilst others did not. Those articles which did not incorporate at least one Web 2.0 tool within a PBL environment were therefore excluded from the study.

When the inclusion and exclusion criteria was applied, the majority of the articles were found to have been rejected and therefore excluded from the study. In total, 18 articles (13 from the Web of Science and five from ERIC) were deemed to have fully met the current study's inclusion criteria and were selected for review (see asterisked items in the References section).

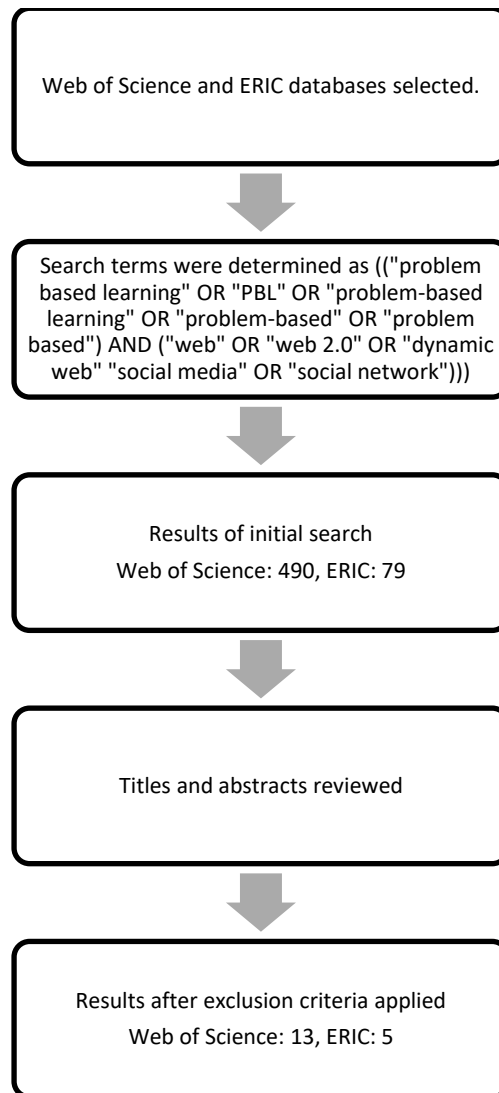A summary of the data collection process is illustrated in Figure 1.

Figure 1: Data collection process

Data Coding and Analysis

In order to examine the selected articles in detail, the article review forms developed by Zheng, Huang, and Yu (2014) and Goktas et al. (2012) were adapted according to the research questions of the current study. The adapted article review form was then reviewed by two experts from the field of instructional technology in terms of its appropriateness and convenience. Based on the expert views received, the final article review form consisted of article identification tag, research domain, research paradigm, research method, Web 2.0 tool(s) (used in the article), sample group, data collection tool(s), data analysis method(s), dependent variable(s), and findings. Each of the sections of the form and their corresponding categories are explained in Table 1.

Section	*Category*
Article identification tag	• Title
	• Year
	• Keywords
	• Index
Research domain	• Natural Science (i.e., science, maths, physics, chemistry, biology, geography, environmental science, astronomy, architecture)
	• Social Science (i.e., politics, education, psychology, linguistics, art, law, literature, archaeology, philosophy)
	• Engineering & Technological Science (i.e., engineering, computer science)
	• Medical Science (i.e., health, medicine)
Research paradigm	• Qualitative
	• Quantitative
	• Mixed
Research method	• Experimental
	• Survey
	• Causal comparative
	• Case study
	• Phenomenological
	• Grounded theory
	• Action research
	• Explanatory design
	• Exploratory design
	• Triangulation design
	• Meta-analysis
	• Review
Web 2.0 tool(s)	• (as per the used Web 2.0 technology(ies) used)
Sample group	• Preschool education students
	• Primary education students
	• Secondary education students
	• High school students
	• Undergraduate students
	• Graduate students
	• Non-formal education learners
	• Teachers/Instructors/Academics
Data collection tool(s)	• Survey (e.g., attitude, perception, aptitude, personality tests)
	• Achievement/Performance Test

	• Observation
	• Interview
	• Data form (i.e., discussion transcripts, email, messages, video records, audio records, log data, think-aloud protocols, screens records)
	• Alternative measurement tools (i.e., performance test, diagnosis, concept map, portfolio)
	• Document
	• Reflection
Data analysis method(s)	• Descriptive (i.e., frequency, percentage, mean, standard deviation, graphical representation)
	• Inferential (i.e., correlational, *t*-test, ANOVA, ANCOVA, MANOVA, MANCOVA, factor analysis, regression-based, non-parametric test)
	• Qualitative analysis method (i.e., content analysis, descriptive analysis)
Dependant variable(s)	• Achievement
	• Perception
	• Motivation
	• Satisfaction
	• Other
Finding(s)	• (as per written outcomes according to findings and results)

Table 1: Sections of the article review form

The articles were analysed according to each section and their corresponding categories. Then, the data were coded using a form created in Google Forms by the researcher. The data were examined based on the content analysis method, which is a systematic technique for reducing text into more manageable data and then classifying the data into categories (Weber, 1990). For the purposes of ensuring the reliability of the data assessment, the researcher reviewed each of the articles at different times in order to achieve an acceptable level of get consistency. Furthermore, the researcher sought additional expert views for the article review process. Therefore, a reliable review process was deemed to have been conducted. Finally, frequencies and graphics were prepared in order to support the presentation of the results.

RESULTS AND DISCUSSION

Distribution of Studies by Years

According to the distribution of the articles by years, Web 2.0 technologies have been used in PBL environments since 2007 (see Figure 2). After the emergence of Web 2.0 technologies in 2004, integration of these technologies into PBL environments was seen in the subsequent years. However, the distribution of articles based on the use of Web 2.0 technologies in PBL environments over the years was found to be fairly consistent.
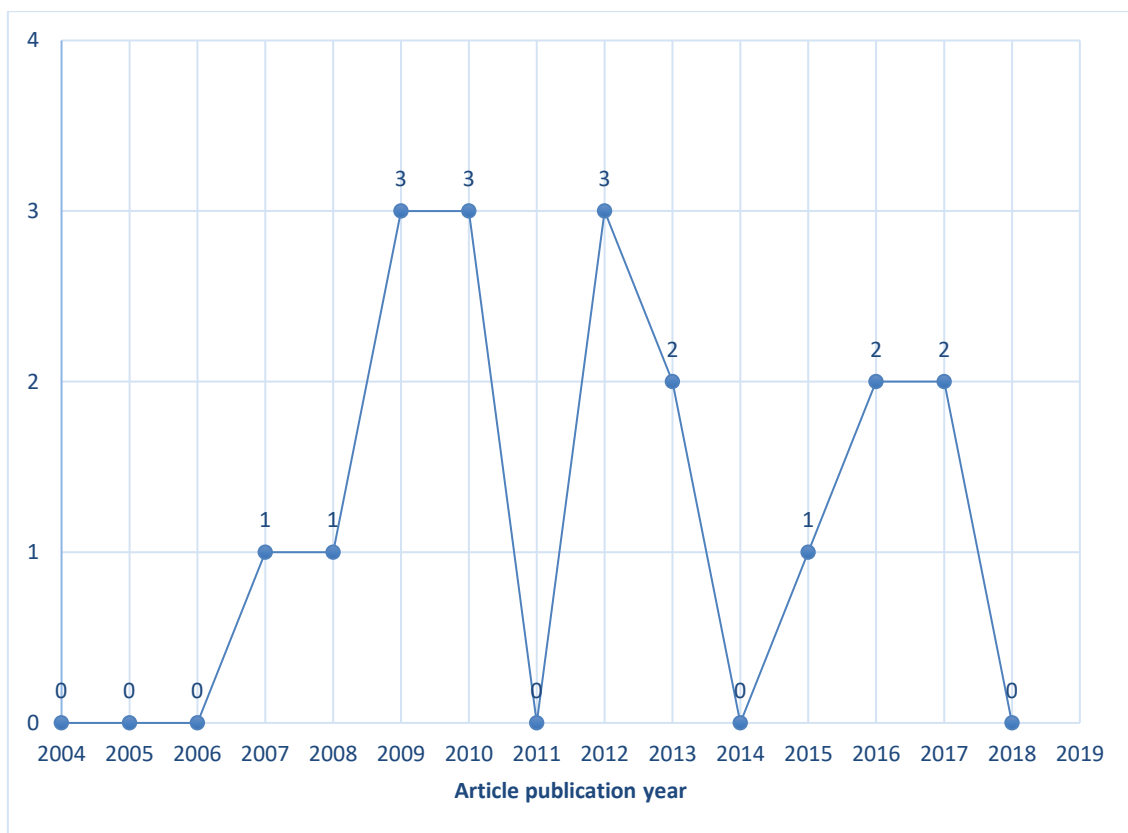

Figure 2: Distribution of articles by year of publication

Research Domain

Studies about Web 2.0 technologies supporting PBL environments were most commonly conducted in the Social Science ($f = 8$) research domain, followed by Medical Science ($f = 6$), Natural Science ($f = 3$), and Engineering & Technological Science ($f = 1$) (see Figure 3). PBL was first implemented in the field of medicine (Barrows, 1996), and has since been developed and implemented across different educational contexts. PBL has been shown to prepare learners to face real-world challenges (Hung et al., 2008), as well

as Web 2.0 technologies changing the learners role from passive to active learners in the learning process (Thomas & Li, 2008). The advantages of PBL and Web 2.0 technologies can lead researchers from different disciplines to conduct studies about Web 2.0 technologies supporting PBL environments. Therefore, it can be said that PBL environments supported by Web 2.0 technologies can be designed and investigated within different domains.
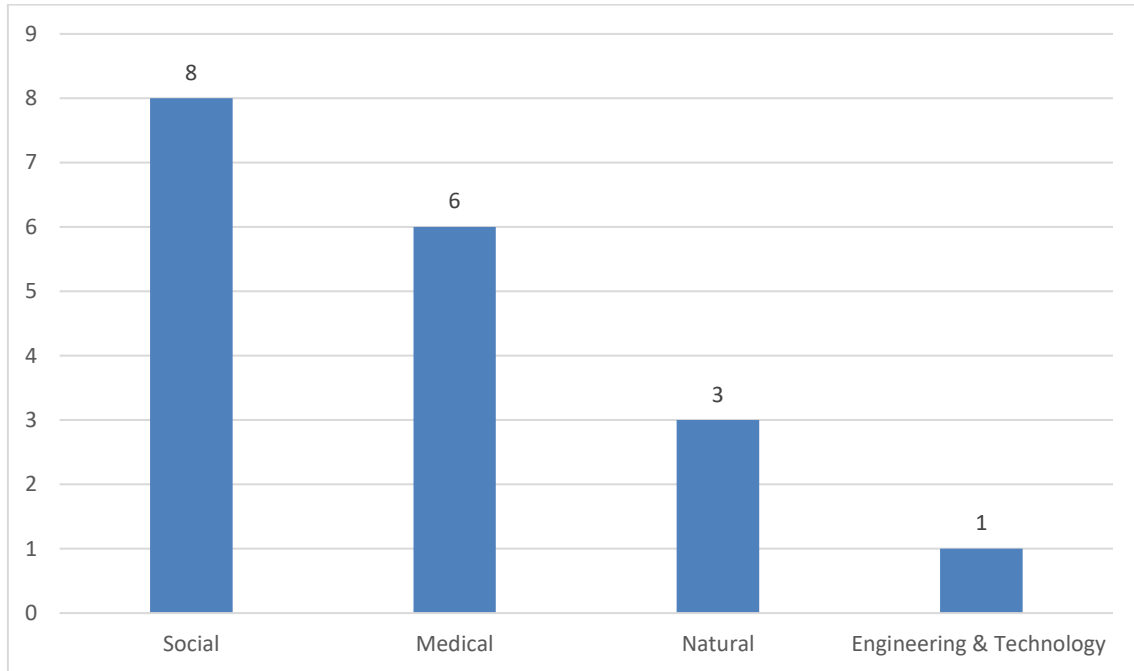

Figure 3: Number of articles by research domain

Research Paradigms and Methods
Most of the articles were conducted within the qualitative research paradigm ($f = 9$). However, mixed method ($f = 6$) and quantitative research paradigms ($f = 3$) were found to have been less preferred in the reviewed articles (see Table 2).

Research Paradigm	Method	f	Total
Qualitative	Case study	6	9
	Phenomenological	1	
	Not specified	2	
Mixed	Triangulation (quantitative + qualitative)	6	6
Quantitative	Experimental	1	3
	Causal comparative	1	
	Survey	1	

Table 2: Research methods and designs used in the studies.

On the other hand, when the research methods used in the articles were examined in detail, case study method ($f = 6$) was the most preferred among the quantitative paradigm. The phenomenological method ($f = 1$) was used in one article, while no method of study was mentioned in two articles. The triangulation method ($f = 6$) was preferred within articles conducted on a mixed methods basis. For the quantitative research studies, the experimental method ($f = 1$), causal-comparative method ($f = 1$), and the survey method ($f = 1$) were each seen in one article.

The case study method may have been preferred in the articles in order to investigate the effectiveness of Web 2.0 technologies supporting PBL environment. This method is often used in order to reveal the features of a learning environment, as well as to detect how the learning environment is seen and perceived by the participants (de Jong, Verstegen, Tan, & O'Connor, 2013). On the other hand, it was found that the triangulation method was used among mixed method research, and researchers used experimental design and qualitative research methods together. Thus, researchers were able to evaluate the effectiveness of Web 2.0 technologies supporting PBL environments and the effect of the environment on educational outcomes (e.g., Kay & Kletskin, 2012; Williams, Woodward, Symons, & Davies, 2010).

Finally, it was found that quantitative research methods were less frequently preferred in the articles. This finding contradicts with previous findings in the literature (Kucuk, Aydemir, Yildirim, Arpacik, & Goktas, 2013; Simsek et al., 2009). However, there is a need for further experimental studies about the topic (Kay & Kletskin, 2012; Pietikäinen, Kortelainen, & Siklander, 2017). Since experimental research attempts to reveal a cause-effect relationship between variables (Fraenkel, Wallen, & Hyun, 2012), the effect of Web 2.0 supporting PBL environments on educational outcomes could be investigated through an experimental design within a more controlled environment.

Web 2.0 Technology
Wiki ($f = 9$) was found to be the most preferred Web 2.0 technology reported in the reviewed studies. However, other tools such as blogs ($f = 4$), Skype/MSN ($f = 3$), discussion boards ($f = 2$), micro blogs (e.g., Twitter) ($f = 2$), Facebook ($f = 2$), and Backchannel chat or chat ($f = 2$) were found to have been integrated into PBL environment in fewer numbers of articles. Video podcasts, online mind-mapping tools, Backchannel tools, interactive whiteboards, YouTube, and interactive online wall tools were seen only once in the examined articles (see Figure 4).
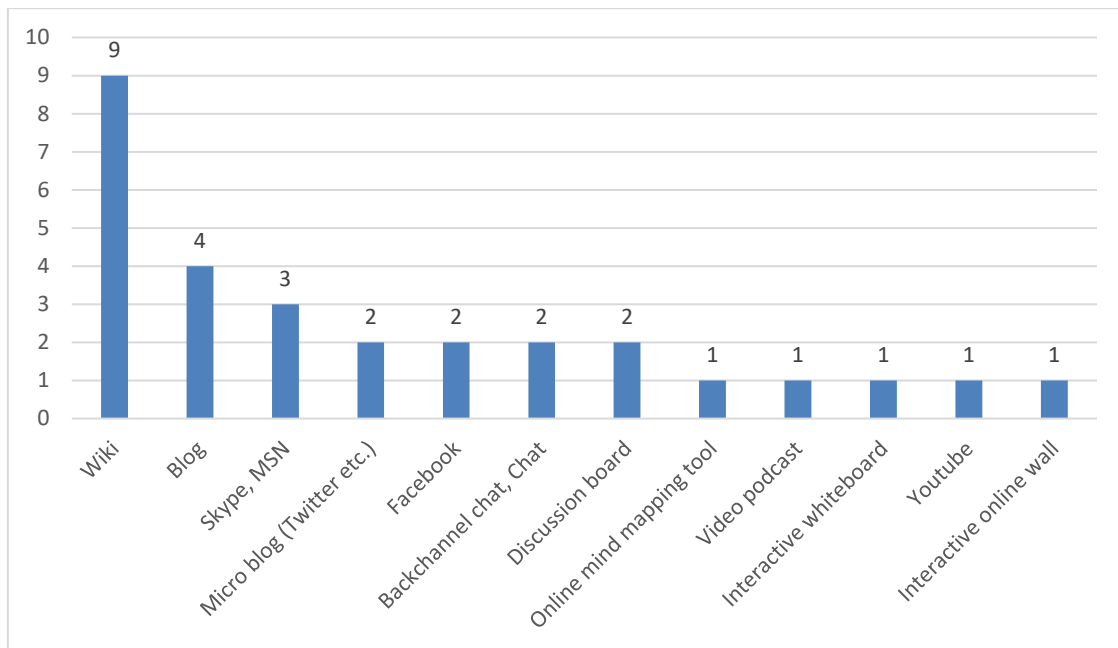
Figure 4: Web 2.0 tools used in studies

The reason why wiki technology was seen to be used more than other technologies within PBL environments may be that wiki as a tool allows for collaborative working. Collaboration is necessary within PBL during the process of knowledge construction (Doolittle & Camp, 1999; Schunk, 2012). It has also been seen in the literature that wikis can have an impact on the knowledge construction of learners (Biasutti, 2017; Fong, Chu, Lau, Doherty, & Hew, 2017; Matschke, Moskaliuk, & Kimmerle, 2013; Neumann & Hood, 2009). Additionally, social networks such as blogs, discussion boards, and Facebook were used in the PBL environments. The discussion environment facilitated by these tools can contribute to the social construction of knowledge. The other aforementioned Web 2.0 tools were also used within different PBL activities.

Sample Groups

Undergraduate students ($f = 10$) were the most frequently studied research sample, which was followed by graduate students ($f = 4$). A few studies were applied to sample groups of secondary school students ($f = 2$) and teachers and instructors ($f = 2$) (see Figure 5).
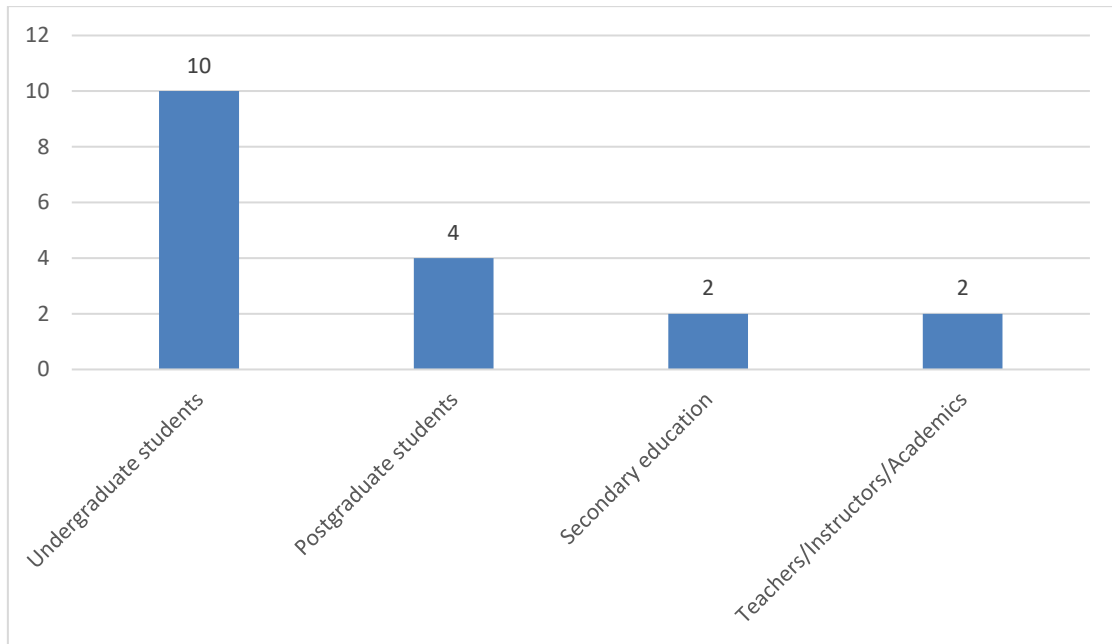
Figure 5: Distribution of sample levels

The finding that undergraduate students were the most studied the sample group is consistent with the literature (Hsu et al., 2012; Kucuk et al., 2013; Şimşek et al., 2009; Tsai & Chiang, 2013; Verstegen et al., 2016). There may be several reasons for selecting undergraduate students as the sample group of a study. First, researchers can readily access undergraduate students as the majority of researchers are university academicians or graduate students. Second, participants should have access to computers and the Internet in studies of Web 2.0 technologies supporting PBL environments. According to European Statistics (2018), 84% of individuals between the ages of 16 and 74 years old have access to computers, and that 87% have access to the Internet. Finally, the design of Web 2.0 technologies supporting PBL environments in higher education can be less challenging than for K-12 education, due in part to the flexibility of designing learning environments at the tertiary level.

Data Collection Tools

Regarding the data collection tools employed in the reviewed articles, it was found that interview ($f = 12$) was the most preferred tool for gathering data. While survey ($f = 10$), achievement/ performance test ($f = 10$), discussion transcripts, e-mail messages, and other records ($f = 9$) were frequently used in the studies, document ($f = 2$) and reflections ($f = 1$) were used in only a few studies to collect the data (see Figure 6).
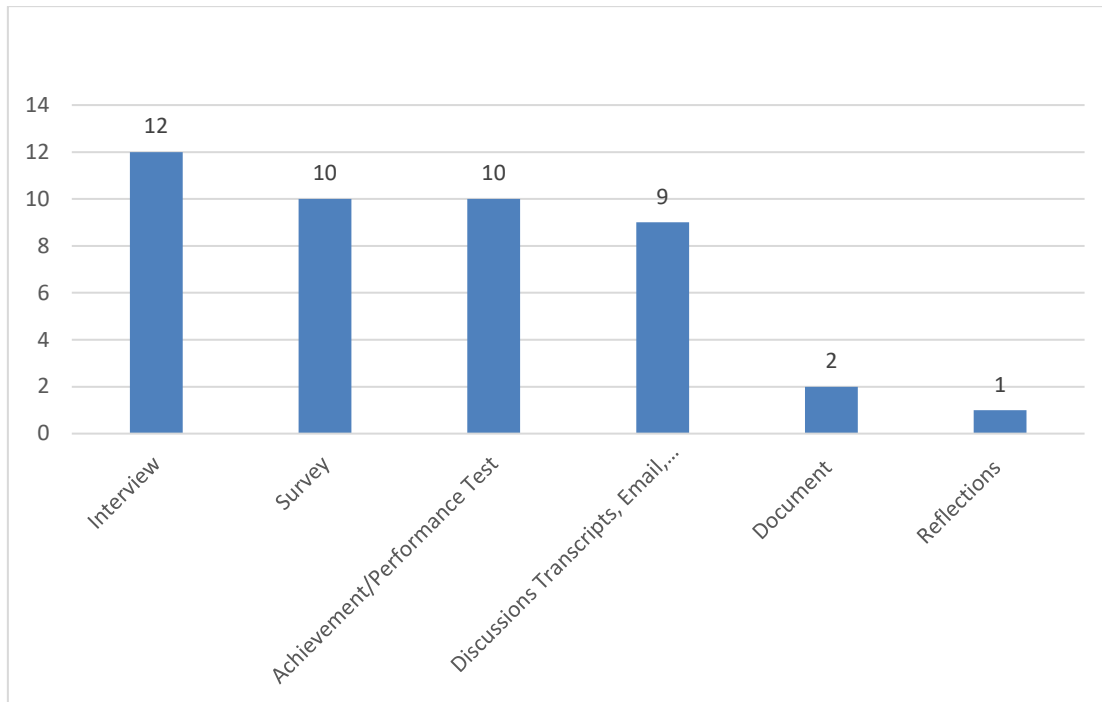
Figure 6: Distribution of data collection tools

Previous research results support the finding that surveys and interviews are employed the most in articles over other tools (Hew, Kale, & Kim, 2007; Kucuk et al., 2013. The reason for using the surveys as a data collection tool can be due to their low application cost, ease of copying, and for collecting data quickly (Baker, 2003). On the other hand, enabling researchers to conduct in-depth data collection can be the reason for conducting interviews as a data collection tool (Bogdan & Biklen, 2007). Achievement/performance test was also found to be widely employed in the articles. Other data collection tools such as discussion transcripts, e-mail messages, and other records were also used. Data such as log files and discussions were also collected from Web 2.0 technologies (e.g., de Jong et al., 2013; Varga-Atkins, Dangerfield, & Brigden, 2010). Document and reflections were only used in a limited number of studies, and in accordance with the research design.

Data Analysis Methods

The qualitative analysis method ($f = 16$) was the most frequently used data analysis method in the reviewed articles, followed by descriptive statistics ($f = 12$) and inferential statistics ($f = 5$), respectively (see Figure 7).
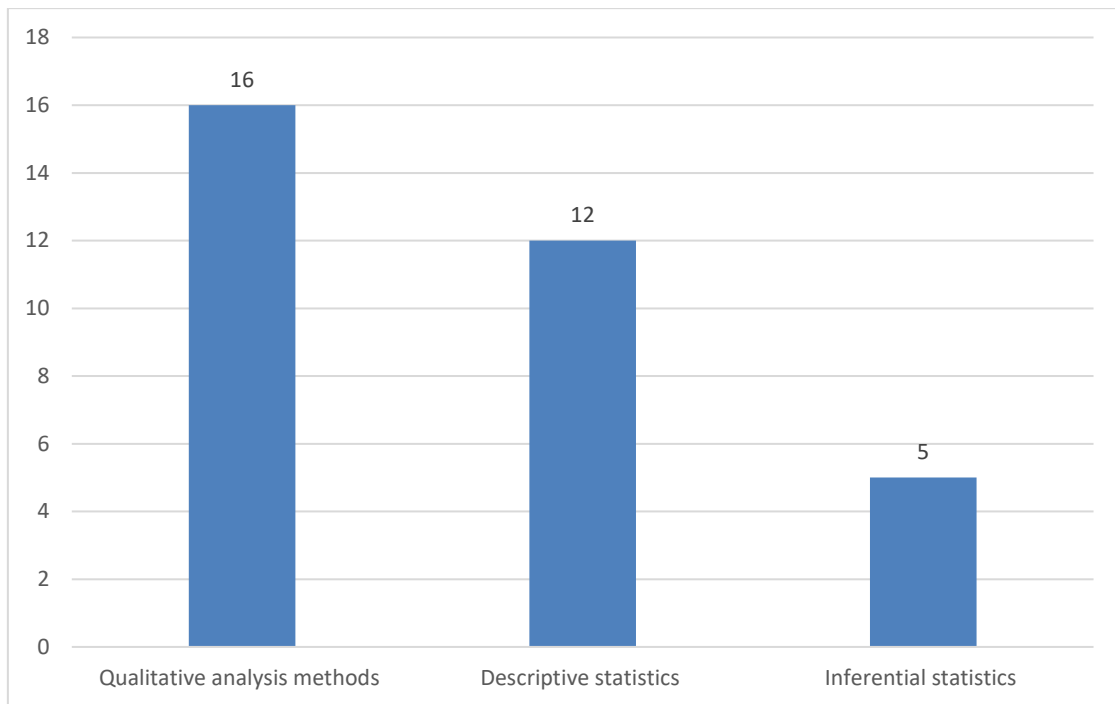
Figure 7: Distribution of data analysis methods

Employment of the qualitative research paradigm over others in the reviewed articles affects the analysis method/s used, hence the qualitative analysis method and descriptive statistics such as percentage, frequency, and average were the most preferred in the articles. This finding is consistent with previous studies (e.g., Hew et al., 2007; Kucuk et al., 2013 Şimsek et al., 2009). Inferential statistics such as correlation, regression, and variance analysis were less frequently used in the reviewed articles.

Variable

Perception about the effectiveness of PBL ($f = 11$), and its achievement ($f = 10$) were the most commonly investigated dependent variables in the reviewed articles. Satisfaction ($f = 5$), motivation ($f = 2$), collaborative affordances ($f = 1$), benefits of wiki ($f = 1$), engagement ($f = 1$), attitude ($f = 1$), and the effectiveness of YouTube videos ($f = 1$) were other variables investigated in the reviewed articles (see Figure 8).
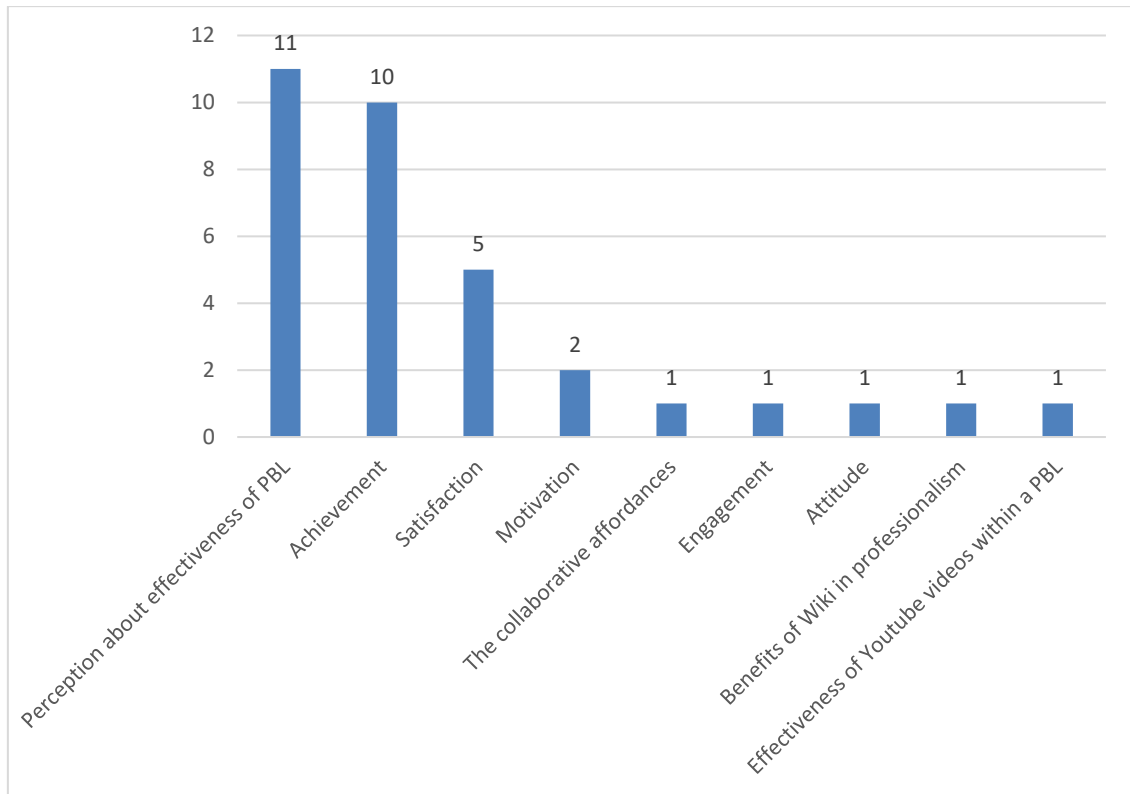
Figure 8: Distribution of variables

The use of different Web 2.0 technologies in research studies may lead researchers to examine the effect of Web 2.0 technologies supporting PBL environments on different educational outcomes (e.g., achievement, satisfaction, motivation), and the perceptions of participants toward this environment (e.g., effectiveness of PBL, collaborative affordances, benefits of Web 2.0 tool) (e.g., ChanLin & Chan, 2007; Ioannou, Vasiliou, & Zaphiris, 2016; Kay & Kletskin, 2012).

Major Findings

The findings and results of the reviewed articles were examined, and each major finding was assigned a code. Then, related codes were sorted into categories, and categories into themes. As a result, major findings of the reviewed articles were found to consist of six themes, as presented in Table 3.

Major Findings	f
Effectiveness of Web 2.0 technologies supporting PBL	
• Participants' perceptions of Web 2.0 tools' advantages in PBL environment	
o Sharing (wiki)	1
o Usefulness (video podcast)	1
o Ease of use (video podcast)	1
o Effective learning tools (video podcast)	1
o Online resource (YouTube)	1
o Collaboration	1
• Effectiveness of Web 2.0 technologies supporting PBL compared to traditional PBL	
o Higher level of satisfaction for Web 2.0 technologies supporting PBL	2
o Higher level of motivation for Web 2.0 technologies supporting PBL	2
o No significant difference between groups in terms of group work	1
• Positive experiences of participants for Web 2.0 technologies supporting PBL	5
Effects of Web 2.0 technologies supporting PBL on participants' skills	
• Collaboration	6
• Communication	3
• Reflection	2
• Self-directed learning	2
• Information and communication technologies (ICT) skills	1
Effects of Web 2.0 technologies supporting PBL on participants' achievement	
• Improvement of achievement following Web 2.0 technologies supporting PBL	10
• No difference between groups (Web 2.0 technologies supporting PBL & traditional PBL)	2
Changes in satisfaction	4
Changes in attitude	1
Improvement of engagement	1

Table 3: The frequencies of major findings in the studies

According to Table 3, the most frequent finding was the effectiveness of Web 2.0 technologies supporting PBL ($f = 16$) (e.g., de Jong et al., 2013; Jaffar, 2012). Three categories were identified in this theme. The category of 'participants' perceptions of Web 2.0 tools' advantages in PBL environment' included sharing in a wiki environment ($f = 1$), the usefulness ($f = 1$) and ease of use ($f = 1$) of video podcasts, the effectiveness

of video podcasts in learning ($f = 1$), collaboration ($f = 1$) and being an online resource (e.g., YouTube) ($f = 1$). The category of 'effectiveness of Web 2.0 technologies supporting PBL compared to traditional PBL' showed participants' level of satisfaction ($f = 2$) and motivation ($f = 2$) to be higher in Web 2.0 technology-supported PBL groups. But, there was no significant difference found in terms of group work between Web 2.0 technology-supported PBL group and traditional PBL groups ($f = 1$). The final category in this theme was 'positive experiences of participants for Web 2.0 technologies supporting PBL' ($f = 5$).

Effects of Web 2.0 technologies supporting PBL on participants' skills ($f = 15$) was the second theme identified in the major findings of the reviewed articles (e.g., Moeller, Spitzer, & Spreckelsen, 2010; Williams et al., 2010). This theme included categories of collaboration ($f = 6$), communication ($f = 3$), reflection ($f = 2$), self-directed learning ($f = 2$), and ICT skills ($f = 1$) of participants which were found to have improved following the application of Web 2.0 technology-supported PBL.

Effects of Web 2.0 technologies supporting PBL on participants' achievement was the third theme identified in the major findings of the reviewed articles. In this theme, participants' level of achievement following the application of Web 2.0 technology-supported PBL was reported. Most of the studies reported that the achievement of the participants increased ($f = 10$) (e.g., Huang et al., 2016; Lo, 2009). A few studies reported no significant difference in terms of the participants' achievement between Web 2.0 technology-supported PBL groups and traditional PBL groups. Therefore, Web 2.0 technologies supporting PBL can be seen as an effective way to increase students' achievement.

Additionally, changes in participants' level of satisfaction ($f = 4$) (e.g., Ioannou et al., 2016; Lo, 2009), changes in participants' attitude ($f = 1$) (Robertson, 2008), and the improvement of participants' engagement ($f = 1$) (Gordon & Gayeski, 2013) following application of Web 2.0 technology-supported PBL were other themes identified in the major findings of the reviewed articles.

The major findings of the reviewed articles were found to be congruent to the known characteristics of problem-based learning and Web 2.0 technologies. In the literature, problem-based learning has been reported to positively affect students' achievement (Duffy & Cunningham, 1996; Hmelo-Silver, 2004), engagement (Delialioğlu, 2012; Marra, Jonassen, Palmer, & Luft, 2014), and the acquisition of 21st century skills (Hung et al., 2008; Şendağ & Odabaşı, 2009). However, technology usage within the learning environment is an important issue. According to Jonassen and Reeves (1996), technology can be used for the construction of new knowledge within the PBL environment.

Therefore, PBL and Web 2.0 technology together can enable students to become more active in the learning process. For example, students can work on ill-structured problems, collaborate with other students, search for solutions, communicate with their instructor and other students, and develop solutions. At the end of the process, Web 2.0 technologies supporting PBL has been shown to have an important effect on educational output. In this regard, Web 2.0 technologies supporting PBL environment can be considered an alternative way to increase students' course achievement, motivation, engagement, and 21st century skills acquisition.

CONCLUSION

In this study, the researcher reviewed studies published on the topic of Web 2.0 technologies supporting PBL in journals indexed as SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, and ERIC between February 2004 and February 2018. Within this aim, 18 articles were reviewed in terms of their year of publication, research domain, research paradigm and method, utilisation of Web 2.0 tools, sample level, data collection tools, data analysis methods, dependent variables, and major findings.

The emergence of studies in this area was in 2007, and has continued to be researched through to the present day. From the 18 articles reviewed, the topic was found to have been examined in different research domains. While the qualitative research paradigm was the most frequently applied, followed by mixed method and quantitative paradigms, the case study design was the most preferred among the qualitative methods. Wiki was the most preferred Web 2.0 tool utilised within the PBL environments. When the sample level in the studies was examined, higher education students were the most studied participant group. Among the data collection tools used in the studies, interview was the most frequently used, followed by survey, achievement/performance test, discussion transcripts, e-mail messages and other records, documents, and reflection. Regarding the type of data analysis method employed, the qualitative analysis methods were mainly used parallel with the research paradigm of the study. Descriptive and inferential statistics were less frequently applied in the studies. The variables investigated most in the studies were perceptions about the effectiveness of PBL and of achievement. When the major findings of the studies were examined, the effectiveness of Web 2.0 technologies supporting PBL was the most frequently reported finding, followed by the effects of Web 2.0 technologies supporting PBL on participants' skills and achievement.

The current situation with regards to Web 2.0 technologies supporting PBL environments is drawn with these results. The following recommendations are put forward in terms of potential future research in this area:

- Empirical studies could be conducted in order to reveal the effect of Web 2.0 technologies supporting PBL environment on learners' educational development (e.g., achievement, engagement, attitude).

- Future studies could be conducted with some of the less studied sample groups, especially K-12 education level students.

- Web 2.0 technologies supporting PBL environments have mostly been designed for the field of social science and medical science. Therefore, this topic could be investigated in fields such as natural science and engineering and technology science.

- Designing an online PBL environment with free Web 2.0 tools is well worth conducting. For example, social networks, online collaborative tools, and online communication technologies could be used in order to support PBL environments in studies of the future.

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Note: References marked with an asterisk (*****) indicate studies included in the analysis only rather than cited

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