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# Systematic Literature Review on Educational Effectiveness of Project-Based Learning for Software Development

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**Abstract**—In light of the social demand for the training of software engineers and the increasing attention to Project-Based Learning (PBL), many studies have conducted software development as the subject matter of PBL. However, the educational effectiveness of PBL for software development and its measurement methods are not uniform, as many methods have been reported. This study conducted a systematic literature review of the educational effectiveness of PBL for software development.

**Index Terms**—software engineering education, Project-Based Learning, Educational Effectiveness, Systematic Literature Review

## I. INTRODUCTION

It is said that recently graduated computer science professionals are not well prepared for facing industrial work [1]. Therefore, it is necessary to train software engineers at universities, and many universities offer classes to foster software engineers.

In recent years, Project-Based Learning (PBL) has been attracting attention as an educational method. PBL is a practical teaching method in which learners work independently (or actively) to solve problems, and is said to be highly effective in cultivating generic skills [2]. And PBL is said to deal with the issue recently graduated computer science professionals are not well prepared for facing industrial work [1].

Against this background, many studies have been conducted as the subject matter of PBL for software development. We suppose students must conduct software development in PBL for software development. There are many methods for measuring the educational effectiveness of PBL for software development, and they are not uniform. In addition, there has been no systematic review of such studies. Therefore, this study conducts systematic review of educational effectiveness of PBL for software development and clarifies the trends.

## II. SURVEY METHOD

This study uses the Systematic Literature Review (SLR) methodology. SLR is a means of identifying, evaluating, and interpreting all available research on particular research

TABLE I  
SLR PROCEDURE

Procedure	Content of the method
1	Setting up research questions (RQ)
2	Selection of databases
3	Setting search terms
4	Practical initial screening (e.g., inclusion and exclusion criteria)
5	Methodological quality screening (e.g., scientific quality assessment)
6	Conducting reliable and valid reviews
7	Integration of results

questions, and aims to present a fair assessment of a research topic using a reliable, rigorous, and auditable methodology [4]. The procedure of the SLR [3] is presented in Table I.

## III. DETAILS OF SLR

### A. Setting up research questions (RQ)

We set up the following research questions.

- RQ1 What is the educational effectiveness of PBL for software development?
- RQ2 How is the educational effectiveness of PBL for software development measured?
- RQ3 If there is educational effectiveness, what are their factors?

### B. Selection of databases to be searched

Scopus<sup>1</sup>, a bibliographic database containing summaries and references to journal articles, is used.

### C. Setting search terms

Search terms and logical operators are set up a search expression as follows.

*TITLE-ABS-KEY*((“software engineering” OR “software development”) AND ( “computer supported collaborative learning” OR “project-based learning”) AND (“effectiveness” OR “impact”))

### D. Search results

A search against Scopus using the above expression formula yielded 54 articles (as of 14/06/2021).

### E. Screening

54 articles were screened using the following inclusion and exclusion criteria. 20 primary studies in total were eligible for SLR.

#### Inclusion Criteria

- Original papers published in peer-reviewed international journals and international conferences
- Referring to the educational effectiveness of PBL for software development

#### Exclusion Criteria

- Papers not published in peer-reviewed international journals and international conferences
- Literature survey that does not include original research

### F. Conducting reliable and valid reviews

The RQs set up in section III-A are reviewed. The SLR process is required to be transparent and reproducible [3]. To ensure them, two or more researchers make a decision for each paper.

## IV. RESULT

### A. RQ1

Many educational effectiveness of PBL for software development were found. This study found two types of skills, generic skills (e.g., “awareness, motivation,” “collaboration, communication,” etc.) and technical skills related to software development.

Other that could not be categorized as either generic skills or technical skills for software development were “skills learned,” and “satisfaction with the class,” but we believe that these items are too broadly defined. What kind of skills are “skills learned”? In the future, we call for research that investigates educational effectiveness in detail.

### B. RQ2

Figure 1 shows the survey results on the measurement methods of educational effectiveness of PBL for software development. 17 studies used questionnaires, checklists, or forms, five studies used written tests or pre/post-tests, one study used teachers’ subjective evaluation, and one study used videotaping. The total number of these papers is 24, but this is because some studies used more than one measurement method. While tests can measure the comprehension of technical skills related to software development, generic skills tended to be measured by questionnaires.

For technical skills related to software development, some of them measured the educational effectiveness using ISO/IEC/IEEE 29148 standards. Since this is internationally standardized, we believe that they can comprehensively assess technical skills related to software development.

For generic skills, some of them measured educational effectiveness using the Common Career/Skill Framework [4] defined by the Information-technology Promotion Agency, Japan (IPA) <sup>2</sup>. However, many studies used their own questionnaires, which were not uniform. It is necessary to define generic skills comprehensively and to establish measurement methods such as questionnaires to measure educational effectiveness exhaustively.

### C. RQ3

Of the 20 articles in the SLR, 11 had descriptions of factors on educational effectiveness. We extracted what we considered to be the factors described in section IV-A. We found that the factors of “awareness and motivation” included supervising each team, leading discussions and answering questions, and having clients in the real world.

<sup>2</sup>IPA Information-technology Promotion Agency, Japan (online), <https://www.ipa.go.jp/index-e.html>.

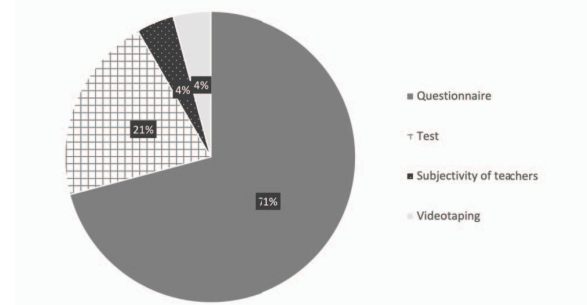


Fig. 1. Methods of Measuring Educational Effectiveness

## V. THREATS TO VALIDITY

The most serious threat to the validity of this study is the small number of papers reviewed. This field has seen a large number of papers published in recent years, and it is expected that research in this area will flourish in the future due to the demand for training software engineers and the acquisition of generic skills.

Human subjectivity may prevent correct decisions from being made. The SLR process must be transparent and reproducible. To ensure them, two or more researchers make a decision for each paper.

## VI. CONCLUSION

This study has conducted systematic literature review of the educational effectiveness of PBL for software development using the SLR method. We found that the educational effectiveness of PBL for software development were diverse, but two types of effectiveness were observed: generic skills and technical skills related to software development. We found that this educational effectiveness are often measured by questionnaires. However, the content of the questionnaires varied from study to study. The reason why the content of the questionnaires varied is thought to be that educational effectiveness are not defined exhaustively, and the educational effectiveness perceived differ from study to study. In the future, it will be necessary to establish an appropriate method of measurement and to search for factors after defining educational effectiveness comprehensively. By identifying educational effectiveness and their factors, we may be able to meet the original objectives of fostering software engineers and acquiring generic skills.

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