The Effectiveness of Implementing Project-based Learning (PBL) Approach in Logistics Education

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Abstract

How to improve students' practical operation ability has become an urgent problem in the course education. This study takes logistics science as an example to analyze the practical effects of project-based learning (PBL) reform. The estimation results of TS2SLS method show that PBL, especially in-post practice, can not only improve students' practical ability, but also improve their theoretical knowledge. Therefore, the need to promote the "combination of industry and education, school-enterprise cooperation", and promote on-site teaching and on-in-post practice.

Keywords: project-based learning (PBL); Logistics Courses; teacher education

1. Introduction

The learning process that allows students to construct their own knowledge into a learning concept has attracted attention in decades. Various innovations in strategies and approaches have been adjusted continuously, both for the needs of students during the school period and for the future provisions that will be faced by students. Therefore, constructivists become an educational philosophy that is very influential of education (Krahenbuhl, 2016) [1]. Constructivist philosophy changes the learning paradigm from teacher-centered learning to student-centered learning. In recent years, project-based learning (PBL) has gained popularity, governments and schools that view this methodology as a tool to improve student learning and promote the skills through the exploration, creation and the construction of solutions to problems. Many schools in China are transforming to implement PBL. This study aims to summarize the project-based teaching of Logistics Science to assess whether the reform is effective and what factors affect the effectiveness.

Constructivism is a learning process that requires students to construct their own understanding through a series of activities. This approach forces students to compare rather than receive knowledge from the teacher. Thus, the special feature of constructivist is student – centered learning. However, the concept of constructivism is also defined variously by each person, including teachers (Amineh et al., 2015)[2]. Various methods, strategies, and approaches are used to apply constructivist learning to become an innovation in learning process.

Project Based Learning (PBL) can be defined as “a model that organized learning depending on projects”. In the process of PBL, students understand a subject matter better since they learn through doing and experiencing. 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 et al., 2014)[3] that lead to meaningful learning experiences (Wurdinger et al., 2007)[4]. Furthermore, based on Dale's Cone of Experience about the learning pyramid, students will also absorb a lot of knowledge gained through direct experiences. One of learning models that requires students to directly compile their knowledge through their experiences is PBL. This learning model is appropriate with constructivist philosophy since the learning process puts the students as the central in learning.

Project based learning (PBL) is a learning model that requires students to solve a problem together in a particular group. The problems presented are usually authentic, in accordance with the curriculum and sometimes consist of various fields of study (Solomon, 2003) [5]. In PBL, students are required to follow certain learning steps, known as syntax, in order to solve the problems given in detail. The stages in PBL include (1) the observation and questioning stage, (2) the trial stage, (3) the associating stage, (4) the simplifying stage and (5) the reconstructing stage. The simpler steps of PBL can also be summarized into the stage of gathering information from various sources, analysing and synthesizing concepts based on the two previous steps (Solomon, 2003) [5]. PBL is a learning process pursued through a series of experiences, therefore, this learning model directly make the students ready to construct their own knowledge through collaborative learning.

Project based learning (PBL) comes as an innovation in learning considered to facilitate the development of students in acquiring knowledge and strengthen the skills needed by students such as self-confidence, communication skills, flexibility, the ability to motivate themselves. Aside of being appropriate with the current general educational needs, PBL is also a model which is suitable to be used in mathematics learning. The positive impact of PBL in various fields of study includes increasing mathematical representation skills, increasing higher-order thinking skills, increasing mathematical communication skills, and increasing academic accuracy (Edmunds et al., 2017) [6].

A number of studies have explored the effectiveness of project-based learning in higher education in different countries. Kokotsaki et al. (2016) [7]found the main influencing factors affecting the effect, those key factors including use of new technologies, qualitative collaborative processes among students, teachers' ability to build learning, balance between direct instruction and research methods, institutional support and school leadership, consistent learning assessment. Hasni et al. (2016) [8]found the key factors: project management, supervision and effective help in learning, regulation of the use of time, curricular integration and consistency of evaluation, initial skills of students, teacher training.

The literature on PBL practice shows that different studies draw conclusions about positive and negative effects. Students generally show positive attitudes towards this methodology (Holm, 2011) [9]. PBL is usually viewed positively by students, which leads them to judge it as more effective than traditional methodologies. This subjective perception is probably related to some effects suggested by research: when PBL is used, students can develop a better view of science and better expectations of pursuing a scientific career (Bennett et al., 2018)[10], a better self-image (Hasni et al., 2016) [11] , and improved perception of their self-efficacy. Chen & Yang (2019) [12] discovery by using the Meta-analysis method, programs in the social sciences and languages are statistically higher than those of science and mathematics. Also positive results for technology and engineering, but not higher than those of science and mathematics.

It should be noted that our review of the literature also shows some studies with zero impact, an impact limited to certain capacities or even a negative impact. These mixed results can be explained by the diverse learning experiences evaluated and PBL's high sensitivity to the context and the conditions in which it is employed. It may also be due to the different evaluation methodologies used.

However, no comprehensive research has been conducted on the experiences of students and teachers as participants in PBL processes throughout, specifically with respect to participants' experiences and personal insights into occurrences, situations, and phenomena (Tsybulsky & Muchnik-Rozanov, 2019)[13]. Moreover, most of the studies used alignment form analysis, while a few used structural equation modeling (SEM) show that the PBL technique improves student engagement by enabling knowledge and information sharing and discussion (Mohammed Abdullatif Almulla, 2020)[14]. Hence, this study aims to develop a model to analyze the efficiency of applying a PBL approach as a method to engage students in learning.

2. Revised Logistics Course

Logistics Science is a course closely related to practice. While strengthening the theory learning of logistics, how to improve students' practical operation ability through practical training or practice has become an urgent problem to be solved in the "Logistics Science" course education. The course of Logistics Science of Jiaxing University was opened in the first semester of the third academic year of the university, with a total of 32 credit hours, including 16 theoretical hours and 16 practical hours. Project teaching has been implemented for nearly 4 years in the early stage. The teaching content of this course is divided into four modules, namely, logistics business process evaluation and design, logistics distribution center evaluation and design, logistics park planning and design, and regional logistics industry planning and design. There are still three problems:

Students have limited opportunities to participate in logistics practices. The practice courses in the first semester of the third academic year are 16 class hours, plus 16 class hours of trade circulation simulation in the second semester of the third academic year. The limitation of the total number of class hours makes students unable to well understand the relevant logistics knowledge, let alone use logistics related knowledge to solve practical problems.

The teachers of "Logistics" need to be strengthened ability. The existing teachers of the course come from economics and management, which need the adjustment of knowledge structure and the increase of practical experience. Logistics needs double-teacher teachers with both theoretical and rich practical experience, as well as part-time teachers with rich practical experience and high theoretical accomplishment in the industry and enterprises.

The current curriculum module design cannot meet students' diverse professional learning needs. According to the training goals of vocational applied talents, the employment scope of students includes industrial and commercial enterprises, third-party logistics enterprises, and logistics related enterprises, such as transportation, warehousing, port and express delivery enterprises. Logistics management has a cross-industry and multi-level nature, with different industries and positions, and different knowledge and ability requirements of employees. Therefore, under the condition of further strengthening the connection between theoretical teaching and practical teaching under the limit of class hours, the teaching is organized according to the project design of integrating theory and practice.

The following three adjustments are made:

Adopt more diverse classroom teaching methods. Guided by logistics professional activities and combined with the seven functional elements of logistics, the course training items are further refined in the original project-based teaching module, so as to achieve the purpose of improving the learning effect and training students' practical ability. A variety of teaching methods are actively used in the teaching, such as case teaching method, task-driven teaching method, role simulation teaching method, simulation and demonstration teaching method, etc.

Guide students to actively participate in the logistics competition. Organize students to participate in various logistics design competitions, and train students' ability to integrate knowledge by writing logistics process design books and conducting practical drills.

Promote the "combination of industry and education, school-enterprise cooperation", and promote on-site teaching and on-in-post practice. Regularly arrange teachers and students to practice in enterprises. Teachers lead students to complete their learning tasks in a real productive environment, which not only improves their professional skills, but also accumulates work experience, and effectively improves the employment competitiveness of students. Invite senior professionals and skilled craftsmen from well-known logistics enterprises to serve as part-time teachers to improve the level of professional construction.

Tables 1 include the sequence of topics for the revised course. Overall, the course is thought to have two foci: (1) skill development, which utilizes concrete experience, reflective observation, abstract conceptualization and active experimentation; and (2) business plan development and implementation, which primarily utilizes active experimentation.

Tables1 Course adjustment content

	Before adjustment	After adjustment
Teaching method	Theory only	Theory and practice
Exercise	Analog simulation	Design contest and so on
On-the-spot teaching	No	Yes
Substituted post exercitation	No	Yes

This paper will later evaluate the effect of the reform one year after its implementation.

3.Research Method

Two models for implementing PBL in schools: （1）Theoretical teaching begun by the teachers: the teachers design and implement their own PBL, doing their own programming in which they can use resources that they find along the way or that are inspired by principles of other works.（2）In-post internship is application of an externally designed PBL curriculum: teachers implement a series of curricular units in the classroom that are designed by organizations or programs outside the school. These programs provide designed content and activities along with methodological materials and instructions.

The project-based learning of this study started in 2015 and has been implemented for four academic years (2015-2018). However, whether the credibility of students in different semesters should be compared and analyzed is a key issue to be considered. This study has done two aspects of the treatment, firstly, PBL is considered a form of learning that encourages students to assume more responsibility for their learning, promoting the search and analysis of information and solving real problems, while delving deep in content linked to their personal interest. The learning intentions of the 2018 students were matched with their final academic performance through questionnaires. Second, the final scores of two samples of different grades were analyzed by the TSLS method. The variables were selected as shown in Table 2, and the explained variable is the school final score, namely, whether the students' test score y can be improved after course adjustment as the outcome variable. Before the adjustment, only the theoretical score x1, and after the adjustment, the internship score x2 was added, but due to the existence of different samples. The x3 indicates whether the new theoretical teaching method is adopted, with =1 and =0 before adjustment. The z1-z9 is a control variable, representing the initiatives related to the teaching reform.

Tables 2 Variable selection

Variable	Variable name	Assignment	Data sources
y	School final results	0-100	Grade 2015,2016 and 2017
x1	Theoretical scores	0-100	Grade 2015-2018
x2	Internship achievement (enterprise mentor)	0-100	Grade of 2018
x3	Use of new technologies	0/1	Student questionnaire
z1	Qualitative collaborative processes among students	0-5	Student questionnaire
z2	Teachers' ability to build learning	0-5	Student questionnaire
z3	Consistent learning assessment	0/1	Student questionnaire
z4	Project management	0/1	Student questionnaire
z5	Supervision and effective help in learning	0/1	Student questionnaire
z6	Regulation of the use of time	2-5h	Student questionnaire
z7	Initial skills of students	science =1 / liberal arts =0	Student questionnaire
z8	Male	boy=1/girl=0	Student questionnaire
z9	Teacher training	0/1	-

Two experts checked the face and content validity to validate the questionnaire, and a 5-point Likert-type scale, 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree, was used to assess students' ratings of various items.

The final results include 39 students from grade 15, 32 students from grade 16, 96 students from grade 17 and 58 students from grade 18. Among them, 58 students were distributed online for the school economy of grade 18, and in-depth interviews were conducted offline. The specific contents include: participating in the logistics competition, practical training visit, in-post internship, enterprise tutorial system, practice and practical training base and other problems are investigated. The survey found that students generally expressed that it is necessary to go to enterprises or institutions for a short semester of "post internship", and it is also necessary to hire business enterprises and other professional and technical personnel to serve as part-time course teachers in the college, which confirmed the necessity of school-enterprise cooperation.

4. Data Analysis and Results

4.1 Construction of Model

The Two-Sample Two-Stage Least Squares (TS2SLS) estimator was introduced by Klevmarken (1982) [15] and applies in cases where one wants to estimate the effects of possibly endogenous explanatory variables x on outcome y, but where y and x are not observed in the same data set. Instead, one has observations on outcomes y and instruments z in one sample (sample 1) and on x and z in another (sample 2). Related Two-Sample IV (TSIV) estimators were proposed by Arellano and Meghir (1992) [16] and Angrist and Krueger (1992)[17].

The structural linear model of interest is given by

$$y_i = x_i'\beta + \varepsilon_i \quad (1)$$

but we cannot estimate this model as y_i and x_i are not jointly observed. Instead, we have two independent samples. In sample 1 we have observations on y and k_z exogenous instruments z. Sample 2 contains observations on the k_x explanatory variables x and z. Denoting by subscripts 1 and 2 whether the variables are observed in sample 1 or sample 2, in the first sample we observe $\{y_{1i}, z_{1i}'\}$ for i = 1,…,n1, and in the second sample we observe $\{x_{2j}', z_{2i}'\}$ for j = 1,…,n2. Throughout we assume that $k_z \geq k_x$. Other explanatory variables that enter model (1), but that are observed in both samples and are exogenous, including the constant, have been partialled out.

The TS2SLS estimator is derived as follows. From the information in sample 1, we can estimate the reduced form model for y_{1i}, given by

$$y_{1i} = z_{1i}'\pi_{y1} + u_{1i} \quad (2)$$

From sample 2, we can estimate the linear projections

$$x_{2j} = \Pi'_{x2} z_{2j} + v_{2j} \qquad (3)$$

$\Pi_{x2} = E(z_{2j} z'_{2j})^{-1} E(z_{2j} x'_{2j})$, a $k_z \times k_x$ matrix of rank k_x by assumption. As (3) is a linear projection, it follows that $E(z_{2j} v'_{2j}) = 0$. Although the x_{1i} are not observed, the data generating process for y_{1i} is given by the structural model (1) and hence it and its reduced form are given by

$$y_{1i} = x'_{1i}\beta + \varepsilon_{1i} = (z'_{1i}\Pi_{x1} + v'_{1i})\beta + \varepsilon_{1i} = z'_{1i}\Pi_{x1}\beta + \varepsilon_{1i} + v'_{1i}\beta \qquad (4)$$

From $\Pi_{x1} = E(z_{1i} z'_{1i})^{-1} E(z_{1i} x'_{1i})$ and $E(z_{1i} v'_{i1}) = 0$, on the basis of equation (2) and (4), we can know that, $\pi_{y1} = \Pi_{x1}\beta$ and $u_{1i} = \varepsilon_{1i} + v'_{1i}\beta$. Obviously, π_{y1} and Π_{x1} identifies the structural parameter β, and the standard 2SLS estimation method for y_{1i}, X_{1i}, and Z_{1i} in the sample combines the sum information contained in the OLS estimation method, meaning that and are as follows:

Clearly, y_1 and x_1 identifies the structural parameters, and the standard 2SLS estimator in a sample with y_{1i}, x_{1i} and z_{1i} all observed combines the information contained in the OLS estimators for y1 and x1, denoted by

$$\hat{\beta}_{2sls} = (\hat{\Pi}'_{x1} z'_1 z_1 \hat{\Pi}_{x1})^{-1} \hat{\Pi}'_{x1} z'_1 z_1 \hat{\pi}_{y1} \qquad (5)$$

with Z_1 the $n_1 \times k_z$ matrix $[z'_{1i}]$.

As x_{1i} is not observed, we cannot estimate Π_{x1} , but we can estimate Π_{x2} using the second sample. Denoting the OLS estimator for Π_{x2} by $\hat{\Pi}_{x2}$, the Two-Sample 2SLS estimator is given by

$$\hat{\beta}_{ts2sls} = (\hat{x}'_1 \hat{x}_1)^{-1} \hat{x}'_1 y_1 = (\hat{\Pi}'_{x2} z'_1 z_1 \hat{\Pi}_{x2})^{-1} \hat{\Pi}'_{x2} z'_1 y_1 = (\hat{\Pi}'_{x2} z'_1 z_1 \hat{\Pi}_{x2})^{-1} \hat{\Pi}'_{x2} z'_1 z_1 \hat{\pi}_{y1} \qquad (6)$$

In the second example, we are interested in estimating the model

$$y = x_1\beta_1 + x_2\beta_2 + x_3\beta_3 + w\beta_w + \beta_0 + \varepsilon \qquad (7)$$

We now observe in sample 1 (Graduated students) the variables y, x1, x3, z1-z9. In sample 2 (Grade of 2018 student) we observe the variables x2, x3, z1-z9.

4.2 Interpretation of result

As can be seen from Table 3, the first stage estimates confirm that reforms substantially increased academic record. The first column indirectly confirms which measures are the project-based learning reform measures that the students want to see by matching the interview results with the scores of the students who have already graduated.

Column (1) represents the OLS estimates for students in grade 2015-2017, showing that the usual theoretical score is proportional to the final score, but the coefficient is small. Column (2) represents OLS estimates of internship performance and control variables for grade 2018, showing a positive relationship. Column (3) shows the estimation results using TS2SLS, and finds that the internship performance has a larger coefficient than the theoretical performance, which has the effect of improving the overall theoretical performance. It shows that the project-based learning not only improves the internship performance, but also improves the usual theoretical performance, and finally improves the final performance.

The estimated coefficients of the control variables z1-z7 are all relatively significant, indicating that these auxiliary measures related to the project teaching have significantly improved the performance. However, the estimated coefficient of z7 in arts and science is large, but not significant, indicating that both arts and science have improved, while the z8 coefficient of gender is significantly positive, indicating that the improvement effect on boys is more obvious. It may be that in general, girls have good theoretical performance while boys have stronger practical ability. The z9 coefficient also shows that the training of teachers themselves has a role in improving student performance.

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Tables 3 The effect of project-based learning (PBL) on Logistics education

Dependent variable	Result of the final exam y	Internship results x2	Result of the final exam y
	(1) OLS	(2) OLS	(3) TS2SLS
Theoretical scores x1	0.061***	-	0.124***
Internship achievement (enterprise mentor) x2	-	-	0.237***
Use of new technologies x3	0.085***	0.076***	0.081***
Qualitative collaborative processes among students z1	0.012***	0.080***	0.010***
Teachers' ability to build learning z2	0.034**	0.052**	0.045**
Consistent learning assessment z3	0.151***	0.211***	0.198***
Project management z4	0.117**	0.202***	0.164***
Supervision and effective help in learning z5	0.230**	0.361***	0.283***
Regulation of the use of time z6	0.064***	0.073***	0.067***
Initial skills of students z7	0.002	0.006	0.004
Male z8	0.020***	0.040***	0.03***
Teacher training z9	0.129**	0.187**	0.161**
Observations N	167	58	225
Test	R^2=0.5	R^2=0.55	F=59.7

Notes: * denotes p < 0.1, ** denotes p < 0.05, *** denotes p < 0.01.

5.Conclusion

There are indications that PBL has a positive and moderate impact on students' academic performance, though the evidence is mixed. The mixed results on the impact of PBL suggest that this depends heavily on the context and the conditions of their use. Our concludes that the success of PBL can be supported by certain key factors.

（1）What impact does work on projects and centres of interest have on student learning? We matched the willingness to get the research with the scores， analyze the impact between PBL and students' academic performance, the affective and motivational aspects involved in learning and crosscutting skills like critical thinking, creativity and digital competence.

（2）What are the characteristics of the most effective programs for project-based instruction? We analyze the results of PBL according to the curricular area, the intensity and the duration of the program, as well as the use of digital technology.

（3）For whom are project-based instruction programs most effective? We analyze the results of PBL based on the students' level of education and profile.

（4）Should this educational practice be expanded in Catalonia? Which conditions should be met? We consider whether it might be appropriate to implement PBL in Catalonia, focusing on the success factors that come with these kinds of programs.

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