Designing PBL steps in vocational course based on students' readiness and teachers' discussion

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Abstract. This research is intended to design project-based vocational courses which focus on CAD construction drawing course using e-learning. The main objective is improving the student's competence in drawing by decomposing the Project-Based Learning (PBL) using flipped classroom strategy with providing course materials in e-learning. The development procedure is arranged as follow: survey and identification, planning, designing, and developing phases. For preparing the planning and designing phase, observations, course reviews, and surveys had been conducted as the result of this current paper as follows: 1) How to decide the vocational course; 2) Student's readiness to access personal computer; 3) Designing PBL steps. Observation, courses review, and group discussion were done for determining the course subject. Surveys were held to know the availability of the course to be conducted with minimum facilities and the student readiness to access personal computer, and determined the principles activities considered for the success of this course project by decomposing the PBL approach and flipped classroom strategy, group discussions had been done to get the views of the vocational teachers and lecturers. The results show that the CAD construction drawing is selected as the vocational course; the student's readiness to access personal computer and their positive opinion of the e-learning is in the very high category; the teachers and lecturers approved the development of CAD construction drawing course using e-learning to be conducted and give the recommendation to do the seven PBL steps.

Keywords: vocational course; project-based learning; flipped classroom; e-learning

1. Introduction

The vocational course has its own characteristic, students should have the same learning experience as in the world of work so that they are ready to work to provide such services or business ventures, have economic value, and produce goods and services to meet the needs of the community [1]. But making the learning process to be the same as the world of work is not easy work and it will be expensive. The effectiveness of all education systems depends critically on the quality of teaching and learning in the classrooms, workshops, laboratories, and other spaces in which the education takes place. While teachers engaged students, well-designed courses, facilities which are fit for purpose, and a good level

of resources are necessary if any kind of educational provision is to be excellent [2]. Besides we know the increasing complexity in all facets of work and community life coupled with persistent calls for educational reform over the past several decades present numerous challenges to professionals in career and vocational education [3]. The study is conducted at the civil engineering education study program at Sebelas Maret University. Observations were conducted to see the learning problem which happens in the vocational course. The study started by reviewed the courses and determined the CAD construction drawing course is the focused course to be developed. Nowadays the drawing skills are so important for supporting many courses in vocational education, especially in civil engineering. For this reason, drawing skills should be learned effectively in every stage of vocational education. In fact, there are unsolved problems in teaching CAD construction drawing to students. From the observation of the previous course, the major problem can be classified as (1) The needs of facilities; (2) The duration of the course (3) Understanding the lesson (3) Doing project activity in a team; and (4) Supervising the project. The designing CAD construction drawing course using e-learning with a project-based learning approach and flipped classroom strategy is expected to answer the problems. Students access the e-learning by their own computer could minimize the school computer facilities, even the school has minimum facilities of computer laboratory, the course still can be conducted. The availability of the course that does not depend on the school computer facilities makes the arrangements of the course schedule become easy, the duration of the course needed will be easy to fulfilled without getting a problem with the laboratory using schedule. Moreover, the students could have more time in studying individually. Understanding the lesson is a big problem when some of the students fail in studying in the class, it will make them feel anxious, lost the motivation and difficult to finish the course, as they have to do assignments without understanding and guidance. The e-learning will give guidance to be followed and learned by self doing experiences or groups. In this case, the e-learning will give much support to the students by giving guidance, demonstration video, and job assignments. The student who fails to understand the lesson in the class could use the tutorial video as they can come back to learn the in class for the demonstration session, and this will give an opportunity to increase the student competence with a minimum cost. The abilities to share information with team members, making decisions together with the team and the abilities to communicate in the project supervising will be gained by the PBL approach.

1.1. Designing project-based vocational course using e-learning
Although the e-learning is believed could help the students in learning, it is must be understood that e-learning is only a media that can not change the condition of the student instantly. However, e-learning will not replace other training instruments, but will rather qualitatively complement them [4]. We need a good instructional design to be implemented using the e-learning. The strategy of conducting a vocational course with a practical lesson oriented. The instructional design to run the course will be prepared by using an ideal approaching in line with the vocational education characteristics. The project method stems from John Dewey's idea of the concept of learning by doing. Student knowledge will develop as students face new experiences that compel to build and modify initial knowledge. Student intellectual development is reached by many new experiences when they are learning and then attempts to solve the problems raised by the experiences they had. Almost all vocational education courses are practical knowledge that needs to be done as a real project for the students. The concept of learning by doing is the process of acquiring learning outcomes by working on certain actions in accordance with the objectives [5]. Piaget also argues that student competence will increase as long as the students face new experiences that push the student to build and modify their initial knowledge. On the other hand, Vygotsky states that individual intellectual development is faced with new and challenging experiences and then attempts to solve the problems raised by that experience. These statements are in line with constructivism theory which emphasizes knowledge built by students by using the experiences and cognitive structures that they already have [6]. PBL is an innovative approach to learning that teaches a multitude of strategies critical for success in the twenty-first century. Students drive their own learning through inquiry, as well as work collaboratively to research and create projects that reflect their

knowledge. From gleaning new, viable technology skills, to becoming proficient communicators and advanced problem solvers, students benefit from this approach to instruction [2].

This approach integrates knowing and doing. Students learn knowledge and elements of the core curriculum, apply what they know to solve authentic problems, and produce results that matter, take advantage of digital tools to produce high quality, collaborative products. It refocuses education on the student, a shift mandated by the global world, which rewards intangible assets such as drive, passion, creativity, empathy, and resiliency. These cannot be taught out of a textbook but must be activated through experience [3]. Projects make the world go around. For almost any endeavor, whether it's launching a space shuttle, designing a marketing campaign, conducting a trial, or staging an art exhibit, you can find an interdisciplinary team working together to make it happen [4]. Taking the advantages of digital tools to enhance the learning environment is a good strategy while the student is ready to have it. The camera phone is familiar for pupils and a meaningful tool for communicating and working. The benefit of a mobile data terminal, such as a smartphone connected to other networked technologies is that it goes where the learners go [5]. The personal computer owned by almost every student let the idea of designing vocational course by using e-learning has the same condition as a student-centered instructional strategy be a reasonable solution for the problem. From the e-learning, the learner gets the knowledge and apply it to solve problems given by the designer to reach the learning goal. The principles of PBL refer to the Gold Standard PBL, articulated by Larmer, Mergendoller, and Boss requires student learning goals in two domains, deep subject-matter knowledge and the ability to transfer learning to new problems and contexts [6]. These learning goals are reached via 7 project design principles: (1) a challenging problem or question, (2) sustained inquiry, (3) authenticity, (4) student voice and choice, (5) reflection, (6) critique and revision, and (7) a public product. The principle will be implemented by learning steps which is designed based on the contextual vocational environment. Survey and discussion were done with a group of vocational teachers and lecturers to determine the learning activities. The George Lucas Educational Foundation developed PBL steps as follow: (1) Start with the Essential Question; (2) Design a Plan for the Project; (3) Create a Schedule; (4) Monitor the Students and the Progress of the Project; (5) Assess the Outcome; (6) Evaluate the Experience, [7]. The syntax is a subject to be brought down to the specific class and get reconciliation with the condition of the specific vocational condition. The learners have their freedom in getting the knowledge, they could get by self-learning or by a group of learners. In the implementation, the student will have the lesson individually and also in a group. The project-based learning approach can be implemented whether students work individually, in pairs, or in groups, having them design something from scratch taps their creative abilities [8]. The learning activity suggested by Hrbek & Stix is divided into nine steps: (1) the teacher sets the stage for students with real-life; (2) students take on the role of project designers, (3) Students discuss and accumulate the background information needed for their designs; (4) the teacher-coach and students negotiate the criteria for evaluating the projects; (5) students accumulate the materials necessary for the project; (6) students create their projects; (7) Students prepare to present their projects; (8) students present their projects; (9) students reflect on the process and evaluate the projects based on the criteria established in step 4. These steps are considered to be ideal for the contextual conditions, the steps are consulted with the result of group discussion and expected to be a new ideal PBL syntax for a vocational course.

1.2. Flipped classroom

Choosing the flipped classroom as the instructional strategy expected to be the best way to solve the problems, it is a type of blended learning that reverses the common learning system by giving the lesson, outside the class. In the flipped classroom model, what is normally done in class and what is normally done as homework is switched or flipped. [9], [10], [11]. It moves the activities outside the class, that may have been considered as homework, into the classroom. Students learn by following the e-learning lectures, collaborate in discussion groups, or carry out the project assignment at home while engaging in concepts in the classroom with the guidance of a teacher. Class becomes the place to work through problems, advance concepts, and engage in collaborative learning. Most importantly, all aspects of

instruction can be rethought to best maximize the scarcest learning resource time [12]. This strategy will be implemented and collaborated with PBL which is inline as a student-centered learning model. The flipped classroom is an innovative pedagogical approach that focuses on learner-centered instruction [18].

2. Method

The method used is developmental research with a descriptive procedural model by adapting the Borg and Gall model. Educational Research and development (R&D) is a process used to develop and validate educational products [13]. In this research, the Borg and Gall model is modified with the process begins by doing research and information collecting by survey and identification. After the information collecting, the next stage is Planning, it begins by references study. After mastering the theory then began to enter the designing phase, then it will be developed in the developing phase, it will be reviewed by relevant experts as expert judgment, revise and the next step is to test the design into a preliminary field testing. Then from the test, it will get corrections and revisions as it will be conducted the main product revision. After revision, it will be tested into the main field testing. Then it will get any revisions as the operational product revisions. The latest product revision as the research and development product will be tested. The test aims to find out whether the product made is feasible to be used or need revision. Model or product trials also look at the extent to which a product is created to achieve goals and objectives [20]. And the result will be disseminated and implemented. The procedure is illustrated in the development cycle in Figure 1.
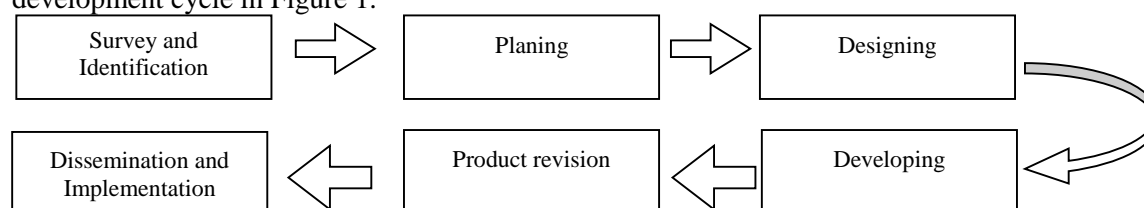
Figure 1. The development cycle of the research.

The first activity in this study is collecting the information. The survey conducted to 272 students from 1st to 4th grades, and 242 students answered the survey. There are 15 Lecturers and 5 teachers participate in the group discussion. From figure 1, it is written as survey and identification, this phase is conducted to give a proper foundation and justification for this study are as follow: (1) reviewed the courses that require a development based on priority scale, it's determined the CAD construction drawing course as the focused course to be developed; (2) survey the availability of the computer facilities from the students and their opinion of the e-learning development as the students' readiness; (3) review and decomposing the instructional strategy of conducting the course with a practical lesson oriented using an ideal approaching, decomposing PBL to be familiar with vocational education characteristics with the flipped classroom strategy. While the result of this phase is stated and give a positive recommendation, the planning phase could begin to be conducted.

3. Result and discussion

As the vocational education has many major fields of study, depend on the certain skill to be expert, for the beginning of the study, it was determined that the study will begin from the civil engineering education major. An observation was conducted in the Civil Engineering Education Study Program by choosing which course is considered urgent to be developed based on the priority scale. There are 69 total courses need to be passed by the students to finish the Civil Engineering Education Study Program as follow: 10 general courses, 5 basics of education courses, 43 major skills courses as we know it by the vocational courses, 5 major skills by interest, and 12 optional courses. Learning process skill including 6 courses, and 1 educational development course. The 43 major skills courses were observed, the observation was based on (1) the level of Linkages with Learning Outcomes, (2) Facility Problem,

(3) Implementation difficulties. The observation was conducted by reviewing the courses' standard competence of each course and interviewing the course lecturer who understands the real situation of the courses. After finishing the course review, then the result was presented in a discussion with members of lecturers to get more correction and justification. The discussion result stated that the highest urgency level is CAD Construction drawing course. The score is 12, the highest score, from the ideal score of 12, in this case, all 3 indicators get 4 scores. The CAD construction drawing is written number 8 at table 1 with urgency level 12 and stated as the first rank.

Table 1. Urgency level summary of 43 major skills courses

Num	Course Name	Level of Urgency	Rank	Num	Course Name	Level of Urgency	Rank
1	Applied mathematics	4	25	22	Steel Structure	4	25
2	Carpentry equipment	9	8	23	Hydraulics and Water Building	4	25
3	Applied physics	4	25	24	Foundation Engineering	4	25
4	Engineering mechanics 1	4	25	25	Drawing Techniques	8	15
5	Engineering mechanics II	4	25	26	Construction Management	8	15
6	Engineering mechanics III	4	25	27	Cost Estimation	9	8
7	Engineering mechanics IV	4	25	28	Wood Structure	10	2
8	CAD Construction Drawing	12	1	29	Plumbing and Mechanical Electrical Engineering	4	25
9	Building Construction I	6	20	30	Masonry	9	8
10	Building Construction II	6	20	31	Practice of Plumbing and Mechanical Electrical Engineering	9	8
11	Building Construction III	6	20	32	Carpentry I	10	2
12	Surveying I	10	2	33	Carpentry II	10	2
13	Surveying II	10	2	34	Furniture Design & Practice	10	2
14	Environmental Engineering	4	25	35	Concrete Practice	9	8
15	Construction checks and repairs	4	25	36	Practice of Steel and Aluminum	9	8
16	Building Materials Science	4	25	37	Field Observation	6	20
17	Soil Mechanics	9	8	38	Industrial Apprenticeship	8	15
18	Concrete Technology	4	25	39	Educational Apprenticeship	7	18
19	Concrete Structures I	4	25	42	Educational Seminar	5	24
20	Concrete Structures II	4	25	43	Thesis	7	18
21	Basic construction of roads and bridges	4	25				

From the result of the course's review, it's determined that the CAD construction drawing is the most urgent vocational course to be developed. The next step was observing the existing CAD Construction drawing learning condition. Curriculum design is a critical point for course development. To give course unites in an efficient way, some units have to be divided into the submodules. By this way, cognitive loads of each module may be balanced for the students [14]. Here is the lesson materials of CAD Construction Drawing course: (1) Building Regulations; (2) Designing building construction; (3) Building construction drawing procedures; (4) Coordinate system and CAD tools; (5) Simple construction objects; (6) Construction objects with modifications; (7) Applied objects in buildings construction; (8) Applied objects with modifications along with dimensions with the specified layer; (9) Complete building construction; (10) Project presentation. The observation was conducted based on the vocational course review focused on the CAD Construction Drawing Course. The observation including the major problem classified as (1) The needs of facilities; (2) The duration of the course (3)

Understanding the lesson (4) Doing project activity in a team (5) Supervising the project. The main reason for this study conducted is about the difficulty of implementing a vocational course which usually needs many facilities to support the student learning experiences, this situation is considered the high cost. This study expected to get a solution in a different way which avoids the high cost.

In the case of minimum facility, this study will solve the problem by giving chance to the student to do all the learning experiences with their own computer without waiting to enter the laboratory and use the laboratory computer that is only available at the time of course schedule. But this condition lay several consequences, the availability of student personal computer will be the main problem, the expected condition is the learners have their own computer, but instead of this condition, the survey also confirms the alternative condition. The alternative conditions will give support for the implementation of the new course design if the first item fails to be fulfilled. These items will keep ensuring the new design course can be implemented in a minimum facility. Beside own the personal computer, the students were asked whether they can borrow a computer from their family, friends or rent the computer from computer rental. A survey was conducted to confirm this prerequisite condition as the consequences of using the computer instead of the computer laboratory facilities. The survey answer the availability of personal computer own by the students, beside that the survey also answer the availability of using the family computer, the availability of using friends computer, the availability of using rental computer, and also it will answer that the student agrees with the importance of designing the course with e-learning. To go on the study, it needs to ensure that the prerequisite condition is fulfilled. The survey was conducted on the students who had passed the course and those who plan to take the course. The questionnaire is consist of 6 questions with 2 closed-ended optional answer, to get the exact answers. Survey items are: (1) availability of the personal computer by self owner; (2) availability of the personal computer by borrowing from families; (3) availability of the personal computer by borrowing from friends; (4) availability of the personal computer by buying new; (5) availability of the personal computer by rent; (6) agree with the course development using e-learning.

The survey was analyzed by a descriptive statistic that gives information about the number of students who had their own personal computer, how many percent, in what category and decided to be a development course using flipped classroom e-learning. The frequencies categories are decided by the principle adapted from Suharsimi Arikunto [15] as we can see in table 2.

Table 2. Percentage Value Category

Number	Percentage Interval (%)	Assessment Category
1	81–100	Very High
2	61-80	High
3	41-60	Medium
4	21-40	Low
5	0-20	Very Low

Suharsimi Arikunto, 2014

Those items then answered by the students who had passed the course and those who plan to take the course.

Table 3. Summary of the Available Frequencies for all the students

Item of survey	Student grade				Average (%)	Assessment Category
	4th (%)	3rd (%)	2nd (%)	1st (%)		
Personal_computer	94,7	94	80	87,1	89,0	Very high
Family_computer	47,4	78	53,8	62,9	60,5	Medium
Friends_computer	61,4	88	86,2	80	78,9	High
Buy_new	49,1	22	43,1	55,7	42,5	Medium
Rent	38,6	18	18,5	55,7	32,7	Low
Agree_with_elearning	80,7	96	92,3	95,7	91,2	Very high

From all the grade, survey results show that the students who have their own computer are in the very high category, the percentage is 89%, the availability of family computer is in the medium category, the percentage is 60,5%, the availability of friends computer is in the high category, it is 78,9%, the student who plans to buy a new computer is in the medium category, it is 42,5%, The availability of computer rental is in the low category, the percentage is 32,7%, and the students who agree to have e-learning for supporting the course is in the very high category, the percentage is 91,2%.

The survey result gives recommendation for the study to be conducted to the next phase. The instructional design to run the course was prepared by using the PBL approach. The review of instructional design was done by observing the PBL theories and adapted into the contextual vocational condition. The view of PBL from The George Lucas Educational Foundation and The learning activity suggested by Hrbek & Stix were compared and review and discussed by group of vocational teachers and lecturers.

Table 4. Comparing the PBL steps by The George Lucas Educational Foundation, Hrbek & Stix, and the group of vocational teachers and lecturers

The 6 steps PBL (The George Lucas Educational Foundation)	The 9 steps PBL (Hrbek & Stix)	The 7 steps PBL (Vocational teacher and lecturers review)
1. Start with the Essential Question;	1. The teacher sets the stage for students with real-life	1. Teacher Setting the stage, give example and essential question
2. Design a Plan for the Project;	2. Students take on the role of project designers,	2. Student design the project by colecting information and negotiate the evaluating criteria
3. Create a Schedule;	3. Students discuss and accumulate the background information needed for their designs;	3. Create the schedule and work on the project
4. Monitor the Students and the Progress of the Project;	4. The teacher-coach and students negotiate the criteria for evaluating the projects;	4. Monitor the progress
5. Assess the Outcome;	5. Students accumulate the materials necessary for the project;	5. prepare for the presentation
6. Evaluate the Experience	6. Students create their projects;	6. Present the project
	7. Students prepare to present their projects;	7. Reflection and evaluate as the criteria planned
	8. Students present their projects;	
	9. Students reflect on the process and evaluate the projects based on the criteria established in step 4	

The results were then taken in to the consideration of The Gold Standard PBL, articulated by Larmer, Mergendoller, and Boss requires student learning goals in two domains, deep subject-matter knowledge and the ability to transfer learning to new problems and contexts These learning goals are reached via 7 project design principles: (1) a challenging problem or question, the project is framed by a meaningful problem to be solved or a question to answer, at the appropriate level of challenge; (2) sustained inquiry, students engage in a rigorous, extended process of posing questions, finding resources, and applying information; (3) authenticity, the project involves real-world context, tasks, and tools, quality standards, or impact, or the project speaks to personal concerns, interests, and issues in the students' lives; (4) student voice and choice, students make some decisions about the project, including how they work and what they create; (5) reflection, students and teachers reflect on the learning, the effectiveness of their inquiry and project activities, the quality of student work, and obstacles that arise and strategies for overcoming them; (6) critique and revision, students give, receive, and apply feedback to improve their process and products; (7) a public product, Students make their project work public by explaining, displaying and/or presenting it to audiences beyond the classroom.

Table 5. The PBL steps revised by the group of vocational teachers and lecturers

7 principles of The Gold Standard PBL	7 PBL steps (Vocational teacher and lecturers review)	7 PBL steps revised by the vocational teachers and lecturers
1. a challenging problem or question	1. Teacher Setting the stage, give example and essential question	1. Teacher Setting the challenging stage by giving example and essential sustained questions.
2. sustained inquiry	2. Student design the project by colecting information and negotiate the evaluating criteria	2. Student actively design the authentic project by collecting information and negotiate the evaluating criteria sustainably
3. authenticity	3. Create the schedule and work on the project	3. Student actively create the schedule and work on the project authentically
4. student voice and choice	4. Monitor the progress	4. Monitor the student activity and the progress of the project
5. reflection	5. Prepare for the presentation	5. Understanding the project to prepare for the presentation,
6. critique and revision	6. Present the project	6. Present the project to collect critique and revision
7. a public product	7. Reflection and evaluate as the criteria planned	7. Reflection and evaluate as the criteria planned

The 7 PBL steps revised by the vocational teachers and lecturers then become the main steps for the CAD construction drawing course development. This will be conducted using the flipped classroom strategy. The implementation of the steps using the flipped learning strategy will also be review by the vocational teacher and lecturer. They give opinions in the implementation strategies while they are experienced in doing the learning activities as their professional job.

4. Conclusion

This paper emphasis the CAD construction drawing is selected as the course to be developed, and the designing of the course is recommended to be continued to the next steps as the surveys conducted that show the student's readiness to join the course with their own computer is in the very high category. The student positive opinion of the importance of e-learning support is in the very high category. Beside the student survey, The teachers and lecturers approved the development of CAD construction drawing course using e-learning to be conducted to the next steps and recommend to do the seven PBL steps which are needed to do as follow: (1) teacher setting the challenging stage by giving example and essential sustained questions; (2) student actively design the authentic project by collecting information and negotiate the evaluating criteria sustainably; (3) student actively create the schedule and work on the project authentically; (4) monitor the student activity and the progress of the project; (5) understanding the project to prepare for the presentation; (6) present the project to collect critique and revision; (7) Reflection and evaluate as the criteria planned.

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