

Assessing and Enhancing Creativity in a Laboratory Course with Project Based Learning

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Abstract: Web technologies laboratory is a course where the students need to practice essential web development features amidst a plenty of distracting features within a time frame of 50 to 60 hours. There are no standard or well defined methodologies to measure the outcomes of the laboratory in terms of creativity. Hence, a sensible mechanism is needed to enhance their creativity and to assess the same. This paper demonstrates a Project Based Learning approach for the course, which is supported by a rubric based assessment system that measures creativity in qualitative and quantitative terms. The study is conducted with 68 Post graduate students of Computer Applications who are not familiar with Project Based Learning and rubrics based assessment as well. The students are divided into Controlled and experimental group, where the Project based learning is implemented with both the groups but the performance of experimental group is evaluated with rubrics. Data collection involves the student feedback, their performance scores and teachers' reviews. The analysis of the system clearly defines a positive impact of Project Based Learning on enhancement of creativity and shows the assessment of creativity with rubrics based assessment.

Keywords: Project Based Learning, Laboratory course, Assessment, Rubrics, Creativity

1. Introduction

In today's learning scenario, advanced laboratory course such as Web Technologies cannot be handled in a conventional methodology of practising a set of given experiments. These kinds of laboratory courses do not involve fixed procedures or manual to adhere to. There are plenty of features available that are impossible be practiced within the time frame of 50 to 60 hours. Also, it is difficult to specify a clear set of inputs and outputs as it involves the creativity of students. The students are expected to practice the essential features in their own style and if time permits, they may practice additional features. Hence, focus on essential features with their own creativity is essential for these types of laboratory courses.

Project based learning (PBL) is an active learning method that supports learning through projects. It is a proven learning activity that triggers real and experiential learning among students by engaging themselves in a complex problem, through which they gain sustaining knowledge and skills. Creativity and fearless work environment are the greatest benefits of PBL. A laboratory course is a good platform to practice PBL, especially a laboratory course that requires focused work and creativity. The success of PBL depends on the assessment practices to ensure that all types of learners are supported in the learning process. With good assessment practices, PBL can

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create a culture of excellence for all students and ensure deeper learning for all.

Rubrics play a specific role in implementing unbiased fair assessment. Rubrics are document that articulates a scoring guide used to evaluate the quality of students' constructed responses. They usually contain evaluative criteria, quality definitions for those criteria at particular levels of achievement, and a scoring strategy. They are helpful to the students for focusing their work and teachers while grading. With these ideas, this research study attempts to study the impact of PBL and corresponding rubrics based assessment for a set of students, who are unfamiliar with the both. The proposed study has been conducted in a laboratory course "Web Technologies Laboratory" with 68 Post Graduate students. Students' feedback , teachers' reviews and performance scores have been collected and analyzed for fetching the insights of the research.

2. Related works

The need and method of implementing Project Based Learning (PBL) has been emphasized in many literature works (Wiek et al.,2014;Ergul, Remziye & Elif, 2014;Fernades & Sandra, 2014; Davcev et al.,2016). A research study (Han et al.,2015) specifies that PBL has diverse impacts on student achievement and attitude. Self-regulated learning is one of the criteria required in PBL approach (Wiek et al.,2014) which could be achieved by specifying expected outcomes out of an activity and periodical assessment. Assessing the performance of students after any innovative teaching learning methodology is usually done by measuring their test performance. Assessment of qualitative factors such as Interest, teamwork and creativity is performed with Feedback, focused interviews and rubric based assessment (Yeh et al., 2012; Jollands et al., 2013; Fernades & Sandra, 2014; Biasutti, Michele & Heba, 2015;Zhang et al., 2016; Poonpon & Kornwipa, 2017;Delos et al., 2017). Performance Comparison of experimental and controlled group has been exercised in few research studies (Bagheri et al., 2013). Surveys are used as data collection tools in few research works in measuring these qualitative factors (Chandrasekaran et al., 2013;Brundieters et al., 2013;Kanigolla & Dinesh, 2014; Dole et al., 2016;Rasul et al., 2017).

Assessment of creativity in PBL is viewed as a challenge by Lee et al. (Lee et al., 2014) and they

recommend multiple check points in measuring the progress. Rubrics based assessment is strongly recommended for better assessment of quantitative features such as creativity (Krause and Magia, 2010;Reddy et al., 2010; McGibbon et al., 2015). From the observation from research studies on PBL, there are relatively very few research works (Dole et al., 2016; Lou et al., 2017) that attempt to measure the creativity of the student. Lou et al. (Lou et al., 2017) measure creativity in terms of interviews with experts and peers in a small team STEM project. Creativity is measured in a research study (Chan & Zenobia., 2013) with focus group interviews and thematic analysis. The team of Lin (Lin et al.,) has found out there is an enhancement in creativity when students follow suggested learning paths with test scores. As observed from the existing literature, there is no quantification for the quality factor Creativity. This research study attempts to introduce such a quantitative factor for creativity in the implementation of PBL and rubrics based assessment. The research study is carried out with students who are not familiar with both the methodologies. The receptiveness of the students, after changing from the conventional teaching methodology, needs to be assessed in this work. To ensure the involvement of students, this research study provide multiple check points in a single project with seven exercises with focused outcomes that span throughout the course and assesses students with rubrics for measuring the outcome of each exercise in the project.

3. Research Questions

The motivation for this research is supported with the following research questions:

1. Is rubrics based assessment helpful for assessing creativity in an unfamiliar group? (Assessment of creativity)
2. Is PBL with rubrics based assessment successful in enhancing creativity in students work? (Enhancement of Creativity)

4. Methods & materials

The first phase of PBL is the formulation of driving question. The proposed research undergoes this phase by making students to formulate a problem for which a project needs to be developed through web development features. Some of the interesting

driving questions detected are

- Can we have a web application for waste disposal management of a city/area?
- What is the web solution for interconnecting people for tree planting?
- Can we improve the web experience of dining?
- Will it not be good to have a web application that recommends recipes based on our refrigerator content? Will it not be good to have a web application that recommends recipes based on our refrigerator content?

A set of guidelines comprising outcomes and rubric based assessment method of the laboratory exercises is given to students before they start. The tutorials for assisting the student in reaching the outcomes are introduced. The students, then work towards the creation of a solution through guided inquiry with the necessary focus. The research study focuses its attention on the two research questions and hence, in a need of suitable data collection and analysis methods.

(1) Assessment of Creativity Enhancement of creativity

This study views creativity as theory of creativity and evaluate creativity through participants' abilities to produce original and appropriate solutions while solving problem as done in few research works (Yeh et al., 2012; Lin et al., 2013). Hence, the students' abilities in constructing efficient solutions are taken as a measure for assessing their creativity. This is measured with the scores obtained by the students from the teacher. In addition to this, teachers' reviews and focused interviews of students are considered for measuring creativity.

(2) Enhancement of creativity

Rubrics based assessment of PBL

As the set of students involved in this study are not familiar with PBL and rubrics, the Student satisfaction quotient through online feedback & teacher feedback are analyzed for measuring the impact of proposed assessment method in enhancing creativity.

5. Experimental Setup

The study is conducted with 68 Post graduate students pursuing Master of Computer Applications (MCA) in Thiagarajar College of Engineering (TCE), Madurai, India, affiliated to Anna University, India. The research is carried out in the laboratory course "Web Technologies Laboratory" in 4th semester of study during the academic year 2016-2017. The course contains seven major exercises to be performed and the outcomes of each exercise are considerably different from the other. The complexity of the exercises grew across the list. The students find projects as individual or as a team of two. The modules of a team project are ensured to be different for each person in the team. The students are expected to practice the web development features in line with their project. A set of rubrics is made ready for each exercise with a focus on essential features that make the students work focused. Personalized rubrics have been developed for all the exercises and made available to all students for their preparation as given in annexure Tables A1 and A2. Also, the best features of student projects are displayed in the laboratory sessions to make them realize their potential to improve their creativity. The laboratory is conducted in two batches with 35 students in Batch 1 and the remaining 33 students in Batch 2 sorted alphabetically. There are two course teachers, Teacher1 & Teacher2, while Teacher1 assesses with conventional methodology of grading from 1 to 10 based on the students performance without any scoring guidelines and Teacher2 assesses with rubrics. First 18 students of Batch 1 and 17 students of Batch 2 undergo rubrics based assessment (Experimental group), while 17 students of Batch 1 and 16 students of Batch 2 undergo assessment with conventional methodology of intuitive grading (Controlled group).

At the end of the conduct of the course, focused interviews of students and teachers and Online Feedback from students are used as data collection tools to analyze the impact of the proposed research. The feedback is framed with a Likert Scale of 4 parameters: Strongly agree, Agree, Disagree & Strongly disagree. A parameter of "Neutral" is intentionally avoided to get clear-cut feedback from the students. The data from focused interviews and feedback is collected from all the students irrespective of the assessment methodology and analyzed for interesting observations.

6. Results and Discussion

The focus of the work is to analyze the impact of Project Based learning in the development of creativity and impact of rubrics based assessment of PBL. PBL is assessed with rubrics based assessment methodology. To measure the effectiveness of the assessment, the students are divided into two groups, the experimental (Number of students = 35) and controlled group (Number of students = 33). The experimental group of students is evaluated with rubrics based assessment while the controlled group is assessed with the conventional method of awarding marks intuitively. However, the controlled group of students is given the rubrics to be aware of the outcome and expected performance measures for the lab exercises. Data for the analysis is collected through teacher and student reviews and online student feedback. Also the individual scores for the laboratory exercises are taken into consideration for measuring the creativity in quantitative terms.

A. Assessment of Creativity

To measure creativity as a quantitative measure, a Creativity Quotient (CQs) is generated for each student s by measuring their scores got from each of the seven exercises. In each of the exercise, there are 3 or 4 parameters that assess the student performance level relating to their creativity. It is shown in Table 2, that a rubric contains major scoring division as Exemplary, Developing and beginning. If a student is marked Exemplary, it is obvious that the student has practiced all the features with a good sense of creativity. Hence CQs is calculated in terms of number of parameters with Exemplary score (Maximum score) as in Equ. (1) & (2). Equ. (1) calculates CQS (Creativity Quotient Sum) for each student s and Equ. (2) derives CQ from CQS. CQ is calculated only for the experimental set of students (Number of students = 35), who have been evaluated with rubric based assessment. For n exercises,,

$$CQS_s = \sum_{i=1}^n \frac{\text{No. of parameters in exercise } i \text{ with maximum score}}{\text{Total No. of Parameters in exercise } i}$$

Equ.(1)

$$CQ_s = \frac{CQS_s}{n} \quad \text{Equ. (2)}$$

Table 1 represents the results of Creativity quotient calculated among 35 students. 25 students out of 35

Table 1. Data analysis from the Creativity Quotient (CQ)

CQ Range	No. of students	Other parameters	Range
CQ \geq 0.8	10	Average	0.606
0.6 \leq CQ < 0.8	10	Standard deviation	0.29561
0.5 \leq CQ < 0.6	5		
CQ < 0.5	10		

(71.4% of students) have a quotient above or equal to 0.5. It is interesting to note that 20 students (57.1% of students) have a CQ of more than 0.6 showing the good level of creativity instilled among them. Thus, Creativity is measured in quantitative terms and found to be at a satisfied level when the course is implemented with PBL.

B. Enhancement of Creativity

From Table 1, the average Creativity level is observed as 60.6% for the group. This shows that there is only less number of students with significantly low Creativity quotient. The study of Lin and the team (Lin et al.,2013) has achieved 52% of students to be above average creativity level with non adaptive learning paths. This study has found that 57.14% of students are above the average creativity level with fixed a fixed set of exercises and thus supporting the implementation of PBL. Fig.1 marks the creativity level of the students.

The measurement of creativity is enabled only with rubrics based assessment, while the conventional grading methodology does not have provision for measuring it. Thus, rubrics based assessment gives a quantitative measure for creativity.

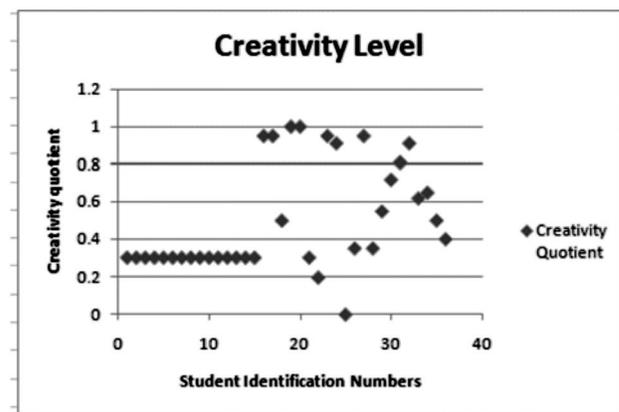


Fig. 1. Creativity level of students

Teachers' reviews, comparing the performance of previous batches of students with the present batch of

students, reveal the enhancement of creativity with PBL approach. The web development features practiced by the students are innovative and relevant to the concept. There are some innovative projects that have been developed at a preliminary level and have the scope of being applied to state level science and technology project schemes. Bus pass system, Waste bin management system, Visual tool for special children, Ration shop management and online dictionary are few among them.

As creativity is a qualitative factor, teacher and student reviews are considered to be the suitable analysis tool. The reviews are collected through focused interviews. Excerpt from the interview of students includes:

1. The rubrics gives us easy view on understanding and outcome of the program expected
2. This approach is good as we are able to practice all the advanced features relevant to our project.
3. The project and the rubrics gave me the ideas about what to include and what not to include
4. Our students are doing great.. When I see the display of my fellow students, I am really surprised at their efforts.
5. I am satisfied with what I built until I know there can be more to improve... there has been always a space for me to improve...
6. Initially, it was very tough for me to cope up with the given task. But the outcomes of the activity focused me to get into it naturally. Initially, it was very tough for me to cope up with the given task. But the outcomes of the activity focused me to get into it naturally.

As mentioned earlier there are two course teachers for the course, one (Teacher1) who has been handling the course for the past 5 years and the other (Teacher2) who has handled the course for the first time. Comments from the teachers on their creativity include:

Teacher 1:

I find a great difference in the performance of this set of students when compared to the previous sets. These

students are more creative. I am not sure whether the PBL or the rubrics has its impact on their creativity.

Lot of features is incorporated into their websites and it shows their focus.

Teacher 2:

It had been a good experience with students working in their domain specific projects professionally.

The design layouts provided by most of the students are really surprising.

I personally recommend PBL for all laboratory courses irrespective of the complexity and discipline. C. Feedback on Rubric based assessment

As the rubrics are introduced to experimental as well as controlled group, data collected from the online feedback given by both the groups is analyzed

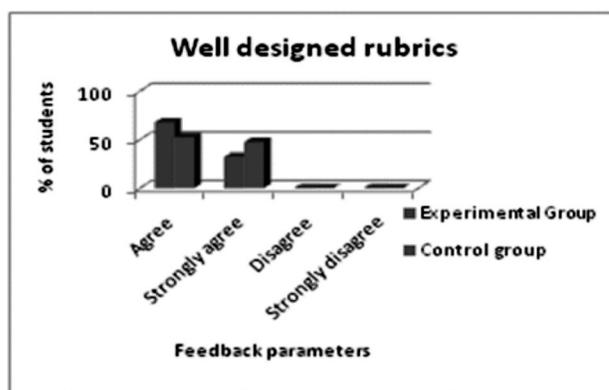


Fig. 2 Feedback on rubrics structure

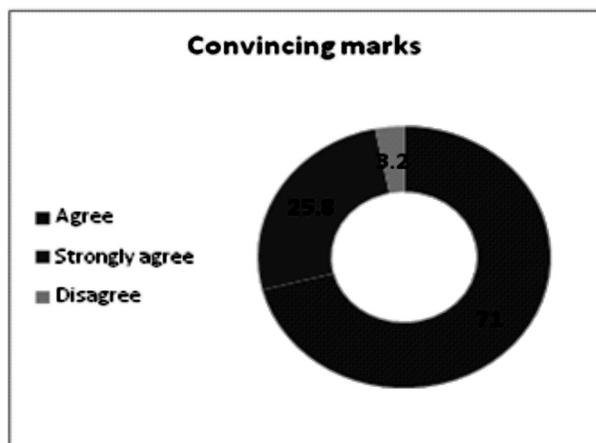


Fig. 3 Feedback on marks

Do you want such a set of rubrics for your laboratory sessions?



Fig. 4 Students' preference to rubrics

to measure the impact of the methodology. Among various parameters of feedback, rubric structure preference to rubrics and student satisfaction are presented here. The rubrics structure is regarded as well defined by the students as shown in Fig.2. Also, it has been examined whether the experimental group of students is convinced with the marks awarded according to the rubrics. Fig. 3 shows that 96.8% of students are convinced with the evaluation method.

It is transparent from the feedback that the rubrics based assessment is preferred by 95% of 68 students from Fig. 4. The feedback contains provisions for the students to record their open comments also. Some of the comments are listed below:

- 1) It is useful to know the outline of our work what to do, and what you are expecting from us, and also what we have to learn.
- 2) It gives the idea what i have to do in my web page..
- 3) Team work may be avoided to practice more domain specific features.
- 4) Well defined rubric structure exists
- 5) Please give additional marks to the extra features practiced.
- 6) We shall have the rubrics for the entire class not for a division of class

The open feedback given by the students demanded the rubrics based evaluation for all the students and inclusion of more marks for additional features practiced. Thus, the results analyzed with the data obtained from various sources in implementing PBL show that PBL is a better choice for conducting laboratory courses where there is a need of focused outcomes and creativity.

7. Conclusion

The proposed research studies the impact of Problem Based Learning (PBL) in enhancing the creativity and impact of rubrics based evaluation in assessment. The mixed-mode data analysis with qualitative data obtained from reviews and feedback of students and teachers and quantitative data obtained from the scores obtained by students in implementing the exercises study convinces that PBL enhances creativity. Rubrics based evaluation ensures the measurement of creativity in quantitative terms. Data analysis of Creativity Quotient favours the implementation of PBL in a laboratory course. Further, the rubrics based evaluation is well received by the students in its first attempt itself. The students find it meaningful and well defined. It is observed that the evaluation increases the clarity of outcomes and focus of work. The students and teachers are comfortable with PBL and its assessment methodology. It is understood from the study that students expect focused outcomes and guidelines. The work conducts focused interviews through oral communication, which may be replaced with discussion forums. Further, the rubrics based PBL extends the opportunity of assessing qualitative outcomes such as Ethics, Teamwork and Communication. Regarding future directions, the research may be extended to laboratory courses of different disciplines and a comparative study on the impact of PBL may be carried out. Also, automation of rubrics may be carried out to ensure quick assessment system. Thus, the research is intended for happy learning, leading to improved performance.

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