A Study Report in the Web Technologies Course: What Makes Feedback Effective for Project-based Learning?

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Abstract

In this work-in-progress paper, we report our experience of applying project-based learning (PjBL) in a web technology course, with a focus on how different feedback tactics affect students' learning outcomes. Giving high-quality feedback can have an immediate impact on students' learning progress. Although process-level feedback is considered more effective than task-level feedback in traditional pedagogies, it is still unclear whether this conclusion can be exacerbated or mitigated when applied to PjBL, as PjBL emphasizes students' ownership and authenticity. We divided students into two groups and applied different feedback strategies. We report findings and insights to help instructors develop feedback policies and practices that are effective and likely to benefit students. Our results suggest that giving low-level feedback still improves students' learning outcomes in the context of PjBL, especially for technical tasks.

Introduction

Project-based learning is a student-centered pedagogical strategy in which students learn by participating in real-world and personally meaningful projects[1]. Unlike course projects where students are expected to provide standard solutions, PjBL emphasizes authenticate, meaningful and challenging projects [2] that provide inadequate solutions. Working on such open-ended projects gives students ownership over their own learning[3] and increases student motivation and engagement[4]. It helps students develop deep content knowledge of the course learning objectives, along with critical thinking, collaboration, creativity, and communication skills, which are essential for their future employment[5]. PjBL is included in recommended sets of best practices for computing curricula such as the ACM/IEEE's CS2013 and has been widely adopted in high-level computer science courses[6].

Despite its benefits, the open-ended nature of PjBL makes giving effective feedback on projects a challenging task for instructors. Instructors giving proper feedback is considered one of the most effective teaching strategies and has an immediate impact on students' learning progress[7]. Although process-level feedback is considered more effective than task-level feedback in traditional pedagogies[8], it is still unclear whether this conclusion can be exasperated or mitigated

when applied to PjBL, as PjBL emphasizes students' ownership and authenticity. When learners feel over supervised and controlled, they may feel a lack of ownership and disengage from project-based learning [9,10]. Without proper insights backed up by data on what properties and circumstances make feedback efficacious for PjBL, the instructors' PjBL methods will be insufficient, affecting students' learning outcomes. This paper reports our empirical research on what makes feedback effective for PjBL in a web technology course.

Related Works

Project-based learning (PjBL) has been widely adopted in high-level computer science courses, spanning all major areas including programming languages[11], software engineering[12], database management systems[13], data virtualization[14], computer graphics[15], computer vision[16], computer architecture[17], operating systems[18], compiler design[19], artificial intelligence[20], web technologies[21], mobile developments[22], data mining[23], computer security[24], cybersecurity[25], and computer networks[26]. Their evaluation results confirm PjBL's *effectiveness* in helping students attain course learning objectives and develop skills for their employment compared with lecture-based learning.

The use of feedback can reduce the discrepancies between current understanding/performance and the desired goal and is regarded as one of the most powerful strategies to improve student achievement[27]. Feedback can be divided into four categories: task-level, process-level, self-regulation level, and self-level[27], with task-level and process-level being the most commonly used[7]. **Task-level feedback** focuses on how well a task is accomplished or performed. **Process-level** focuses on processes underlying the tasks or relating and extending tasks (e.g., strategies for error detection, and explicitly learning from errors).

Process-level feedback is considered more effective than task-level feedback in traditional pedagogies, as it requires learners to relate or extend tasks and is more effective for augmenting deeper learning than that of task-level feedback[27,7]. However, some researchers reported that process-level feedback may make the students feel too strictly monitored and controlled[28,29], given that PBL emphasizes students' choices and voices. As far as we know, our research is the first work toward examining how to make feedback effective for project-based learning in a Computer Science course.

Methods

This study uses mixed methods in a case study of a course assignment to explore the delivery and impact of different types of feedback during PBL. The course involved a semester-long course project, for which students worked in groups of four to build a website to benefit the university's students and faculty members. In the web technologies course, students attend 3 hours of class per week. The instructor gave lectures first, and then students worked in groups to practice exercises related to the lecture content.

Students in the Web Technologies course, are at least in their sophomore year of college Regardless of university year, all students had to take prerequisite courses before enrolling in the course Prerequisite courses include programming and software development content that prepare

students for the Web Technologies course This ensures that all students enrolled in the course are well equipped with previous development knowledge to be able to successfully take the course Regardless of University year, all students in the course have prior knowledge of the content

The course instructor divides the project into five levels and requires each group to submit 1) Project proposal; 2) HTML files and CSS; 3) Database design and SQL files; 4) PHP files; 5) Test results. For the course of the semester, the instructor gave students two to three weeks to work on each checkpoint. Students submit their checkpoints, which are graded by teaching assistants as formative assessments.

At the end of the term, we asked each team to present their website within 5 minutes. We asked the students to think of the final presentation as a roadshow, think of the evaluators as investors, and try to convince the evaluators to invest in their projects. We also provide a recommended structure for the presentation: 1) introduce the project idea and team members in 1.5 minutes, highlight why the website is important; 2) introduce the website interface/functionality/module design and what optimization (or testing) techniques did the team use in 2 minutes; 3) briefly demonstrate the workflow of the website in 1.5 minutes. Each team has a Q&A section where they can answer questions from other students and assessors.

We invited three evaluators to grade students' projects, including two females and one male. The evaluators have had at least 3 years of experience working as full stack/back-end web developers. They were asked to grade the students' presentations from five aspects: 1) the novelty of the idea; 2) the technical depth; 3) the website's design; 4) the presentation; and 5) the Q&A session. The final grade for each team was 25 points, which was evenly divided between these five aspects. The evaluators are not aware of our experiment on the impact of different feedback strategies.

Feedback Strategies The class consisted of 56 undergraduates, mostly seniors, who worked on 15 projects. The professor of the course randomly assigned each project to one of the two graduate student teaching assistants to get feedback on all their checkpoint submissions. One teaching assistant (TA-a) is a former lecturer who has taught the course at the university level, and the other (TA-b) has 4 years of experience as a web developer.

The two TAs worked together to provide process-level feedback on the first checkpoint assignment, to make sure the proposed project falls into the scope of the course. For the other four checkpoints, TA-a gave task-level feedback (high-level), i.e., specifying whether the students' submission fits the requirements or not without giving more details. TA-b gave process-level (low-level) feedback, i.e., specifying not only whether the submission fits the requirements or not but also giving suggestions on how to improve.

Results

All 15 projects are hosted on `http://www.fall2022web.tech/`. As a submission for each project, the students provided a website, a short introduction, and a 5-minute video of the main features. These projects have brought a variety of new concepts, including interactive campus maps, online dating, second-hand book exchanges, e-commerce, resource sharing among fellow practitioners, and more. The first eight projects received high-level feedback from TA-a, and the

rest received low-level feedback from TA-b.

Table 1: Presentation Grade Comparison

Feedback Strategy	Novelty	Design	Technical	Presentation	QA	Total
Task-level (high)	3.8 ± 0.7	3.9 ± 0.7	3.9 ± 1.0	4.1 ± 1.0	4.5 ± 0.5	20.3 ± 2.8
Process-level (low)	4.3 ± 0.8	4.5 ± 0.8	4.6 ± 0.7	4.7 ± 0.8	4.9 ± 0.4	22.9 ± 1.9
Difference	0.5	0.6	0.7	0.6	0.4	2.6

By comparing the scores received by projects with different feedback strategies, we see that the group that received low-level feedback scored significantly higher than the group that received high-level feedback. The biggest difference comes from the "technical soundness" of the project, while the differences between "Novelty" and "QA" are lower. Although neither the instructor nor the TAs helped the students with their presentations, the average grades on "presentation" are still different for these two groups. We think this is caused by the evaluators extending their feeling of the projects to the presentations.

We also conducted semi-structured interviews with the TAs to get their opinions and observations. Our initial analysis identified the following three main themes:

- Task-level feedback is beneficial, especially for subjective tasks (e.g., color scheme, page layout, website functionality design). Task-level feedback preserves student autonomy in ways that are helpful to students. With high-level feedback, some students tried to solve the mistake first before asking questions and receiving feedback. With process-level feedback, some students learned about their mistakes from the feedback they have received, but had questions about why they had to solve the mistake with the given steps.
- Both TAs reported that students preferred in-person feedback over written feedback. When meeting in person, students can ask the TA for clarification. A limitation related to this finding is that students' preference is not always aligned with maximized student learning.
- Although we didn't ask the TAs to document their workload during the semester, we asked each TA to individually estimate his workload at the end of the semester. From their rough estimations, we found that giving low-level feedback is more time-consuming. Additionally, we observed that providing process-level feedback required TAs to be more experienced on the course topic. For example, TA-a is unfamiliar with some process-level instructions given by TA-b, who worked for four years as a web developer. Such instructions include creating indexes in database tables, using Memcached for caching, using Ajax to prevent refreshing web pages, and employing automated testing tools.

The main conclusions from our quantitative and qualitative findings are as follows: 1) In the context of PBL, process-level feedback remains more effective than task-level feedback; 2) however, providing process-level feedback necessitates more domain knowledge and adds to the workload for instructors.

Future Work

In the subsequent iterations of this course, we intend to do a more extensive experiment. In our subsequent run, we specifically wish to continue gathering the following data from students and TAs: As the students come from a variety of web technology backgrounds, we want to administer

an entrance questionnaire and compare the results with their final grades to accurately measure their learning outcomes; second, we will meet with the students on a regular basis throughout the semester to get their thoughts on various feedback strategies; third, we will ask the TAs to report their hours weekly to get a more accurate measurement of their workload. Additionally, we want to collaborate with instructors of other courses to see if our findings about what makes feedback helpful for PBL can be applied to other fields as well.

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