ISSN 2522-6398 Vol. 6, Issue 28: 79-83, DOI: 10.25236/FER.2023.062811

Research on Project-Based Learning in Computer Science Education

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Abstract: *Nowadays, students of the Z generation are living in a digital world surrounded by all kinds of information, resulting in the need to reform traditional teaching methods in line with the changing times. In order to reach better curriculum performance, project-driven learning, as an effective pedagogical approach, is used for mobilizing students' motivation, strengthening students' capacity for active thinking, and metacognitive awareness can be established along the way. Students themselves are responsible to learn, think, monitor, and adjust their learning process, fostering a pretty unique, deep, and complete understanding of a certain subject. And the metacognitive formation may equip the students with enough ability to face and solve real-world problems big and small. This paper explores the integration of project-based learning strategy within the computer science curriculum and investigates the effect of milestones set for different stages of knowledge in a particular course. These milestones are arranged as assignments inside and outside classroom, promoting the ability of students to think positively and the interactivity between teachers and students. Additionally, the high-quality interaction provides students with better personalized guidance, teachers with more dynamic and engaging teaching atmosphere, and the course enough and real feedback from students. Feedback is a kind of assessment, which includes many other forms as sources for future adjustment and improvement towards the course.*

Keywords: *Teaching reformation, Project-based learning, Metacognitive strategy, Milestone, Teacher-student interaction, Course assessment*

1. The Necessity for a Reformation in Teaching Methods

In the digital era, students are more willing to interact with knowledge that resonate with their interests and align with their goals. The “teacher-led” approach, the conventional teaching method, can no longer meet the demands for university students to require knowledge in class. The situation is a lot more serious when it comes to computer science than to other fields of study, for the reason that the subject of computer science can be always tedious and challenging. On one hand, computer specialized courses are consisting of abundant of basic concepts and algorithms which are very dry and need a lot of patience to understand and remember sometimes. Students might get tired of continuously concentrating on a lot of obscure knowledge points a whole lesson, and might be distracted or late for a session causing some important algorithms to be missed in the lecture, etc. All these situations above may cause negative attitude for students to behave in class. On the other hand, most of the courses in this major are focusing on many different programming languages and many lines of coding in practice, which can be too challenging for some students to keep engaged and motivated. Therefore, a reformation is in great need in teaching methods to achieve a better course performance, and a better adaption to the society demands. With the reformation , an innovative and student-centered teaching approach will be established, injecting enthusiasm, practicality, and relevance into the learning process, making it a more exciting and fulfilling journey for students.

Many studies have conducted research regarding to the reformation. Flipped classroom is proposed to counteract the traditional lecture-driven teaching style, and personalized guidance should be applied in tandem.[1] Teachers can organize some classroom activities ahead of class, raise questions during class, which can stimulate the interests, increase student engagement and a sense of collaboration in the classroom.[2] Considering software engineering, a specialized course for computer science major, the teacher could apply virtualization platform in reality with the help of the academy and even the school for billing, so that students can experience and enjoy the real environment. Pair project and learning-by-doing method also play important role in the process of building the course.[3] Teachers

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can search and select an on-line learning platform as virtual classroom to design tasks and instructions, and to monitor students' actions and activities for better understanding of students' situation on different stages.[4] Knowledge graphs can be added into the teaching process to perform a more effective project-driven learning. Group cooperative teaching is also a really good way to ancillary the project-driven learning by group discussion, group support, and group division of labor.[5] Moreover, students' learning process of computer science, especially algorithms and coding, can be enhanced through practical gamification that helps stimulate active learning.[6] Various games using various technologies concerning several computer science topics can be further tested and then be used to develop computational thinking and programming skills.[7]

2. Establish a Project-driven Learning Strategy and Metacognitive Strategy

2.1. Project-driven Learning Strategy

Project-driven learning is a "student-led" process with several milestones in the path towards the final output of the project. Unlike conventional learning, students rather than teachers are the focus in the course establishment, which requires a lot of participation and self-learning exploration from the students based on a given topic from the teacher or an interested area from the students themselves. A well-designed process may integrate the knowledge learned and the practice conducted, and equip students with capabilities to tackle challenges and solve authentic problems in their future careers. Computer science especially counts an important part to perform the project-driven learning, because the theoretical knowledge and the real world scenarios are so much in need of combining that students may spend a lot of work on.

2.2. Metacognitive Strategy

Metacognitive strategy is a cognitive process that is student-oriented. No one but you will decide "what to learn" and "how to learn it". The strategy involves self-monitoring, self-management, and self-adjustment of the students' learning and thinking processes. Students as the focus need to figure out where they want to go, how they go there, and with what tools may be suitable to go to the destination. Teachers provide guidance and help to students, in case they can not find the right way to solve the problem or a more optimized alternative approach is ready to be raised to simplify the overall procedure. Metacognitive strategy also encourages students to actively engage in learning, enhancing autonomy and depth of learning, enabling them to better cope with various academic and professional challenges.

3. Course Design

3.1. Overall Arrangement

At the start of constructing the course, the sketch of the overall knowledge should be well captured, meanwhile the teaching goal should be set properly. Teacher himself need to have a clear thought of what the students' final outcome could be like with the process. Only in this way, can students be well guided, and can students be helped for a better perception at the end. Then comes the project-driven learning strategy. Teacher should prepare a bunch of reading materials, interactive questions, meaningful discussions, etc to serve the course based on the initial consideration. During the whole process, students will be guided, helped, and even questioned based on their own project selected with a given topic at first.

Take a course, Cloud Computing and Cloud Storage Technology, as an example. I have a leading principle document to keep in mind the full picture of the overall program at the start of the course. The final outcome from the students at the end of the course will be a small hybrid cloud established with different purposes and services to provide, for example, a hybrid cloud for a game company, a cloud for an online shopping company, an infrastructure providing cloud, a virtual reality could, etc. The course itself is student-oriented and requirement-oriented, leading it a metacognitive process. Students need to figure out what company they want to establish, and focus on the core thoughts along the way with the help from the teacher. All the knowledge and methods required by the students are self-driven, manifesting the motivation for better performance.

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3.2. Milestones

As the curriculum evolves, different goals should be put forward progressively based on the curriculum setting to help students moving on to higher levels of stages reaching their final outcome. These milestones should be set properly guiding students keeping the track of the course, thus proper introduction to concepts and enlightening questions proposed are really important in each milestone.

We still take the example presented above to make further explanation and analysis. After proposing a leading principle document for the course, Cloud Computing and Cloud Storage Technology, we teachers should use the principle to set several milestones progressively from simple to profound for the purpose of leading students to the final outcome they established at first within the curriculum arrangement. The teacher in the first two classes introduce what is cloud computing, what characteristics it has, what its advantages and disadvantages are, and how to choose a proper platform, etc. For the first milestone, students will be given a task choosing a direction for a company to build at the start, talking about the reasons why it should promote some services to the cloud, and what opportunities and challenges it may come up with. For the second milestone, students should choose a deployment model for the company, like IAAS, PAAS, and SAAS, which will be illustrated by the teacher ahead of the milestone, and the reason for choosing the model. For next several classes, teacher will talk about three main platforms for cloud computing, Google cloud, Amazon web services(AWS), and Windows Azure. The main architecture and core mechanisms will be taught in detail. And for the last milestone, students will be encouraged to choose one of the platforms among the three cloud services listed above for the established company with the knowledge of the advantages and disadvantages. At last, a paper of the whole process can be generated as the final outcome.

Above all, with the leading principle document of the course, and the time schedule, teachers can have an overall control towards the course, during which students are self-motivated and knowledge is discussed as the background information helping students to move forward and have better performance at the final stage. Different stages are arranged scientifically promoting the development of the course and enhancing the concepts coming out of the textbook. With all these requirements, the teacher need to think thoroughly and properly, and tasks in each milestone need to be set interesting, propulsive, and challenging. All these methods combined can portray a good course.

3.3. Result

Figure 1 displayed below shows the number of visits to the course, Cloud Computing and Cloud Storage Technology, resources online within 60 days set in the leading principle document. Both lines represent the same number of days from day the course started, and the same number of students of 80. Therefore the two lines shows the students' participation situation towards the course.

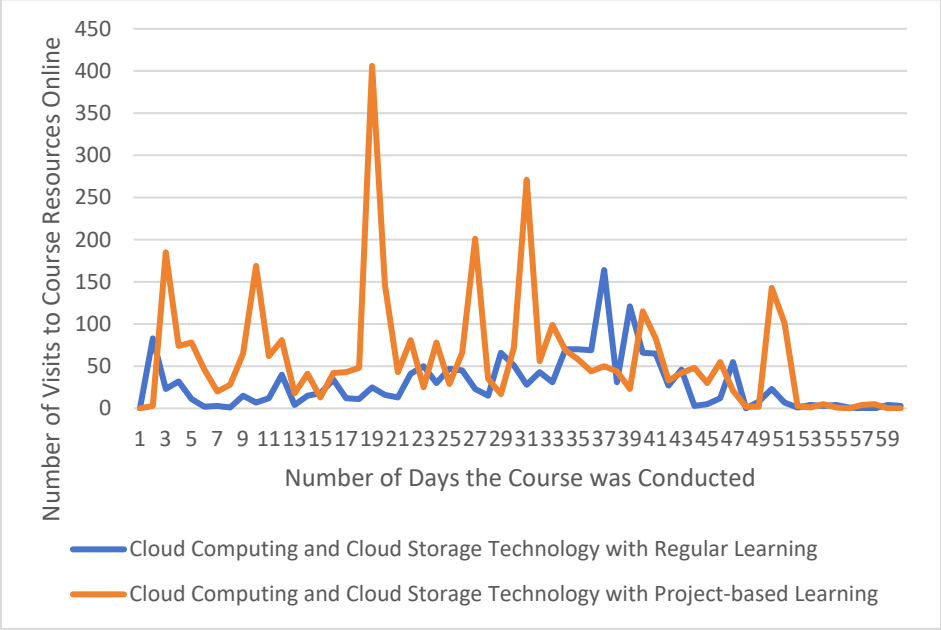

Figure 1: Number of Visits to Course Resources Online in 60 Days

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Cloud Computing and Cloud Storage Technology with Regular Learning is conducted during a time period of 2022.4 - 2022.6, meanwhile Cloud Computing and Cloud Storage Technology with Project-based Learning is conducted during a time period of 2022.10 - 2022.12. We can see from the graph that the number of visits to the online course resources is much higher for the project-based learning compared to the regular learning, meaning the students' class participation is lot higher with the teaching method of project-based mechanism.

4. Assessment Makes Improvement

Assessment is a kind of feedback based on both objective results and subjective evaluation. After the whole process of a certain course, feedback from all kinds of dimensions plays a very important role in the course establishment. The assessment may come from a review by the School's Teaching and Learning Steering Group, Faculty Teaching and Research Team in the academy, the final grades the students could achieve, and teachers' self-reflection. All these kinds of assessment provide teachers with huge number of statistics to evaluate and think fully about the course, from the overall structure to the progress settings for each session. These stuffs are very important for future improvement of the course itself.

The result of a certain assessment, the final grades of students from two semesters explained above in the 3.3. section, regular teaching and project-based learning in Cloud Computing and Cloud Storage is shown in Table 1 and Table 2. By the way, the general objectives of the course and evaluation criteria are the same within the two semesters.

Table 1: Students Grades of Cloud Computing and Cloud Storage Technology with Regular learning.

Grades of students	90 and above	80 and above	70 and above	60 and above	Below 60	Total
Number of students	2	14	33	31	0	80

Table 2: Students Grades of Cloud Computing and Cloud Storage Technology with Project-based learning.

Grades of students	90 and above	80 and above	70 and above	60 and above	Below 60	Total
Number of students	7	18	41	14	0	80

From the two tables above, we can see there is a huge difference of students' performance between the two groups of students. Students under the project-based learning method performed better with the excellence rate of 31.25% than the students under the regular learning method with the excellence rate of 20%, creating a 11.25% gap (The excellence rate is understood here as the percentage of students scoring 80 or above). These statistics show that students have a better performance in project-based learning mechanism, making the teaching reformation a success.

5. Conclusion

This paper illustrates the need for reformation of teaching method for university education. Teaching method should be transformed from teaching-centered to student-centered, which requires a complete change to the ideology towards the educational philosophy. Students should be responsible to their own study, for the reason that they decide themselves with all the processes as the course going on, for example, the final purpose to reach, the method to use, the architecture to build, and also knowledge to assist. All these things are settled in several milestones with each one having a core requirement.

Furthermore, there are still a lot to refine with the project-based learning mechanism. Firstly, the mechanism requires that teachers have good control over the entire content of the course, which usually costs several years of teaching experience on a certain course repeatedly. Secondly, the mechanism requires the teacher having a really helpful guidance through the whole process, which means whenever there is a question put forward by the students, the teacher should always lead students to think correctly rather than tell them the correct answer directly. Thirdly, the mechanism requires the teacher pushing students who are not willing to conduct the project, making everyone in the class a participant and enjoying the process of establishing the curriculum. Fourthly, the mechanism also requires a lot from the students keeping up with the whole process, setting the final goal, dealing with different milestones, focusing on the key problems, checking out solutions online, communicating with classmates, constant revision of the thinking process, etc. Finally, the mechanism requires the college

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and school leadership to take more concentration and to provide as much help as possible in terms of moral support and financial support. Therefore, there is still a long way to go for future development of project-based leaning mechanism.

Acknowledgement

This paper is part of the 2022 Taiyuan University of Science and Technology School-level Teaching Reform and Innovation Project "Reform and Practice of Big Data Course Teaching in the Context of New Engineering" (JG202141).

References

[1] Yuan Chen. Research on the Integration of Flipped Classroom and Traditional College English Classroom Innovation in the New Era[J]. Advances in Higher Education, 2023, 7(20).
[2] Xiaojie Chen et al. Research on Online Teaching Mode Reform Based on POGIL Model[J]. Advances in Higher Education, 2023, 7(20).
[3] Ma K, Teng H, Du L, et al. Project-Driven Learning-by-Doing Method for Teaching Software Engineering using Virtualization Technology[J]. International Journal of Emerging Technologies in Learning (IJET), 2014, 9(9).
[4] Glava C, Glava A. On-line learning platforms as virtual classrooms. Case study of initial primary teachers training at Babes-Bolyai University of Cluj-Napoca, Romania[J]. Procedia Computer Science, 2011, 3(C).
[5] Chunhong L, Haoyang Z, Jieyu Z, et al. Group Cooperative Teaching Design with Knowledge Graphs in Project-Driven Learning[J]. International Journal of Information and Communication Technology Education (IJICTE), 2023, 19(1).
[6] Mohammed H J, Samir T. Gamifying Computer Science Education for Z Generation[J]. Information, 2021, 12(11).
[7] Maja V, Tone V, Linda K, et al. Game-based learning in computer science education: a scoping literature review[J]. International Journal of STEM Education, 2023, 10(1).