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INTEGRATE ONLINE QUERY&DEFENSE INTO PROJECT BASED LEARNING TO PROMPT ENGINEERING AUTHENTIC EXPERIENCES

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Abstract

As an effective student-centered pedagogical approach in improving students' academic knowledge, teamwork skills, communication skills and leadership, Project Based Learning (PBL) has been widely adopted in engineering courses delivering during the last decades. However, there is a challenge for both the teachers and the students during the PBL: Most project results are fragile to their operation environment because of the students' poor understanding of the engineering authentic problems and integrity requirements or even neglect these, while engineering complexity and functional integrity is essential characteristic in aviation and other safety related fields, engineering authenticity and integrity analyzation ability and habit are basic requirements for future aviation engineers. Taking navigation principles and systems course PBL as a case, use online query & defense challenge competition to promote the students to conduct in-depth discussion and analysis on the engineering authenticity and integrity requirements in the early stage of project implementation, so as to improve the students' project participation and outcomes. Project outcomes are assessed and compared with no query & defense activities integrated ones, data are collected and analyzed, the test results show that the online query & defense pedagogical form can effectively help the students to improve their engineering authenticity and integrity thinking.

Keywords: Project Based Learning, Online Query & Defense, Engineering Authenticity and Integrity, Project Implementation

1. Introduction

The Accreditation Board of Engineering and Technology (ABET) defines engineering as ‘‘The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.’’ The engineering graduate should have the ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve engineering problems, the result of their work is to design or develop products or processes[1].

The roots of Project Based Learning (PBL) extend back over a hundred years, to the work of educator and philosopher John Dewey (1959), whose laboratory school at the university of Chicago was based on the process of inquiry. In the following decades, learning science researchers have refined and elaborated Dewey's original insight that active inquiry results in deeper understanding. They found that deep understanding occurs when a learner actively constructs meaning based on his or her experiences and interaction in the world, the development of understanding is a continuous process that requires students to construct and re construct what they know from new experiences and ideas, and prior knowledge and experience[2]. In project based learning, students actively construct their knowledge by participating in real-world activities similar to those that experts engage in. Project

Based Learning approach is an effective method for teaching and learning in the engineering classroom, and thus be adopted in engineering courses delivering during the last decades[3]. This has resulted in ‘‘lecture plus project’’ course options where students can learn theoretical concepts in a lecture-based classroom and apply practical understanding in a project design.

During PBL, the teachers give several real-world and authentic projects, while the students work in groups of three to five as an engineering consultant team to select one of the projects and try to solve it. Team members need to use their mastered knowledge, consult relevant materials, to analyze the engineering requirements of the project, use relevant knowledge, simulation software and some design tools to design, and finally build a prototype and written a project design report. The design usually culminates with a symposium event where student teams make formal presentations to show their design results.

Include in the project, students are given choice, they make their decisions about the project, including framework design and tools, they can choose to improve an existing design or to create their own inventions. Their ability and willingness of problem analyzing and solving are directly reflected in the quality of design results. In this ever-changing world, filled with technology and seemingly instantaneous answers to everything via a web-based search, it’s a little hard to keep all the students engaged in project design, some students have a lower level of participation and engagement, they would rather to choose existing design even with no improvement.

If the PBL teaching mode can’t stimulate students' sustained inquiry, deepen and broaden their unique understanding of project design and form their own independent and unique opinions on the project, the PBL Teaching mode will become a mere formality, which is no different from conventional lecture-based course, or even worse, because they may not be able to cover as much material as the latter, which makes the students’ knowledge gap. According to the questionnaire, lower level of project participation and engagement comes from mainly two aspects: (a) lack of project design experience, (b) feel difficult to find the engineering authentic problems and integrity requirements about the project [4][5]. Therefore, in the PBL teaching mode, it is important and a challenge for the teachers to stimulate students' curiosity and learning enthusiasm, guide the learning process and promoting an environment of inquiry.

The purpose of this paper is to offer an online query & defense competition method for engineering educators to prompt engineering students to effectively participate PBL and improve their real-world and authentic experiences.

In civil aviation university of China, we took the course "navigation principles and systems" as a case, using online query & defense competition to help the students authentic experiences in their project design. This course is delivered for electronic & information engineering program students in their second semester of junior year, who have already finished studying of their subject basic curriculums and start aviation system learning. At this stage, students are not very clear about the flight operation and system architecture of the aircraft. There are about 60 students in the class each year.

2. Purpose of online query & defense

Generally, the PBL process includes four stages: (1) teachers’ projects planning and hand out; (2) students engineering consultant teaming and project selection; (3) Project design process; (4) Project result presentation[6].

In stage (1), The teachers design projects with driving questions that guides the students find meaningful and important. Projects for engineering students better be anchored in a real-world situation which students can explore learning goals and scientific practices, understand the key scientific concepts, principles and practices during the solution pursuing. Performance requirements should be specified in the project task paper. In stage (2), Students be teamed by mutual selection or designated directly by the teacher, project selection adopts the same rules. Stage (3) is the longest stage, which will last for one to several months or even several semesters, depending on the projects requirement. During this stage, the students consult a variety of web-based sources or library books,

explore the project under real-world and authentic environment and application, clarify the project requirements according to the project task paper, including the functions should be realized, the parameters should be given and its accuracy or other indicator, the corresponding key problems and various constraints in authentic engineering, this is the conceivement process. Based on the project conceive, they determine the project architecture and its functional modules, their interaction and interface, make a clear, continuous and determined logic and timing relationship, choose the appropriate digital tools for implementation. The team members modeling, simulate and implement each module and combine them together into a final product. The final product is tested for function and performance verified and validation. The whole process is completely consistent with the industrial engineering process. Stage (4) is the final presentation and defense.

From the perspective of engineering, the PBL process forms a V-shape from the beginning to the last presentation, highly similar to the authentic project process, which we can find clearly in figure1. Project conceivement, which transforms project requirements into product functional concept plays a key role in the quality of design. The adaptability of project products to its operating environment and its functional integrity highly depends on this stage.

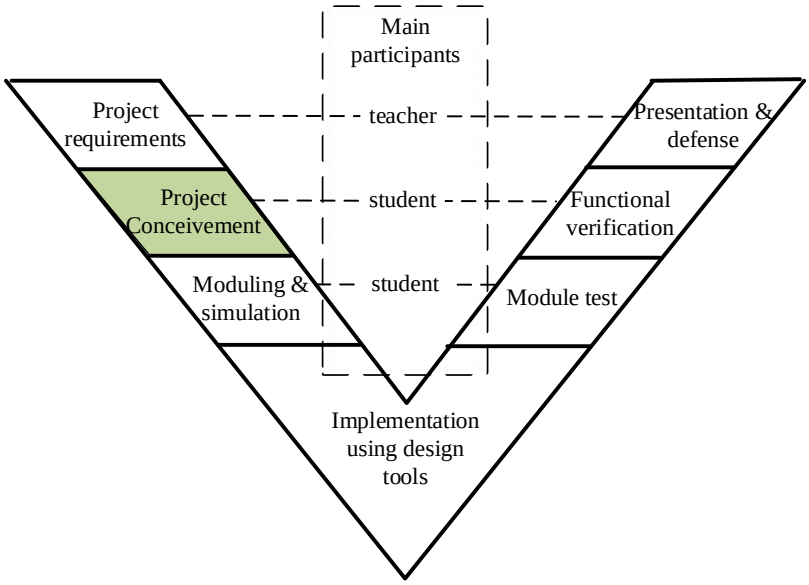

Figure 1. PBL implementation process

In Figure 1, We can find that, during the PBL process, students are the main participants while the teachers are the guiders and supporters behind, playing the role of questions answering and proposal providing. Most of the time, guidance is conducted through weekly discussions or other fixed cycle meetings with the engineering consultant team.

Generally, the authentic operation environments of the industry systems or products are complex and safety critical, especially aviation related or safety related ones. The projects for aviation related students are usually part of the aviation systems. At the most beginning of the research, their aviation background in depth and breadth aren't enough to support their mastering of the comprehensiveness and integrity of the operating environment, which easily makes them to focus purely on function realization while ignore the complexity and diversity of function application environment Intentional or unintentional. After task paper receiving, the project team usually google on internet directly and find some examples to follow, ignoring detailed investigation, analysis and inquiry of the project task requirements and its operation environment, let alone the impact of specific environment on equipment performance and possible hazardous action. This practice not only leads to the vulnerability of products and omission in students' knowledge mastery, but also gets the students into bad habits in engineering design, which would be the latent risk in his future engineering career. This is exactly not what PBL wants to do.

Process management is an effective means to solve the above problems. Learning sciences research shows that providing feedback on the artifacts that students develop is critical to the learning process, quick and effective collaborative inquiry among teachers, teammates and students from other teams would make the students engage in a rigorous, extended process and thinking critically, they can give, receive and apply feedbacks to improve their project. Incorporating real-world experiences into the process would expands and deepen their understanding of key elements in engineering.

The periodic meeting can't achieve rapid and effective communication between teachers and students, because the students' work progress and problems encountered are not periodic, which leads to less or poor communication between them. The students can't get instant feedback for their questions or obstacles, which influence the project activities, and it is difficult for teachers to find the students' problems and call their attention in time.

In "navigation principles and systems" course project, using online query & defense competition as excitation strategy to push and support students in collaboration and information consultation, strengthen the guidance role of the teachers at the initial stage of project research.

Online query & defense competition compels the teachers and students to query on any project he or she interested in, teams should critique and provide feedback to each other's explanations. This activity breaks the closed state of team working during project design, introduces external challenge, helps the students to think more consciousness and enthusiasm. Multiple rounds of query & defense competition promote students to understand the real-world operating environment of the project products deeply, continuously to improve their design scheme and promote its rationality and integrity before moving into the next stage. Online query & defense competition moves forward the project evaluation and improvement, allows teachers and other group students to critique and hunt design defect in the beginning. The online pedagogical approach makes it possible for the teachers to devote continuous attention to the students' project progress and keeping assessment, while promoting student engagement in a digital format any time they can. Online query & defense competition not only reduced waiting time for feedbacks but also improves the efficiency of discussion, students seem more like to query & defense on internet.

Online query & defense provides students opportunities to query and be queried, explain and be explained during PBL. Online competition not only keep students' interest and consciousness of active thinking, but also scaffold students learning in systematic thinking.

3. Method

In the project design of "navigation principles and systems", a challenge arena is added before the implementation of project design. The project process consists of five stages, which are: (1) teachers' projects planning and hand out; (2) students engineering consultant teaming and project selection; (3) Project conceivement and online query & defense; (4) Project implementation and verification; (5) Project result presentation. The project design process is divided into two stage: project conceivement and online query & defense stage and project implementation and verification stage. project conceivement and online query & defense stage will last from several weeks to several months depending on the project duration.

The horizontal cognitive interaction (interaction between students) theory in the principles of developmental psychology holds that: Students at the same cognitive level produce internal cognitive contradictions through slightly different viewpoints and cognitive collision. The solution of this cognitive contradiction will lead to the reconstruction of each individual's internal cognitive structure. The collision of differentiated views and understanding among the members of the group can promote their deepening understanding of the ideological content of the problem situation and optimize the ideas of solving the problem. Discussions between different groups (query & defense) provide opportunities for students to think from a variety of perspectives and affected by intensive thinking. Through the query & defense between teams, they can share ideas with other teams, broaden their understanding of the project and deepen the situation awareness. While vertical cognitive interaction

(the interaction between teachers and students) ensures that: teachers scaffold the discussion by providing students with consultation, guidance, evaluation and supplement, when discussions among students are confused or misguided, and ensuring that the process of problem-solving is effective and intentional, filled with wisdom and creativity.

The online query & defense provides a challenge game learning platform for students and teachers to fully communicate and interact, cultivate students' interest and curiosity in problem exploring and active thinking, find design defects and improve their project architecture continuously during the inquiry and defense, this is the process of real-world experience and operation environments understanding, and the progress of the key elements and implementation of engineering design mastering.

The online query & defense competition starts after each team gives out their preliminary design scheme according to the project requirements. It is carried out by inquiring and defending. Each team is the defending party of its own project, and the inquiring party is all the teachers and students of other teams. Super-star learning platform is adopted in order to facilitate the real time competition among all the teams, there is a PBL module especially for PBL teaching. All the grouping, project task papers, design schemes, queries and explanations can be uploaded and browsed by the teachers and students, inquiring and defending can be carried out in different webpage under each team. Figure 2 is an example of query and defense information screen copied from the webpage[7].

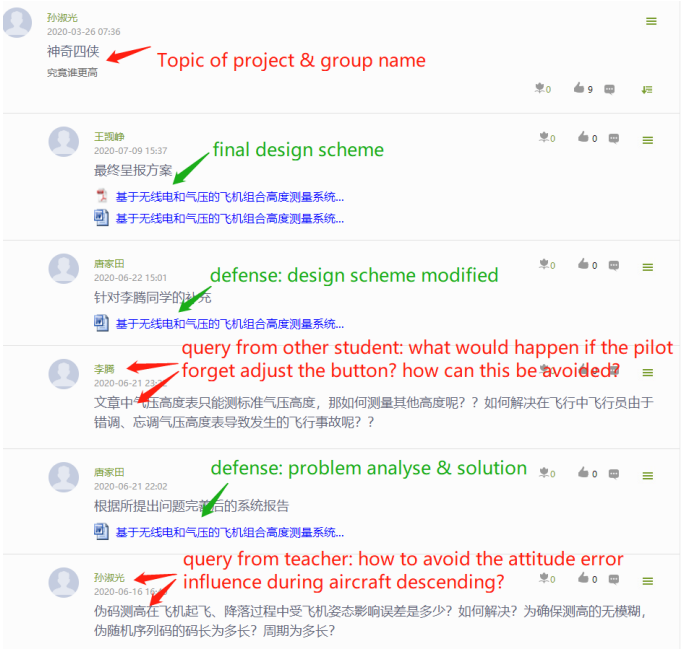

Figure 2—PBL webpage from super-star platform

The real-time and flexibility of the online teaching platform enable students to query and defense at any time, avoid the limitations of the periodic offline guidance meeting. Teams' query response and revise of design scheme improvement are quickly. For complex problems or unclear online communication, the project team can make an appointment to their institutor for offline in-depth discussion. The online discussion is more flexible, timely and smooth.

3.1 Project Grouping

According to the teaching goals of the navigation principles and systems, the teachers pose nine project topics covering the key navigation parameters measurement and calculation in aviation, including aircraft attitude, heading, altitude, airspeed, ground speed, distance, track, relative position and position in geodetic coordination, etc. Students are teamed in 14 groups, and each team selects one of the seven projects according to their interest. On average, there is 1~2 groups for each project. The projects selection and its undertaking team's name are listed in table 1.

Table 1- Project selection

Name of the Project	Topic focus on	Team name
After a somersault, is the monkey king head up or head down?	Attitude	Navigator Alliance
Where is the home in the vast universe?	Flight Track	Spirit guys; The latecomer
How to find the safe way backing home?	Landing guide	Navigation principle B
How far are you from me?	Distance	Platonic team; Excellent engineering team
I know clearly where I am even in the darkness	Position	Thunder team; Navigation A
Who on earth is higher?	Altitude	Fantastic four
How fast is the ideal wings flying?	Speed	Rookie team; Excellent youth
How does the stars light up my ways?	Satellite navigation	party train
How hard is it to keep the original heart?	Heading	Night flight in the starring sky; Doraemon

The project topics cover the key contents of the navigation principles and systems, hoping the students can understand and master the authentic application of the elements of their own project by the project researching and query defending, and master the rest contents undertaken by other teams by challenged querying and explanation evaluating. During the PBL process, students can comprehensively analyze and compare the measurement and calculation methods of different navigation parameters, as well as their advantages and advantages, so as to realize the horizontal and vertical comparison of navigation systems which is proved to be very effective for course in-depth learning.

3.2 Resource Support for Project Integrity

For PBL, the closer the problem scenario is to the real engineering environment, the better the students' mastering the problem. To a large extent, the online query & defense challenge arena is mainly used to help students build their authentic work situation awareness as detailed and real as possible by sustained instructor and peer querying and reviewing. The introduction of real-world experience and engineering authentic cases are mainly guided by the teachers who are supported by a navigation-systems engineering cases database. The engineering authentic cases of the database mainly come from the avionics corporation, Maintenance Repair Overhaul (MRO), and airlines, through irregular technical exchanging between university staffs and the enterprises engineers, some cases come from aircraft accident investigation report. The authentic engineering case resource database is mainly used for the project task paper preparing and sustained online querying.

Case database of unsafe events caused by navigation system failure or unreliable data is founded for the course project, including the flight accident caused by pitot probe icing, the intermittent fault of angle of attack (AOA) sensor caused sudden change of AOA value outputting to air data & inertial reference unit (ADIRU) for several times which caused the wrong judgment of the aircraft stalling, false traffic collision avoidance & alerting system (TCAS) signal caused by the suppressed coaxial cable, etc. Take two cases as example: (1) There was date error on A320 aircrafts in 2011.09.16, which was caused by GPS week number (GPS WN) rolling-over in the onboard GPS receiver and the time transfer logic between GPS receiver, air data inertial reference unit (ADIRU) and flight management system (FMS). This case is used to guide the students with queries such as “how can we get correct UTC time on aircraft using GPS receiver?”, “which date is used to determine the aircraft date when there are several dates from different unit?”, etc. (2) Peruvian Airlines flight 603 crash on October 2, 1996 is a heartbreaking lesson. It is used in speed and altitude related projects for integrity instruction. Queries such as “how can we avoid of excessive barometric altitude/airspeed difference warning in

the atmospheric data system?", "what will influence the accuracy of air data measurement?", "what would happen when the aircraft is maneuvering, and how to avoid the airspeed error caused by static pressure error?" would be given according the teams design. These problems are easily being ignored in the students' independent project design. These hidden problems are put forward by the teachers or other students in the form of query, which is convenient to remind the students of design defects, helps them to consider and analyze these problems in the project design scheme, avoid design loopholes, and improve its engineering authenticity and integrity.

After more than one month of query & defense, the teams have gradually clarified the project function and performance objectives, improved the project design scheme, transformed the functional requirements into different modules, defined the operation logic between and among modules, and the interface correlation between modules, which provide clear route for latter realization.

3.3 Guarantee for Effective Promotion of Online Query & Defense

In order to give full play to the role of the online query & defense, encourage the team members to participate in actively and put forward sufficient and effective queries, rules have been formulated in terms of the query numbers and quality, defense requirements, and take these as the basis for part of scoring. The rules and objectives of the online query & defense are shown in Table 2.

Table 2- Rules for online query & defense

Items	Rules	Objectives
Query requirements	✧ All students can query about the design scheme of other teams. The queried team must give explanation and modify or supplement the design scheme if necessary. The query times has no limitation. ✧ The teachers can query about the design scheme of all the teams at any time. The teachers' queries are limited to no more than 5 for each team. However, additional queries for imperfect or unclear defense explanation is not included in the 5 questions. ✧ The queries should go deep into all flight phases and flight conditions, which can be about functions or technical parameters.	Query about all other design schemes and self-defense makes students' understanding and mastery of all aircraft navigation systems, which promote the students' knowledge internalization or self-study.
Defense closed requirements	✧ The queried team explained all questions correctly, and no more queries appeared; ✧ If the queried team voluntarily abandons its original scheme and redesigns the scheme, the problems for the original ones will be automatically cancelled; ✧ Deadline for online query & defense reached.	Modify the design scheme continuously to real-world engineering approach
Scoring	The score of online query & defense is part of the course final scoring. The score of this part depends on the effectiveness of query & defense. ✧ Score for design scheme and defense (A): According to the design scheme and the correctness of defense. The full score for this part is 20 points. Too much queries will degrade the team score as indicating that the design scheme may be not well organized or with low feasibility. ✧ Score for query (B): The full score for this part is 10 points. Score is given according to the percentage of the effective queries posed by the team member over the whole queries except queries posed by the teachers.	Specify the number and quality of queries and explanations to ensure most of the students' participation and participation effectiveness; Teachers' participate to introduce real-world experience and avoid the process deviation.

	✧ Score from team member (C): The full score for this part is 10 points. Score from team members is given by other members in the same team according to the students' contributions in group work. ✧ Final score of this part for each students is: A+B+C	

The rules aroused the enthusiasm of students querying, they read the design scheme again and again, try to pick holes of other teams' scheme and stop their own loopholes by scheme integrity improvement, thus promote the students to think deeply, consult more resources, and conduct in-depth research on the project.

3.4 Impact of Online Query & Defense on Project Design

Thanks to the full discussion and demonstration of the project design scheme during the online query & defense stage, the product functions of each module and their relationship are clear. Task assignments for each team members are clear with continuous and smooth communication. The project implementation moves significantly faster than the ones undertaken in the previous semesters without online query & defense, discussions are more smooth and effective.

Taking the project on satellite navigation as an example, project is divided into four parts: receiver output information processing module, navigation and positioning calculation module, navigation and positioning performance analysis module, and GNSS civil aviation application advantages and disadvantages analysis. In the project, the team analyzed GNSS civil aviation application under performance based navigation (PBN) operation conditions. The impact of GNSS receiver usages in navigation operation, how to avoid unexpected actions of GNSS receiver and ways that should be taken under these cases are considered. Although some schemes stay in the state of paper design, the integrity of the project has been greatly improved compared with the previous design.

The final score of the project consists of two parts: one part is the score of online query & defense (40%，A+B+C) , the other part is the score of project design products, writing paper and presentation (60%, D). The students show richer project results and are more confident during their presentation.

4. Data Collection and analysis

The online query & defense lasted for a month. Students queried and defensed for 96 cycles, with a total of 145 cycles including the teachers' queries. Some solutions even exceeded the expectations of the teachers and achieved gratifying results.

Table3- statistics of query and defense

Team	Number of queries	Number of effective defense	Revision of scheme
Navigator Alliance	10	10	2
Spirit guys	9	9	4
The latecomer	14	14	2
Navigation principle B	10	10	2
Platonic team	16	16	4
Excellent engineering team	11	11	2
Thunder team	5	7	4
Navigation A	9	10	3
Fantastic four	11	12	4
Rookie team	16	16	2
Excellent youth	9	10	2

party train	12	12	2
Night flight in the starring sky	6	6	3
Doraemon	7	9	3

Project scores are compared between two neighboring semesters with and without online query & defense competition. To ensure the effectiveness of the comparison, multiply 0.6 for the project score without online query & defense, compare it with the score of project design products, report and presentation (D), what we find is that the average score of project with online query & defense is 4.3 higher than the one without online query & defense.

According to the students, as the online query & defense taken up some time, the project implementation time has been compressed, and the overall performance improvement of the project product has not been significantly improved as expected.

After course questionnaire of the students' satisfaction about the project process are carried out, and the statistical results are shown in Table 4. The satisfaction level is set into five levels, namely 1 very dissatisfied, 2 dissatisfied, 3 fairly, 4 satisfied and 5 very satisfied.

Table 4- Students' satisfaction about the project

About the design scheme	defense	Influence of query on design scheme	Outcomes self-appraisal	Satisfaction of the project process	Satisfaction of the project time	Online query & defense
3.8	-	-	4	3.9	4.1	without
4.2	4	4.6	4.5	4.3	4.0	with

About 84% of the students agree that extend the project design time would help to get better design products. Most students are satisfied with the integrity of their project, but it is obvious that there is still improvement room in the teachers' opinion.

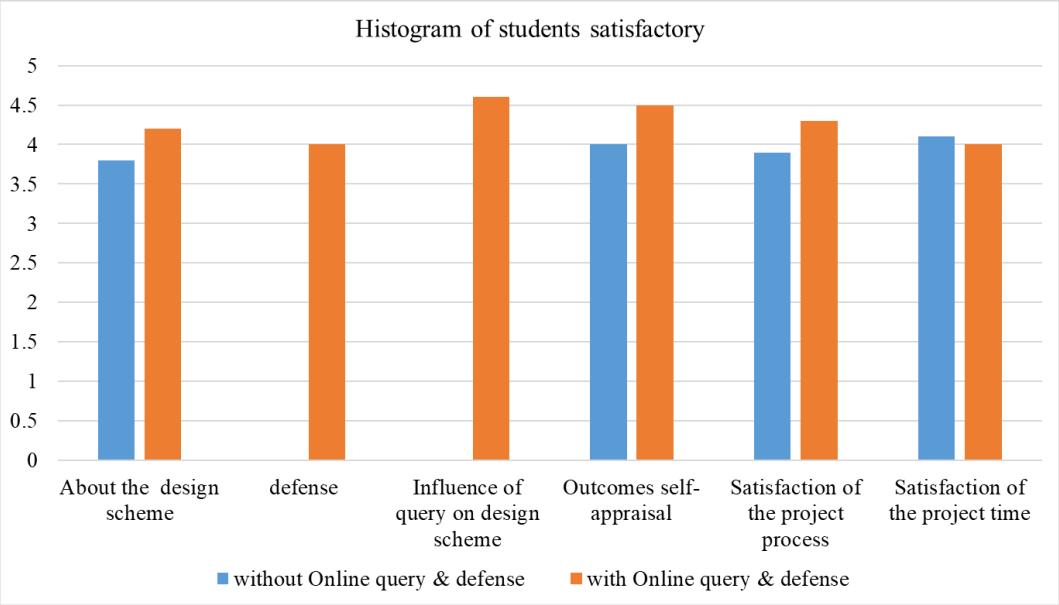

Figure 3—Histogram Results Showing Student Satisfaction

5. Conclusion

Online query & defense is used to improve the students' weakness in PBL teaching in this paper. We analyzed the reason of poor design integrity in students' project design, try to strength the teacher's influence and guidance at the conceivement stage of the project, and push the students to think more about the design products' operation environments and safety requirements by requisite online query

& defense activities. The results show that online query & defense build quick linkage among instructors, team members and different teams which help the students' participation enthusiasm keeping and real time confusion answering, depth of students' project participation. The teachers' conscious guidance promotes the students' understanding and analyzing of the engineering authentic operation environment of the project products, which are introduced into the project design, improve the project design integrity, and play a great role in cultivating students' excellent engineering design habits, and this habit is very important for safety-critical complex systems.

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8. Copyright Statement

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