Project-Based Learning at a National University
– A Collaboration between English and Engineering Departments –

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In this paper, the authors outline the theoretical background for the creation of an engineering project-based learning English course, describe the actual content creation and implementation of this course from April 2014 to August 2014, and identify positive and negative themes analyzed through grounded theoretical coding from students' feedback, which lead to significant alterations of future iterations of the course. The major positive themes resulting from this analysis include *presentation*, *knowledge acquisition in other fields*, *design*, and *research*. Negative themes expressed by the students in the first iteration of the course include *more TOEIC*, *time-consuming*, *more English*, and *burdensome*. The authors conclude the paper by commenting about ongoing research concerning the longitudinal effects on engineering students who participated in an English language project-based learning class, and ambitions for creating a robust and informed engineering project-based learning model for English students that can be easily transferred to and utilized in other university English programs.

Key Words **:** Project-Based Learning, ESL, Second Language Acquisition, Engineering, Collaborative Learning

1. Introduction

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) emphasizes project-based learning as a vital element in reforming Japan's education system by 2030. The objective is to make Japan a place able to thrive in the 21st century (Suzuki, 2015). In this reform effort, MEXT highlights critical thinking skills as a requirement for success in a 21st century globalized world. With the timeline of 2030, MEXT implies a long-term view in reforming education and in preparing Japanese society for the future. This longitudinal view of reform is the core of the current research endeavor that will be described in this paper. Within that core is the objective of enhancing student critical thinking skills.

The authors designed a longitudinal research study that looks at the effects a project-based learning class taught using English has on multiple groups of engineering and architecture students at a national university in Japan. Through this lens, they have set up a research structure that follows the students who have participated in the project-based learning course at the university where they teach. By the end of the research project, three separate iterations of the project-based learning course will have been taught with a total of 72 student participants. Moreover, the authors will have collected a wealth of qualitative data from various sources including open-ended questionnaires, professional journals, and student and faculty interviews. For the purposes of this paper, the authors are focusing on giving a brief outline of the initial iteration of this course in 2014, student reactions to that course, and analysis of those reactions to create informed revisions to course structure and content. Data used in this paper was

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drawn primarily from questionnaires completed by the student participants.

First, the theoretical framework will be given to describe the big picture vision of the project, and to show what literature the authors drew from in order to support and fill their knowledge base. After that, the methodology will be laid out describing the data gathered from a questionnaire completed by the students after the conclusion of the first iteration of the course in the spring of 2014. This data will be analyzed using theoretical coding research methods to precisely interpret student feedback. This feedback will lead to a final discussion on revisions that were implemented for following iterations based on the analysis results.

2. Theoretical Framework

Critical thinking as Mergendoller (n.d.) defines is "ordinary thinking done well, that is reflectively, with attention to criteria, and with the goal of making a defensible, reasoned judgment" (para. 4). Researchers from the University of Louisville (2016) say, "The ability to think critically calls for a higher-order of thinking than simply the ability to recall information" (para. 1). Chan and Lau (2016) define critical thinking as "the ability to think clearly and rationally about what to do or what to believe" (para. 1). In another form, Paulo Freire's (1996/1970) concept of *conscientizacao* takes ideas of critical thinking to a more activist realm. One has to be engaged in his or her environment in a critical manner by being literate enough to know what messages are being communicated on their behalf. This engagement will allow for greater social, political and economic empowerment thus placing power in the hands of the individual. Once people know how to engage through being literate they can think critically and conscientiously (Freire, 1996/1970). These understandings of critical thinking support and frame the project-based learning approach employed by the university instructors in their objective to foster a learning environment where critical thinking was a major organic compound for the students to develop their linguistic as well as scientific abilities.

As described, critical thinking was central to the formation of the class being presented in this paper. The class itself is a STEM-based project-based learning course, so the identification of critical thinking as a key building block of the class is natural. Capraro, Capraro, and Morgan (2013), who write specifically about STEM-based project-based learning, asserted that central to project-based learning was critical thinking. Mergendoller and Larmer (2015) identified eight essential elements of project-based learning that include:

1. Challenging problem or question
2. Sustained inquiry
3. Authenticity
4. Student voice and choice
5. Reflection
6. Critique and revision
7. Public product
8. Key knowledge, understanding, and success skills

When cross-referenced with the theoretical definitions and concepts presented earlier, unity between critical thinking and project-based learning is complimentary. The following excerpt from Capraro, Capraro, and Morgan (2013) highlight the stated complimentary aspects of project-based learning and critical thinking,

> Project-Based Learning is…composed of several problems students will need to solve. It is our belief that PBL provides the contextualized, authentic experiences necessary for students to scaffold learning and build meaningfully powerful science, technology, engineering, and mathematics concepts supported by language arts, social studies, and art. STEM PBL is both challenging and motivating. It requires students to think critically and analytically and enhances higher-order thinking skills. STEM PBL requires collaboration, peer communication, problem-solving, and self-directed learning while incorporating rigor for all students. STEM PBL builds on engineering design as the cornerstone and as the foundation on which students bring their compartmentalized knowledge of science, technology, and mathematics to bear on solving meaningful real-world problems (p. 2).

The connection between project-based learning and critical thinking is clear. Project-based learning could not be what it is without critical thinking.

3. The Course

3.1 Inspiration

The current state of Japan seems to be defined by a search for identity, or a reaffirmation of a perceived dominance painted by astronomic success throughout the 1980s. Whatever the perception, the actions on the ground by governing bodies and socio-economic and socio-politico organizations informs observers that Japan is trying to invigorate the populous as a way to deal with the very real implications of being a major economy in a world defined by globalization. This macro-understanding of the world has real implications for institutions of higher education responsible for educating and training the human resources of the future: the designers, builders, and leaders of tomorrow.

Therein lies the simple inspiration for creating an English language class utilizing a project-based learning pedagogical approach. The driving force was to create communicatively competent professionals who will be able to contribute to Japan as a nation, and a member of the world of nations (Ravestejin, et al, 2006). Also, this class was created based on prevailing actions by government ministries like MEXT to create funding programs specifically designed to allow institutions of higher education to create and implement programs that will advance the critical thinking skills of the student body, while preparing them with practical English language skills to do the work of a professional in the 21st century. Society is not built upon one static force. Be it pure economics, or health and welfare, or art, or education, etc. Multiple forces push and pull society creating the dynamism needed for a successful standard of living. University students are being called upon by business and society to engage more with the world in order to bring the benefits of globalization to Japan. Without the ability and skill to think critically, Japan could be on the negative end of what globalization has to offer. Our goal was to make sure the students experience a course that prepares them to be able to harness the forces within globalization and focus the best of those forces into Japan.

3.2 Planning

The development of this project-based learning course can be summed-up with two words, *collaboration* and *meetings*. From October 2013, the authors and the director of the department where they teach met with a group of four engineering teachers with the goal of designing projects suitable for second year first semester mechanical engineering and architecture students. Even before these meetings in October of 2013, the director met with various administrators to ensure adequate class time and financial resources could be allocated for a course of this nature. Also, department heads in the engineering faculty met with the authors and their director to determine which engineering teachers wished to be a part of this class, which was unique for the university.

By October 2013, the course facilitators of the class were known. What was needed was a tangible curriculum, and students. All the details were worked out over weekly meetings between the director and the English and engineering faculty and syllabus was developed by April 2014. Also, 24 students were chosen to be in the class. Twelve mechanical engineering majors and twelve architecture majors were selected based on the highest TOEIC scores within each major. A lot of discussion was had regarding how to choose the students, and because all engineering students were taking the TOEIC regularly, this gave the planning group some relatively objective way of choosing the most English-proficient students in terms of ability to read and understand technical English. This was not a perfect solution, but one the planning group thought was the most practical given time and resource constraints. When the students were selected, a meeting with the selected students was scheduled. During this meeting the students were informed about the parameters of the class in Japanese so they could more easily comprehend what was being asked of them. The choice to participate in this class was 100% voluntary. If a student did not want to participate in this course, they had the ability to opt not to and instead be placed in regular non-PBL English class. There was no penalty of any kind for not choosing not to participate. In the end, all the students who participated in this class volunteered to do so. (This has remained the student selection policy for all following iterations of this class.)

3.3 Course Objectives

In designing the objectives that would guide the course, looking back to the theoretical framework was important. Based on the literature the following objectives were derived:

1. To improve engineering English skills;
2. To improve professional presentation skills;
3. To improve collaboration skills; and
4. To improve critical thinking skills

As one can see, a main objective was dedicated to critical thinking. The rationale being that students may not have ever heard of project-based learning, or know the epistemological and ontological roots of the approach. This emphasis was also important to make faculty and administration aware of this critical component of the class. The authors did not

know the level of understanding various populations at the university brought to the development of this class. However, critical thinking, as it has been such a catch phrase for quite some time, is a more recognizable term, in English and Japanese. Finally, making critical thinking skills a distinct objective allowed the teachers to focus on it immediately and without ambiguity.

3.4 The Projects

The following sections will lay out the details of each project as designed by the engineering faculty, who were a vital part of this class, and the English language instructors. These are brief descriptions containing the core elements of each project. Throughout all projects, engineering faculty who work in professional circumstances provided technical support to the groups by means of lectures and class-to-class feedback concerning the process of building the projects. At any given time there were at least three faculty members in any one class – two English language instructors and one engineering instructor. All projects were all completed by the first iteration class within one semester – April 2014 to August 2014.

3.4.1 Make a Bridge (Engineering Proctor – Keigo Suzuki)

In teams of four, each team was given materials to make a bridge that could carry the weight of ten kilograms. All teams were issued the same materials – plywood planks and beams sufficient to make a miniature bridge. Grading criteria included weight – the less the finished structure weighed the higher the points to be awarded; aesthetics – a judging and ranking system was employed to determine the best looking bridge by where the students chose the top three most aesthetically-pleasing bridges; and displacement of the bridge when holding up to ten kilograms – the engineering professor collaborating for this project used a laser displacement mechanism to determine the structural integrity of the bridges by where the bridge that held the steadiest and bent the least received the most points.

3.4.2 Make a Luminaire (Engineering Proctor – Yukio Akashi)

Again, in teams of four, students were tasked with designing and building a lighting fixture – a luminaire. With this project each of the teams had to buy original materials they had planned to use in constructing their luminaires. All student expenses were reimbursed through department budget allocated for the class. As for grading, students were graded on the aesthetics of the luminaires. To decide the most aesthetically pleasing lighting fixture, a judging and ranking system was again employed.

3.4.3 Design Eyewear (Engineering Proctors – Masayuki Kawai and Yasuyuki Sakai)

The third project was a little different than the bridge and luminaire projects. Students were presented with a challenge to design eyewear for particular country markets – Italy, Germany, Dubai (United Arab Emirates), India, Denmark, and the United States. The president of a local prominent eyewear production company presented this challenge with the goal to only design the glasses. For this project there would be no physical product made. Students designed the glasses based on market research, then proposed the idea to the

president of the company in a public presentation. The president of the company selected the best three designs. As this was the final project, it was planned to culminate in a community-wide public presentation, which was open to and attended by the university and surrounding community, and covered by local and national press.

Throughout all three projects student teams had goals they had to reach, but how they traversed the path to achievement of those goals depended a lot on team dynamics, instructor support, and ability to understand the materials provided to them. Each project resulted in student teams giving a presentation to their classmates and instructors. The final presentation was larger and more consequential than the final grade. Following the success of the graded public presentation, the student groups had the opportunity to bring their presentation from university grounds to an actual local community eyewear event where they were able to present their designs to real people working in the eyewear field.

4. Methodology

4.1 Research Methods

The researchers utilized several methods for obtaining and analyzing data. This allowed for a better understanding of student needs. They could also adjust course content to better align with the course objectives listed above. In this section, these research methods will be outlined.

4.1.1 Triangulation of Data

The researchers utilized the triangulation method of data collection in order to obtain and synthesize multiple types of data obtained from the course participants (Wolcott, 1994). The data collected included: (1) journals and (2) questionnaires. While there were only two types of data collection tools, they allowed students substantive ways to organize and express their thoughts.

All course participants kept journals, what the authors called *Professional Journals*. The content of the *Professional Journal* was a freewriting and a project diary worksheet (Beckett & Slater, 2005). For freewriting, students were required to answer certain questions that varied week by week and write their thoughts on anything involved with the class over the previous week. The project diary worksheet has more prescribed sections for the participant to write comments about language used and skills learned over the previous week. Each participant was required to fill this out every week and turn into the instructors for grading and comments. For the purpose of this research paper, the authors will focus on a 2014 questionnaire which provided course participants the opportunity to free write, in general, their reactions and feelings to the course. The researchers were able to obtain 24 responses.

5. 2014 Student Questionnaire Analysis

5.1 Theoretical Coding

The researchers have been utilizing a grounded theory method of theoretical coding on the data obtained to not only analyze the data, but also allow them to “choose or construct new data collection methods and revise earlier ones” as necessary (Boyatzis, 1998; Prince et al., 2006; Thornberg et al., 2014). For this paper, the researchers conducted a line-by-line version of initial

coding on data gathered from the questionnaire. From this, initial coding themes emerged that allowed for insight into course improvement for the second iteration of the PBL course, as described in the next section.

5.1.1 PBL First Iteration – December 2014 Questionnaire Results

A total of 24 participants filled out the questionnaire in December 2014. In these questionnaires, certain themes emerged through the initial coding process. The researchers have divided themes into positive – the participant appears to believe this was a positive aspect of the course – or negative – the participant appears to believe this was a negative aspect of the course. Interpretations of whether an item was positive or negative were determined by the context of the answer. These free-response answers were written in full sentences and all were quite clear in context during the transition of data to themes during the initial coding stage. The specifics are indicated in the table below:

Table 1: Theoretical coding themes mentioned by three or more participants for December 2014 Questionnaire (out of 24 respondents)

Initial Coding Theme	Number of participants	Positive (P) / Negative (N)
presentation	14	P
knowledge acquisition in other fields	7	P
more TOEIC	6	N
design	5	P
time-consuming	5	N
research	5	P
more English	5	N
burdensome	4	N
new	3	P
anxious	3	N

5.1.2 Discussion of the Results

Using the results outlined above, it is clear the infusion of presentation and specialized knowledge elements – specifically engineering – into an English class was viewed positively by students of the class, with more than half the students (14 of 24) recognizing the *presentation* elements and over one-fourth (7 of 24) recognizing the *knowledge acquisition* elements. Furthermore, a substantial number of students seemed positive on the *design* and *research* skills gained from participating in these projects, with five of 24 – or more than 20% – referring to each of these themes.

However, a number of negative themes emerged along with positive themes. In particular, four negative themes stood out due to the number of appearances they made in the data – (1) *more TOEIC*, (2) *time-consuming*, (3) *more English*, and (4) *burdensome*. In response to this, the researchers made amendments to course content, for subsequent iterations, in order to achieve more of the positive aspects and reduce the negative aspects as outlined by course participants.

5.1.3 Changes to Course Based on Results

A number of revisions were made to the course content of subsequent course iterations based on the theoretical coding results from the December 2014 questionnaire. These changes took effect for the second iteration of the course, which was conducted from October 2015 to February 2016. These revisions were implemented in order to encourage more of the positive themes referred to by participants and minimize the negative themes.

As far as the *presentation* theme, course content was amended to include a two-minute

presentation (referred to as 'mini-presentation' in-class) in nearly every project-related class in order to build students ability to speak English comfortably and professionally in front of an audience. The *knowledge acquisition in other fields*, *design*, and *research* themes were promoted through the use of more group-oriented critical thinking exercises in English. An example would be an activity called "Craggy Rock," in which students work in groups to determine which types of bridges must be used in certain, predefined scenarios. This more effectively ensured their use of technical vocabulary in English to solve problems.

A number of revisions were also made to address negative themes. The most major change was reduction of the number of projects designed by students from three to two, retaining the bridge project and the luminaire project. This revision addressed all negative themes – *more TOEIC*, *time-consuming*, *more English*, and *burdensome* – first by freeing up 10 classes to be specifically targeted for TOEIC study. By adding this TOEIC element, it can be argued that the *more English* theme was also addressed. It also freed up students' time and lowered the burden on students since often project work had to be conducted outside of class hours in order to properly build a project. This also addressed the *time-consuming* and *burdensome* themes.

One other major revision was the streamlining of the project work for each the bridge and luminaire projects. In the case of the bridge project, students used styrene building materials in lieu of wood, drastically reducing the building time for students. In the case of the luminaire, students designed and built thin plastic or paper slips for cube-shaped, prefabricated lamps as opposed to building lamps using wood or metals, and designed from scratch. Both of these streamlining processes were incorporated to address the *time-consuming* and *burdensome* themes expressed by the first iteration participants.

6. Summary

In this paper, the authors outlined the theoretical background for the creation of an engineering project-based learning English course, described the actual content creation and implementation of this course from April 2014 to August 2014, and identified positive and negative themes analyzed through grounded theoretical coding from students' feedback, which lead to significant alterations of future iterations of the course. The major positive themes resulting from this analysis included *presentation*, *knowledge acquisition in other fields*, *design*, and *research*. These themes were encouraged in the second iteration of the course through the inclusion of mini-presentations in nearly every project-related class, and through the inclusion of critical thinking activities. Negative themes expressed by the students in the first iteration of the course included *more TOEIC*, *time-consuming*, *more English*, and *burdensome*. These negative themes were addressed through two major changes in course content: (1) the reduction of three projects to two projects for the semester, and (2) the streamlining of the bridge and luminaire projects.

In future papers, the authors will analyze similar qualitative data from following iterations of the course – starting with the second iteration conducted from October 2015 to February 2016 – to understand the effects

the revisions made to the course. The authors will also continue to work on the base research project of tracking student participants longitudinally in order to understand the effects of an English project-based learning class on engineering students. They will continue the collection of data and analysis of the first and second iteration participants, and begin the data collection process with third iteration participants beginning in October 2016. Included with the data collection methods used to this point, the authors wish to begin interviewing students – in focus groups, individually, or both – to begin probing deeply into the theoretical coding themes that have emerged through this research analysis. Finally, a driving vision is to create a robust and informed engineering project-based learning model for English students that can be easily transferred to and utilized in other university English programs.

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