WHERE LANGUAGE AND ENGINEERING MEET: FOSTERING EMERGING ENGINEERING IDENTITIES AMONG INTERNATIONAL ENGLISH LANGUAGE LEARNERS

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Abstract –This paper explores the impact of incorporating discipline-specific content into a university pathways program designed for first-year engineering English language learners.

In an effort to increase feelings of connectedness and encourage the development of student identity for students who must complete the bridging program before beginning full-degree studies, a collaboration with First-Year Engineering, FIRST Lego League and the Engineering IDEAS Clinics began whereby students worked with instructors, professors, and students from the Engineering Faculty as part of their language courses.

Student motivation and sense of faculty connection increased through the integration of these discipline-specific assessments and activities, and, overall the students reflected positively on these experiences.

Keywords: Teaching practice, English language learners, student motivation/identity, integrated language courses

1. INTRODUCTION

Since 2011, the number of international undergraduate students in the University of Waterloo's Faculty of Engineering has more than doubled, with international students now comprising roughly 15% of all first year admits [3]. Many of these students experience both language and transition difficulties, and for the Faculty, encouraging participation and engaging international students in engineering "has proven to be one of the biggest challenges" [3]. This challenge is compounded for English language learners (ELLs), particularly those who must first complete eight months in the university's official bridging program – BASE (Bridge to Academic Success in English) – in order to meet the university's English language requirement before beginning their full degree-studies within the discipline. While the BASE students have been conditionally admitted to their program of choice within Engineering and are even permitted to take one core credit course per term (in addition to their BASE language

courses), it has been an ongoing struggle to help them feel connected to and engaged with their faculty.

1.1. The Bridge to Academic Success in English (BASE) program

The Bridge to Academic Success in English (BASE) pathways program was launched in the fall of 2013 with the main aims of improving students' performance in all language skill areas and strengthening vital academic skills by facilitating a path of academic integration that aligns with the demands of higher education. During the pilot year of BASE, the Faculty of Engineering conditionally admitted sixteen students. Interviews with six of the original sixteen Engineering students following their first full term of degree studies yielded some important insights into the efficacy of the BASE curriculum and the students' experience of it.

When asked to characterize their time in BASE, all six students discussed not 'feeling' like engineering students (despite taking credit courses with their non-BASE engineering peers), nor did they think of themselves as a part of the on-campus engineering community while in BASE. As one student expressed, "I was feeling like I'm a BASE student instead of a University of Waterloo student or Engineering student." When asked how their BASE language courses could have been more helpful, all wished they had used their time in BASE to become more proficient in their understanding of technical terms and concepts and the majority struggled with the programming knowledge required in their first year.

- "Most of the former BASE students have difficulty with programming instructions. The words are not difficult; I don't know why I don't understand."
- "I would have liked to have more skill set development and getting experience...I don't know if the machine shop was open to BASE students...they can create some simple project and work one hour or two in the machine shop and that would be a great experience for them."

While the majority of the original sixteen Engineering – BASE students went on to achieve academic success in their first full year of undergraduate study, it is clear that the eight months spent in the bridging program could have done more to foster their emerging engineering identities by creating opportunities for situated experiences within the discipline. It was presumed that by doing so, student motivation for learning within the program would also increase.

1.2. Identity as a Motivational Variable

Within any learning context, interest and identity develop through interactions with content. “Interest refers to a learner’s predisposition to reengage particular disciplinary content over time. Identity refers to a learner’s self-representation as a person who pursues particular content” [2]. Learners in the BASE program are admitted to the university first as engineering students. Engineering, and not English, provides the content that triggers their interest; it is as ‘engineering students’ and not ‘English students’ that these learners wish to see themselves. While “the desire to reduce the discrepancy between [their] actual and ideal selves” can be seen as a powerful motivator to learn English [4], the BASE students are, nevertheless, immersed in language classes for twenty hours each week. Renninger [2] asserts that “both interest and identity develop in relation to available experiences and to how learners perceive, understand and represent these experiences”. If students in BASE perceive their language experiences to be disconnected from their interest in learning about engineering and becoming engineers, then the likely result is a lack of motivation. Having both cognitive and affective impact, identity and interest can be considered motivational variables that are experience-based and situational, particularly when opportunities for situated learning are understood by learners to be highly relevant and capable of generating positive outcomes.

This paper presents an investigation of how integrated curricular changes within a language course designed for undergraduate Engineering English language learners have, over the course of two years and three different student cohorts, created opportunities for students to engage with disciplinary content, thus positively impacting their learning and identity formation.

2. METHODOLOGY FOR COURSE DESIGN

2.1. FIRST Lego League

In an effort to stimulate motivation and foster a sense of connection with the Faculty of Engineering, an engineering design component has since been incorporated into one of the BASE language courses, offered for the first time in the

CEEAA17; Paper 36

University of Toronto; June 4 – 7, 2017

2016 winter term and again in winter 2017 as well as in the intensive BASE summer program (iBASE) in 2016. A collaborative effort between the BASE program and professors/instructional staff from First Year Engineering, along with support from FIRST and the IDEAS Clinic, this design component involves BASE students working together to design and build LEGO robots to complete FIRST LEGO League challenges. Specifically, the course objectives focus on developing students’ familiarity and use of technical terms in verbal and written communication, critical thinking skills in making evaluative comments on design, and teamwork skills (using task management tools and team contracts) to create a collaborative and positive working environment. Another focus of the course is to cultivate technical and problem-solving skills through the robot design and programming graphical code.

BASE students also experience “external” examination by periodically having ‘technical experts’ (instructional staff) from the Faculty of Engineering formally and informally assess them. During each of the three assessments, the student teams participate in a robot demonstration and a subsequent Q&A session (external assessment) where they have to defend and explain their design decisions. The first assessment is highly structured and scaffolded. However, subsequent assessments build on the students’ experience from the first assessment, and the students are asked to set their own objectives, giving them more flexibility to challenge themselves. As a result, the complexity of the task increases as they move through the three assessments. The external assessment emphasizes both the accountability the students should have for the technical aspects of their robots and the clarity with which they must give their verbal explanations. Following each of these sessions, the students deliver either a presentation summarizing their performance and design approach or a written report to the same effect, similar to the laboratory outcomes accompanying subject area courses. This course also gives the students an opportunity to work with an Engineering student on a work-study term, who attends all classes in the design component of the course and provides tutorial assistance and peer mentoring support for the students.

2.2. Engineering IDEAS Clinic Activities

Because iBASE students do not take a credit course, helping these students to connect with their faculty and future program is a priority. In addition to the aforementioned FIRST LEGO component, the iBASE program has integrated the university’s Engineering IDEAS Clinic activities into the curriculum by adding three sub-units. Each subunit is themed and contains three components: thematically-relevant, supplementary

reading/listening material, a 50-minute guest lecture from professors/experts and a hands-on IDEAS Clinic activity which is hosted by Engineering professors and TA's. Language support is provided to prepare the students for these activities, and subsequent assessments test their language and technical understanding.

2.3. Data Collection

At the conclusion of each course iteration, the students, BASE instructor, work-study student and Engineering instructor were asked to provide feedback on the FIRST LEGO component and IDEAS Clinic activities and their impact on student learning. Feedback from the students was gathered by way of an end-of-term survey (see Table 1). End of term notes were collected from the BASE/iBASE instructor, the work-study student and the Engineering instructor.

Table 1: A section of the end-of-term academic survey.

iBASE/BASE	
Did the Engineering (LEGO) Design component of Academic Skills help you to...(Please circle Yes or No and provide a brief explanation.)	
• expand your knowledge of technical vocabulary?	YES / NO ____
• improve your ability to work as part of a team?	YES / NO ____
• improve your knowledge of programming?	YES / NO ____
• deepen your knowledge of the design process?	YES / NO ____
• experience what being a University of Waterloo Engineering student will be like?	YES / NO ____
iBASE only	
Did you benefit from attending the Engineering Ideas Clinic Activities?	
☐ Yes	
☐ No	
If yes, in what ways? If no, why not? ____	

3. RESULTS

The feedback from students, BASE instructor, Engineering instructor and Engineering work-study student points to several benefits of the FIRST LEGO and Engineering IDEAS Clinic initiatives, including improved motivation and sense of connectedness to the Faculty of Engineering, as well as overall language, technical and teamwork skills.

CEEAA17; Paper 36

University of Toronto; June 4 – 7, 2017

3.1. FIRST Lego League: BASE & iBASE

Students in both iBASE and BASE reflected positively on the LEGO course component. Above 80% of students in both cohorts reported improved skills in teamwork and the design process (See Figures 1 & 2). They also reported increased knowledge and understanding of technical terms - 78% for iBASE and 86% for BASE. Approximately 66% of iBASE and 73% of BASE students reported an improvement in their programming skills.

Fig. 1. Student survey results for iBASE.

Fig. 2. Student survey results for BASE.

Of particular interest were the student responses to the survey question designed to provide some insight into their developing identities as engineering students: "Did the Engineering Design component help you to experience what being a University of Waterloo Engineering student is like?" Overall, 73% and 63% of iBASE and BASE students, respectively, responded positively, citing their exposure to technical lectures, report writing, troubleshooting, data tabulation and team building. One student claimed that "classes seemed more like a university class than an English course, and that is good". Another summed up the relevance of the course: "What we learned here is very useful to my future engineering studies." Some students commented specifically on the LEGO component, stating that it involved "working effectively together and thinking deeply". One student also reflected, "FLL challenge is the most useful part because we learnt about group work, mechanical design and programming in the

same assignment”. Another student specifically identified the value of external assessment by First Year Engineering: “people from the campus assessed us”.

Students who answered ‘no’ to the question, cited the following reasons:

- “[not] near to UW level”
- “[the experience] seems to be specific [to] BASE...”

End-of-term observations from the BASE instructor (Table 2), Engineering instructor and work-study student echoed the predominantly positive student sentiments, highlighting not only stronger technical skills in the students but also a stronger sense of professionalism and a better connection with their future discipline.

Table 2: Comments for Lego component in BASE.

BASE Instructor
<p><i>“Additional contact with Chris Rennick and Mary Robinson motivated students to produce better work.”</i></p> <p><i>“The Engineering co-op student provided both peer and mentoring support.”</i></p> <p><i>“Overall, the students developed professionalism... strengthening their connection to the faculty.”</i></p>
First-Year Engineering Instructor
<p><i>“The biggest improvements were in the presentations and teamwork displayed by the 3rd session”</i></p>
ENG work-study student
<p><i>“I think having the LEGO project on top of their midterms...is a good eye opener to the importance of time management and the course load of first year without piling too much on right off the bat.”</i></p> <p><i>“...as the term went on, the students were making better base robots and much more innovative attachments”</i></p>
Student comments
<p><i>“FLL challenge is the most useful part because we learnt about group work, mechanical design and programming in the same assignment”</i></p> <p><i>“...want more classes related to engineering work. Good example:...robot lego”</i></p> <p><i>“...there should be more lego”</i></p> <p><i>“Teamwork [was the] most effective [component of the iBASE program] ...for Lego”</i></p> <p><i>“Give[s] me [a] glimpse of my future engineering life”</i></p>

3.2. Engineering IDEAS Clinic Activities

Student end-of-term surveys reflect an overall positive experience for the 2016 iBASE Engineering cohort. Approximately 89% of the students reported that they benefitted from attending the Engineering IDEAS Clinic activities, stating they “gained a lot of practical experience” and that “it helped [them] understand what an engineer should think about” (See Table 3).

Table 3: Comments for IDEAS Clinic activities.

iBASE 2016 student comments
<p><i>“It was interesting! It taught us about data analysis and some mechanical designs.”</i></p> <p><i>“Gained a lot of practical experience”</i></p> <p><i>“It helped me understand what an engineer should think about.”</i></p> <p><i>“I like every Engineering Ideas Clinic Activities' theme. We learnt how to implement research.”</i></p>

4. DISCUSSION

Integrating discipline-specific tasks into the BASE (and iBASE) language curriculum helped foster student Engineering identity and encouraged students to connect with their faculty. Students were motivated to improve their technical skills and practice their language skills.

A main impetus for the changes made to the BASE course design was the desire to better connect students with their discipline, thus providing opportunities to ‘feel’ like an engineering student. While 67.6% of the total course participants stated that the LEGO design component helped them to experience what being a University of Waterloo Engineering student is like, the remainder of the class were unable to make the same connection to the course content. It is possible that these students, lacking knowledge about engineering as a discipline, may have had perceptions of being an engineering student that were not compatible with their experiences in the course. This may explain student comments which claim BASE courses are quite different from degree courses. Another example of this perceived dissonance could be a student admitted into an Environmental Engineering program might not have as readily connected with some of the mechanical processes involved in building and programming a robot, as, for instance, a Mechanical or Computer Engineering student might have, even though the skills required to do so apply to any stream of engineering.

Some of the students also questioned the relevance of the LEGO graphical programming, suggesting that it is not ‘real programming’ because future degree programs use other programming languages. However, the work-study

student expressed that even though there are differences between languages, “the differences come down to syntax, so ...the important thing is understanding how to approach a coding problem rather than learning as many languages as [possible]” [1]. Again, some students were not able to connect course content, in this case, developing programming skills, to their future study. The work-study student further explained that “this LEGO program is a really good way for the students to dip their toes into thinking about programming without spending too much time learning syntax” [1]. This is especially important to consider since the outcomes for the activity do not include practising or learning programming.

Task engagement, as a behavioural expression of motivation, was, according to the instructor and work-study student, quite high for most student teams. Indeed, motivational ‘flow’ was observed among some teams who spent many focused hours (both during and after class) designing and programming their robots. This flow experience may have been facilitated by the course-based activities associated with the engineering design cycle and its iterative nature involving creativity and problem-solving. However, the handful of students who expressed dissatisfaction with the learning outcomes of the course were the same students who also experienced challenges in working with their team.

5. CONCLUSIONS

Identity development is challenging to measure; however, it can be concluded that overall, the BASE program, in collaboration with First-Year Engineering, gave students an opportunity to develop their identity as UW Engineering students by experiencing some similar tasks and communicative learning outcomes as their counterparts in first year. Moving forward, one way to make these similarities more explicit to the BASE students and, therefore, enhance the connection of BASE course content to studies in Engineering, regardless of the specific engineering discipline, is to align technical writing, presentation and teamwork outcomes in BASE with the Engineering Graduate Attributes. To address possible teamwork challenges, which can counteract positive engagement with course content, future iterations of the LEGO course component and IDEAS Clinic activities will

continue to emphasize accountability in teamwork and provide further support in developing healthy team dynamics.

The longer-term impacts of the BASE – Engineering initiatives have not yet been measured. Future research will investigate the importance of this collaboration in helping to orient BASE students during their first year of full degree studies while also considering the transferability of the skills developed and acquired in BASE to their full degree studies.

Acknowledgement

We would like to thank the following collaborators without whom this initiative would not have been possible: Mary Robinson, Associate Director of First Year Engineering, Ajoy Opal, Professor & Director of First Year Engineering, Peter Teerstra, Director of the Sedra Student Design Centre, FIRST Lego League, Sanjeev Bedi, Professor of Mechanical and Mechatronics Engineering and the Engineering IDEAS Clinics.

We would also like to acknowledge the continued support and contribution of Chris Rennick, Engineering Instructional Support Tutor, First Year Engineering and Engineering Educational Developer, Engineering Ideas Clinic in his willingness to work with our BASE students and in helping to edit this paper.

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