THE IMPACT OF PROJECT-BASED LEARNING ON SELF-DIRECTED LEARNING READINESS

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Abstract: All incoming students at the University of Calgary's Schulich School of Engineering take a first year Design and Communication course that requires them to work in teams of 4 on a number of open-ended design projects. The projects require students to be persistent, self-disciplined, and curious, while carefully organizing and pacing themselves to reach their end goal. In this paper, we use the Self-directed Learning Readiness Scale (SDLRS) survey to determine if, by practicing these skills, students' self-directed learning readiness is improved. We compare a compare a new cohort of first-year engineering students with a cohort of first-years students with project-based learning experience. The results suggest that project-based learning experiences do have a positive impact on self-directed learning readiness.

1 INTRODUCTION

For more than a century, the world has experienced a period of unprecedented technological growth that, while greatly improving living conditions, has threatened the very environment in which we live. As engineers, we can look back with pride on the accomplishments of our profession, but we also look forward with trepidation to the challenges our technologies have created.

Our goal as engineering educators in the 21st century should be to equip students with the skills they will need to face these challenges; however, if the next 25 years are anything like the last 25 years, it is impossible to predict with any certainty what direction technological innovation will follow, and consequently, what specific technical skills will be needed. Despite this, we can say with some certainty that the next generation of engineers will need to be life-long learners to keep pace with the rapid change in technology. As educators, in addition to providing a strong scientific and engineering foundation for our students, we must find ways to foster their capacity for life-long learning.

In this paper, we look at both the assessment and the development of life-long learning skills in undergraduate engineering education. The research in this area has focused on the link between self-directed learning readiness and life-long learning (Candy, 1991; Garrison, 1997; Oddi, 1986) and has pointed towards the Self-directed Learning Readiness Scale (SDLRS) as a tool that can be used for this purpose. The SDLRS was developed by Guglielmino (1977) and has been well validated across as large population (Field, 1999; Maltby et al., 2000). Recent studies in with both business (Dynan et al., 2008) and engineering ((Jiusto and D. DiBiasio, 2006; Shuman et al., 2005) undergraduate students show that students' readiness for self-directed learning can be positively influenced by the choice of learning activity. We look at the impact that experiential learning activities have on the development of life-long skills in undergraduate students.

Our paper begins with an overview of the assessment of self-directed learning readiness. Next, we describe our research methods in Section 3, then present the results of our study with a group of first year design and communication students in Section 4. The paper concludes with a discussion of the link between the choice of learning activities and life-long learning development, as well as our future work in this area.

2 SELF-DIRECTED LEARNING READINESS

As noted by Litzinger et al. (2005), life-long learning has been recognized as a critical engineering skill for many decades (e.g., (ASME Goals Committee, 1968; Cervero et al., 1986; National Academy of Engineering, 2004)). In recent years, this importance has been highlighted by the inclusion of a life-long learning outcome in both the ABET engineering accreditation criteria within EC2000 (ABET, 2014) and the CEAB graduate attributes criteria (CEAB, 2014).

ABET criterion 3(i) states that U.S. undergraduate engineering programs should prepare students to recognize the need for and have the ability to engage in life-long learning (ABET, 2014). CEAB criterion 3.1.12 states that graduates of Canadian undergraduate engineering programs should have an ability to address their own educational needs in a changing world in ways sufficient to maintain their competency and allow them to contribute to the advancement of knowledge (CEAB, 2014).

Life-long learning is multifaceted, and can be thought of in terms of both attributes (e.g., openness to learning opportunities) and skills (e.g., basic study skills). However, at its core, life-long learning involves taking responsibility for one's own learning. As a result, work in this area has recognized the tight link between life-long learning and readiness for self-directed learning. This can be seen when comparing Guglielmino's definition of the self-directed learner and the ABET and CEAB definitions of life-long learning:

> "A highly self-directed learner, based on the survey results, is one who exhibits initiative, independence, and persistence in learning; one who accepts responsibility for his or her own learning and views problems as challenges, not obstacles; one who is capable of self-discipline and has a high degree of curiosity; one who has a strong desire to learn or change and is self-confident; one who is able to use basic study skills, organize his or her time and set an appropriate pace for learning, and to develop a plan for completing work; one who enjoys learning and has a tendency to be goal-oriented." (Guglielmino, 1977)

Despite wide-spread agreement on the importance of life-long learning, there is a lack of understanding within the engineering education community about the best means to develop and assess life-long learning skills within the curriculum. As early as the mid-1980's this challenge was tackled by the U.S. Panel on Continuing Education [18], who looked at types of activities associated with life-long learning skills development, and by Cervero et al. (1986), who studied the ways in which practicing engineers engage in life-long learning.

Tools for assessing self-directed learning readiness were developed by Guglielmino (1977) and Oddi (1986), while research on the characteristics and models of self-directed learning was conducted by Candy (1991) and Garrison (1997). More recently, work is being conducted on the impact of learning activities in undergraduate education on the development of life-long learning skills. For example, Litzinger et al. (2005) use Guglielmino's Self-directed Learning Readiness Scale (SDLRS) (Guglielmino, 1977) in a cross-sectional study to determine if and how readiness for self-directed learning varies across the years of undergraduate engineering programs and type of learning activity at Pennsylvania State University. Their results show that SDLRS scores are significantly correlated with year of study and GPA; however, neither year of study nor GPA were shown to be strong predictors of SDLRS scores. They also show that problem-based learning increases the average readiness for self-directed learning. A similar study was performed by Dynan et al. (2008) with business students. They use the SDLRS to show that student readiness for self-directed learning increases when students are involved in learning activities that require self-directed learning practice (i.e., unstructured environments where students are afforded greater opportunities to shape their work).

In the next section, we describe the approach used in our study of first year engineering students' readiness for self-directed learning.

3 DESIGN OF THE STUDY

3.1 First Year Design and Communication

This study was conducted in the Fall 2013 and Fall 2014 terms in the Schulich School of Engineering first year common core course, Engineering 200 "Engineering Design and Communication". This course is intended to provide all Schulich School of Engineering students with an introduction to engineering principles, design, communications, leadership, and project management through a sequence of tea, Project-based Learning (PjBL) design projects. Students are taught a design process and work in teams of 4 on a number of design projects. These projects vary in length. At the start of the semester they are one-week projects and multi-week projects (4 to 5 weeks in length) during the second half of the semester.

Presently, the course is offered each Fall term to approximately 715 first-year students, who are divided into 4 lecture cohorts of approximately 180 students and 24 laboratory cohorts of approximately 30 students. The laboratory cohorts are further divided into student teams of 4 students.

The first year student population at the Schulich School of Engineering is drawn predominantly from a high-school admission cohort. Given that the survey reported in this paper was conducted in the middle of the Fall term, the results are representative of a young adult population with limited exposure to post-secondary education.

3.2 The SDLRS Survey

As noted previously, we chose Guglielmino's Self-directed Learning Readiness Scale (SDLRS) (Guglielmino, 1977) to assess graduate attribute 3.1.12 "life-long learning" (CEAB, 2014). This choice of instrument was made (1) for consistency with similar studies in the engineering and business education literature, and (2) because of the instrument's established reliability and validity as a measure of readiness for self-directed learning.

For our survey, we use the "Learner Preference Assessment" instrument, developed in 1982. The Learner Preference Assessment instrument is provided with a distribution of scores for adult learners for whom the mean score is 214 and the standard deviation is 25.59. Scores of 202-226 are considered to be "average"; scores of 227-251 are considered to be "above average"; scores of 252-290 are considered to be "high". The survey was conducted online both in the Fall 2013 and the Fall 2014 terms using Survey Monkey (2015), and students were encouraged to participate with an incentive of a $5 gift cards (from a national coffee shop) was offered to each of the first 100 participants.

To determine the effect of the choice of learning activity on self-directed learning readiness, we first ran the survey early in the Fall 2013 to gauge the self-directed learning readiness on incoming engineering students, then ran the survey at a later point in the Fall 2014 term after students have had experience with experiential learning activities. Although it would have been preferable to run a pre- and post-survey in a single term, we did not want to over burden our first year students with surveys. In the Fall 2014 term, we also provided students a choice between two PjBL activities for the third project of the semester: a game design project based on the novel *The Martian* (Weir, 2014) and a service learning project where students design for development using biomimicry (sustainable design inspired by nature). Our hope in providing this choice of learning activity was that we would see students with a higher propensity for life-long learning (i.e., higher SDLRS scores) choose the more open-ended service learning project.

3.3 Research Question

In order to investigate the effect of the choice of learning activity on self-directed learning readiness, we explored the following research question:

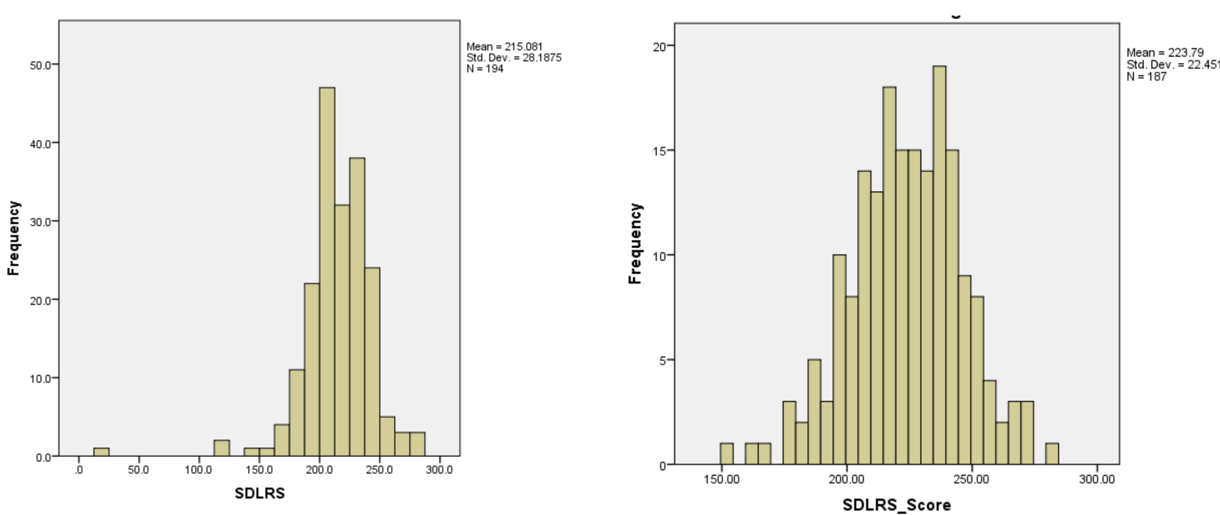
Does the choice of learning activity impact students' self-directed learning readiness (as predicted by the SDLRS)?

4 RESULTS

In this section, we summarize the results of the surveys our first year design and communication students that were run in Fall 2013 (response rate = 28%) and Fall 2014 (response rate = 32%). We begin by comparing the Fall 2013 and Fall 2014 cohorts to determine if more experience with PjBL activities has an impact on self-directed learning readiness, then we focus on the Fall 2014 cohort to determine if there is a relationship between project preference and self-directed learning readiness.

4.1 Comparing the 2013/2014 Cohorts

The results of the first year design and communication course survey are shown in Figure 1. As can be seen one the left of this figure (Fall 2013 results), our entering first year students' readiness for self-directed learning is very consistent with the adult average reported by Guglielmino (1977) (i.e., SDLRS of 214 with a standard deviation of 25.59). This is not surprising given that the survey was run early in the term when these students were fresh out of high school, and had relatively limited exposure to learning activities that require self-directed learning practice.



(a) Fall 2013 (b) Fall 2014

Figure 1: SDLRS results – Engineering 200

Alternatively, the Fall 2014 survey results (on the right of Figure 1) show that average SDLRS has improved relative to the adult average for the first year cohort who have had multiple PjBL experiences. To test this hypothesis, we define the null hypothesis as follows:

H_o: $\mu \leq 214$ (i.e., average student SDLRS, μ, is not affected by PjBL experience)

The alternative hypothesis in this case supports our belief that PjBL activities do positively impact students' self-directed learning readiness: i.e.,

H_1: $\mu > 214$

Given that we are comparing our survey results to a population mean (i.e., Guglielmino's adult average for the Learner Preference Assessment), we have used a single-sample *t*-test for our analysis. As expected, the Fall 2013 SDLRS average is not significantly different from the population mean ($t_{obt}(189) = 1.324$, $p < 0.05$, *sig*. = 0.187), showing that our entering first-year students have self-directed learning readiness consistent with the adult population norm. However, we can safely say that the Fall 2014 cohort does show a self-directed learning readiness that is above the adult population norm ($t_{obt}(186) = 5.964$, $p < 0.05$, *sig*. = 0.000). In this case, the increase in SDLRS score (mean difference = 9.79) is very likely a result of the PjBL experiences in Engineering 200; however, since first year students take four to five additional courses in mathematics and science and are also exposed to extracurricular activities, we cannot say with certainty that the entire effect is a result of the Engineering 200 course.

4.2 Self-directed Learning Readiness Propensity

As noted previously, students in the Fall 2014 cohort were given a choice between two PjBL activities for the third project of the semester: (1) a game design project, and (2) a service learning project where they designed for development using biomimicry (sustainable design inspired by nature). To test our hypothesis that students with higher self-directed learning readiness would show a propensity for projects of a more open-ended nature (i.e., requiring more self-directed learning skills), we compared the two cohorts using an independent-samples *t*-test:

$$H_o: \mu_{biomimicry} - \mu_{game} \leq 0$$

$$H_1: \mu_{biomimicry} - \mu_{game} > 0$$

In this case, we failed to reject H_o: i.e., we cannot show that there is any significant difference between the two cohort's SDLRS scores. In fact, the game design project group appears to have a higher SDLRS score (M = 228.3, S = 20.96) compared to the biomimicry design project group (M = 221.2, S = 22.83). However as noted, the independent-samples *t*-test shows that there is no statistical difference between the two cohorts.

It is very likely that the effect of the earlier experiential learning activities in the course overwhelmed any differences that we might have seen in these two cohorts. As well, students may not have seen a large difference in the two projects from the perspective of the level of “self-direction” needed to perform one or the other.

5 CONCLUSIONS

Although we cannot conclusively link self-directed learning readiness to PjBL learning activities, the results are encouraging. In particular, given that the projects in Engineering 200 are of an open-ended nature, it follows that student success is dependent on self-directed learning skill and attributes (e.g., persistence, self-discipline, curiosity, organization and pacing, goal-oriented, etc.). The results in Section 4.1 appear to support, and certainly do not refute, this notion.

Our future work in this area will focus on more explicit comparisons of learning activities than those performed for this study. Since all of our first-year engineering students are required to take Engineering 200 in their first term, we will look at comparisons with students from other programs who have a more structured first year experience. As well, we plan to track students in different engineering disciplines to determine if curriculum has an impact on self-directed learning readiness. For example, some of our programs have been developing a “design stream” (a sequence of courses that provides students with a project-based learning experience each year), while others have chosen to follow a more traditional, engineering science route in second and third years.

Acknowledgements

The authors wish to thank the Suncor Energy Foundation and the Schulich School of Engineering for their generous support of this research. As well, we would like to thank the students of Engineering 200

“Engineering Design and Communication” for their support and commitment to continuous improvement at the Schulich School of Engineering.

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