EFFECT OF FIRST-YEAR SERVICE-LEARNING PROJECTS IN CDIO SKILLS AND MOTIVATION

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ABSTRACT

The goal of this paper is to assess the effect that the exposure to a service learning project carried out during the first-year Civil Engineering introductory course had on students' academic motivation and personal, interpersonal and professional CDIO skills in a one-, three- and five-semester timeframe. The effect of the service-learning (S-L) project on students' CDIO skills was measured with an instrument built by the authors (*Effect of Service-Learning on CDIO Skills - ESLCS*) and the academic motivation was measured using the Academic Motivation Scale (AMS). Both instruments were applied to four cohorts (2015, 2016, 2017 & 2018), during the second semester of 2018. Among some of the results, a very strong correlation was found between the perception that students had on the effect that the S-L project had on their CDIO skills, their intrinsic motivation and their identified regulation.

KEYWORDS

Active learning, Service learning, Academic Motivation, CDIO skills, Introduction to Engineering. Standards: 4, 7, 8 and 11

INTRODUCTION

In the year 2011 the UCSC School of Engineering redesigned its five engineering programs using a CDIO-based approach (Crawley, Malmqvist, Ostlund & Brodeur, 2007), being Civil Engineering one of them. As a result, the Civil Engineering introductory course was redesigned according to CDIO Standard 4 and the course's learning outcomes were changed based on the CDIO Syllabus (Crawley, Malmqvist, Lucas & Brodeur, 2011). With eight hours a week, the goal was to properly introduce students to their chosen field of study, to familiarize them with the role of the engineer in today's society and to develop personal and interpersonal skills (Loyer et al., 2012). Students teamed up to work on designing and implementing simple well-structured projects. In spite of the positive results, as part of a continuous improvement process, in 2015 the course was re-structured by a multidisciplinary team. A service-learning methodology was adopted in order to broaden the scope and

impact of the project by placing students in real engineering situations, where they must conceive, design and implement solutions for the community partner's needs. (Loyer et al., 2016). Also, S-L helps students incorporate UCSC's core values, such as ethics, which is consistent with CDIO skill 2.5.1 (ethics, integrity and social responsibility).

Once the new introductory course was implemented, teachers' perceptions were that students were much more motivated and committed than previous years, resulting in better grades and a more positive attitude. This perception was shared by the faculty that had the same group of students the following semester, who even remarked upon their differences with students from other engineering programs (Loyer et al., 2016). This same study reported high proficiency levels of students' CDIO skills, which was consistent with other studies. But most studies don't properly assess the effect that S-L has on students' motivation.

In an effort to understand the effect that being exposed to a service learning project in the first year has on students' CDIO skills and academic motivation, this study will address the following questions: What are students' perceptions on the effect that the service learning project experience had on their CDIO skills after one, three and five semesters? Is there a relation between students' perceptions of the impact of the service-learning project on their CDIO skills and their academic motivation?

FRAMEWORK

Service-Learning

There are several definitions of Service-learning in the literature. Furco (1996) states that service-learning is a teaching method that combines academic instruction and community service, focusing on critical thinking, reflection and civil responsibility. Service-learning programs are distinguished from other approaches to experiential education by their intention to equally benefit the provider and the recipient of the service as well as to ensure equal focus on both the service being provided and the learning that is occurring.

Bringle and Hatcher (1996) view service-learning as a credit-bearing, educational experience in which students participate in organized service activities that meet community needs and reflect upon their service activities so as to better understand their course material, gain appreciation for their discipline and develop their civil responsibility. Also, service-learning has been shown to produce positive personal, social, and learning outcomes, such as improvements on personal identity, spiritual growth, moral development, commitment to service, and analytic and critical thinking skills (Eyler, Giles, Stenson & Gray, 2001).

Several studies have concluded that the implementation of service-learning in Engineering courses enhances generic skills such as communication, leadership and team-working, as well as specific engineering skills and learning outcomes (Cannon, Deb, Strawderman & Heiselt, 2016; Tsang Van Haneghan, Johnson, Newman, & Van Eck, 2001; Siniawski, Luca, Saez, & Pal, 2016; Wang & Calvano, 2018; Sevier, Chyung, Callahan & Schrader, 2012; Eyler et al., 2001), while increasing students' awareness of the diverse nature of their profession (Hernandez & Ritchie, 2015). However, none of these studies assess the effect that S-L has on students' academic motivation.

Motivation

Motivation is an internal process determined by biological, cultural, social, learning and cognitive aspects that impel a subject to initiate, develop or end a behavior (Jeno, Adachi, Grytnes, Vandvik & Deci, 2018). The importance of this construct lies mainly in its explanatory and predictive power of human behavior (Guay, Morin, Litalien, Valois & Vallerand, 2015).

The study of motivation has been approached from different theoretical paradigms, among which the self-determination theory (SDT) stands out (Ryan & Deci, 2000). According to SDT, motivation is not a global, undifferentiated concept. Rather, motivation is defined as a multidimensional concept that varies in terms of quality. SDT proposes different types of motivation that reflect different levels of self-determination (Ryan & Deci, 2000). SDT postulates that motivation is placed along a continuum where behavior can be amotivated, extrinsically motivated or intrinsically motivated, that is, going from the lack of control to self-determination (Ryan & Deci, 2000).

Amotivation is a state of lack of motivation that implies a perception of incompetence and inability to act, absence of intention or control to perform a certain behaviour, little or no valuation of the task, feelings of helplessness and lack of expectations and beliefs to produce or achieve the desired result. Subjects do not perceive that there is a relationship between their actions and their results (Guay, Morin, Litalien, Valois & Vallerand, 2015).

Extrinsic motivation is defined as a multidimensional construct. The four types of external motivation ordered from lowest to highest level of self-determination are: (1) external regulation, which refers to the performance of an activity in order to obtain rewards or avoid punishments; (2) introjected regulation, where behavior is partly controlled by the environment and the individual carries out his conduct to avoid guilt or anxiety or to enhance his ego or pride; (3) identified regulation, where the subject attributes a personal value to his/her behavior because he/she believes it is important and the activity is perceived as his/her own choice and, (4) integrated regulation, which occurs when the consequence of the behavior is congruent with personal values and needs (Deci, Eghrari, Patrick & Leone, 1994, Ryan and Deci, 2000).

Intrinsic motivation (IM) has to do with the development of an activity for the inherent satisfaction derived from it. It does not require external reinforcements and represents a natural tendency of human nature to seek novelty and challenge, expand and exercise his/her own abilities and explore and learn (Ryan and Deci, 2000). Intrinsic motivation is also considered as multidimensional. The three types of intrinsic motivation are: (1) IM to knowledge, which is related to concepts such as curiosity or motivation to learn; (2) IM to achievement, defined as the commitment in an activity for the pleasure and satisfaction experienced when trying to overcome obstacles or reach a new level; and (3) IM to stimulating experiences, which takes place when someone engages in an activity to have fun or to experience stimulating and positive sensations derived from their own dedication to the activity (Gagné & Deci, 2005).

For engineering students, motivation decreases during the first years in both men and women and motivation levels predict different academic performance results (Jones, Paretti, Hein & Knott, 2010). Also, engineering students exhibit a significant relationship between motivation and learning outcomes, adequate performance in the classroom and efficiently achieving academic performance (Silva, Villa-Navas & Curiel-Gómez, 2018).

Introduction to Civil Engineering course

Introduction to Civil Engineering is a freshman course that has three main goals: a) properly introduce students to their chosen fields of study and familiarize them with the role of the engineer in today's society b) emphasize CDIO standard 1, in terms of having them be aware that engineers conceive, design, implement and operate; c) develop specific personal, interpersonal and engineering skills. The courses' learning outcomes can be grouped in three dimensions: Engineering Role (ER), Oral and Written Communication Skills (OWC) and Development of Personal and Interpersonal Skills (DPIS), which are integrated through a Service Learning Project (SLP), as seen in figure 2 (Loyer et al., 2016).

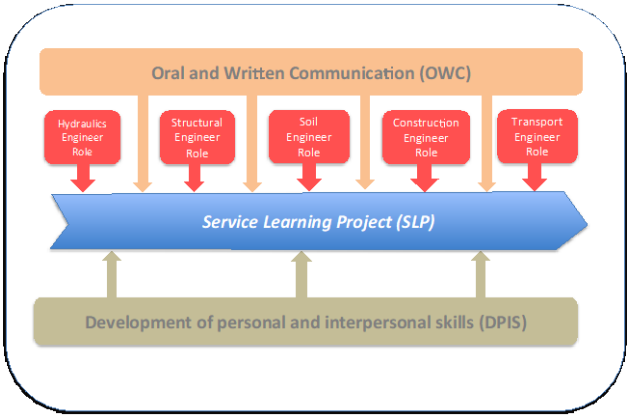

Figure 1. Introduction to Civil Engineering Course Structure (Loyer et al., 2016)

METHODS

Design

A descriptive-correlational, cross-sectional design was used to study students' perception of the impact that exposure to a service-learning project has on their CDIO skills and academic motivation, and the relationship between these variables.

Participants

A total of 123 Civil Engineering students selected through non-probabilistic accessibility sampling were surveyed from a university in the Province of Concepción in Chile. The questionnaires were applied during the second semester of 2018. 22.05% of the sample were first year students, 37.03% second year, 15.13% third year, 19.60% fourth year and 6.20% fifth year. The average age of subjects was 21.18 (SD = 2.78), with a minimum of 17 and a maximum of 36. With regard to gender, 50.79% were men and 48.92% were women.

Instruments

Effect of Service-Learning on CDIO Skills Scale (ESLCS)

The *ESLCS* instrument was built by the authors, based on the CDIO syllabus (Crawley et al., 2011). It is a unifactorial scale that aims to measure students' perception of their level of proficiency in CDIO skills after being exposed to a service-learning project as freshmen. It is a Likert scale self-report instrument with response options between 1 to 5, where 1 is not

applicable, 2 is strongly disagree, and 5 is very much in agreement. It has a total of 21 items regarding CDIO skills (Crawley et al., 2011), that are part of the learning outcomes of the course. Cognitive interviews were conducted to assess students' comprehension of the items. The trustworthiness of the instrument is high (see table 1). The conceiving, designing and implementing skills were assessed by the instructors using a project rubric.

Academic Motivation Scale (AMS)

Students' academic motivation was assessed using the Academic Motivation Scale (Núñez, Martín-Albo, Navarro & Suárez, 2010). This scale consists of 28 items, distributed in seven subscales: amotivation (AMO), external regulation (REGEX), introjected regulation (REGIN), identified regulation (RGID), intrinsic motivation to knowledge (MICON), intrinsic motivation to accomplishment (MILO) and intrinsic motivation to stimulating experiences (MIEXP). Each subscale has four items that refer to the reasons why students go to college. The answers were scored using a seven-point Likert scale, from (1) does not correspond at all, until (7) corresponds exactly, with a mid score of (4) being corresponds moderately. This scale has shown adequate psychometric properties in previous studies with a reliability between α=0.73 and α=0.88 (Núñez et al., 2010). In this study it also had a high reliability in all 7 sub-scales, fluctuating between α=0.73 and α=0.87 (See table 1). Prior to the application, cognitive interviews were conducted to assess students' comprehension of the items.

Table 1. Reliability of the dimensions of the ESLCS Scale and the AMS

Dimension	Alpha	Omega
ESLCS	*0.93*	*0.95*
Academic Motivation Scale:		
AMO	0.87	0.91
REGEX	0.84	0.89
REGINT	0.79	0.83
REGID	0.73	0.78
MICON	0.85	0.87
MILO	0.83	0.85
MIEXP	0.78	0.84

The Cronbach alpha coefficient (α) is used to measure the scale's reliability, but it has several limitations: it is affected by the number of items, the number of response alternatives and the proportion of the variance of the test. Also, it only considers continuous variables, which is not the case with social science variables such as motivation and is influenced by the sampling error. The omega coefficient (ω), unlike the alpha coefficient, works with the factorial loads, which are the weighted sum of the standardized variables, a transformation that makes the calculations more stable and reflects the true level of reliability. It does not depend on the number of items and it's considered an adequate measure of reliability if the principle of such equivalence is not met, which can be violated if the coefficients of the items that make up a factorial solution matrix have very different values.

RESULTS

The results of the application of the Effect of Service-Learning on CDIO Skills Scale are shown in Figure 2. Even though all cohorts scored high on all skills, students from 2018 reported the highest proficiency levels in CDIO skills obtained because of the S-L project.

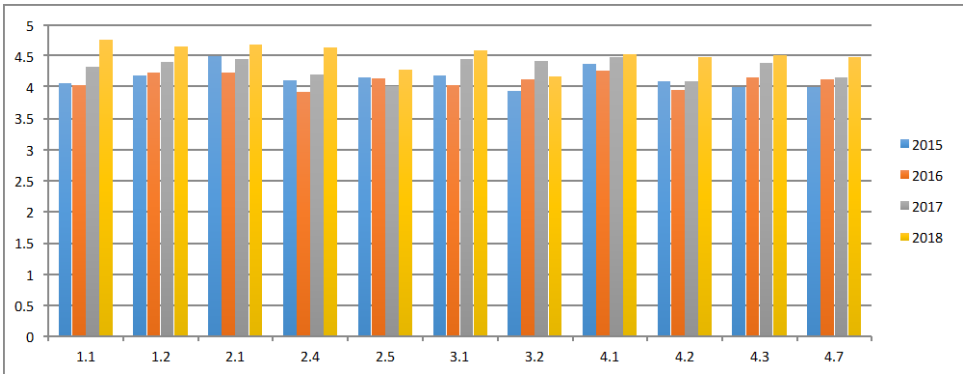

Figure 2. Average Results of the Effect of Service Learning on CDIO Skills (ESLCS) Scale

In terms of academic motivation, students reported higher levels of intrinsic motivation to knowledge (6.06), identified motivation (6.01), and intrinsic motivation to accomplishment (5.58), as shown in figure 3 and table 2.

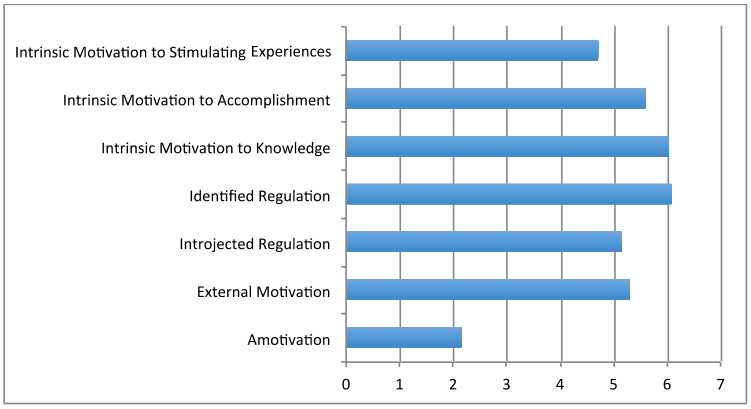

Figure 3. Average Results of the ESLCS Scale for all cohorts

Table 2. Descriptive variables for all cohorts

Variable	n	Mean	Sd	Skew	Kurtosis	Shapiro .wilk	Alpha
ESLCS	120	4.23	0.64	-1.46	4.17	6E-08	0.93
AMO	123	2.13	1.67	1.59	1.4	3E-14	0.86
REGEX	123	5.28	1.4	-0.76	0.26	9E-06	0.83
REGINTRO	123	5.13	1.46	-0.69	-0.33	1E-05	0.78
REGID	123	6.06	0.99	-1.11	0.26	5E-10	0.71
MICON	123	6.01	1.03	-1.11	0.4	1E-09	0.85
MILO	123	5.58	1.27	-0.92	0.47	4E-07	0.82
MIEXP	123	4.7	1.42	-0.55	-0.13	0.0016	0.78

Note: ESLCS: CDIO Skills Scale; AMO: Amotivation; REGEX: External Regulation; REGINTRO: Introjected Regulation; REGID: Identified Regulation; MICON: Intrinsic Motivation to Knowledge; MILO: Intrinsic Motivation to Accomplishment; MIEXP: Intrinsic Motivation to Stimulating Experiences

In terms of gender, there was no significant difference in any of the dimensions (Table 3)

Table 3. Comparison of results according to gender

Variable	Mean F	DE F	Mean M	DE M	Test statistic	p
ESLCS	4.33	0.79	4.22	0.57	U=1640.50	0.09
AMO	2.25	1.75	2.08	1.65	U=1699.50	0.35
REGEX	5.46	1.12	5.21	1.49	U=1625.50	0.63
REGINTRO	5.41	1.58	5.02	1.4	U=1857.50	0.07
REGID	6.11	0.98	6.04	1	U=1612.00	0.69
MICON	6.09	1.01	5.99	1.03	U=1634.00	0.6
MILO	5.86	1.19	5.47	1.29	U=1822.50	0.1
MIEXP	4.79	1.46	4.66	1.4	U=1619.00	0.66

* $p < .05$

As shown in table 4, no significant difference was found in any of the motivation factors between cohorts. The same cannot be said when comparing the effect that the S-L project had on students' CDIO skills between cohorts. This suggests that students were equally motivated, regardless of how long ago they enrolled in the university but those who enrolled more recently perceived a greater effect of the S-L project on their own CDIO skills.

Table 4. Results for each cohort

Dimen.	2013(sd)	2014(sd)	2015(sd)	2016(sd)	2017(sd)	2018(sd)	Test Statistic ($X^2(6)=$)	p
ESLCS	3.44(1.27)	4.04(0.63)	4.13(0.50)	4.02(0.68)	4.28(0.49)	4.53(0.42)	20.09	0.00*
AMO	1.33(0.44)	1.50(1.00)	1.63(0.91)	1.68(1.00)	2.32(2.01)	2.74(1.97)	9.98	0.12
REGEX	5.54(0.93)	4.98(1.42)	5.13(1.65)	5.35(1.51)	5.04(1.29)	5.50(1.41)	3.44	0.75
REGIN	4.83(1.48)	5.22(1.00)	5.34(1.29)	5.05(1.63)	4.82(1.70)	5.37(1.31)	3.4	0.76
REGID	6.08(0.79)	6.31(1.10)	6.09(0.98)	5.82(1.19)	6.13(0.89)	6.15(0.95)	3.52	0.74
MICON	5.67(1.04)	6.22(1.29)	5.82(1.38)	5.86(1.13)	5.91(1.06)	6.31(0.63)	5.32	0.5
MILO	5.08(1.48)	6.19(0.78)	5.61(1.41)	5.13(1.55)	5.56(1.32)	5.80(1.05)	5.86	0.44
MIEXP	4.44(0.46)	4.91(1.13)	5.11(1.17)	4.56(1.50)	4.96(1.23)	4.49(1.68)	5.85	0.4

* $p < .05$

As seen in table 5, a very significant correlation was found between the effect of the S-L project on CDIO skills and all the intrinsic motivation factors, and with the identified regulation factor, which is the dimension of external motivation with the highest level of self-determination.

Table 5. Correlation between the AMS Dimensions and ESLCS

Dimensions	ING	AMO	REGEX	REGIN	REGID	MICON	MILO	MIEXP
ESLCS	-	0.11	0.08	0.24*	0.39**	0.45**	0.40**	0.29**
AMO		-	0.29**	0.22*	-0.21*	-0.02	0.06	-0.11
REGEX			-	0.50**	0.35**	0.20*	0.17	0.05
REGIN				-	0.46**	0.53**	0.57**	0.42**
REGID					-	0.58**	0.58**	0.63**
MICON						-	0.69**	0.51**
MILO							-	0.57**
MIEXP								-

* p < .05; ** p < .01

CONCLUSIONS

This study focused on analyzing the effect that the service learning project experience had on students' CDIO skills and academic motivation for different cohorts and if there was a relation between students' perceptions of the impact of the service-learning project on their CDIO skills and their academic motivation.

All cohorts scored high on all of the CDIO skills obtained because of the S-L project, but the 2018 cohort scored the highest. These results could mean that students perceive that the service-learning project has a very strong effect on their CDIO skills and students who developed the S-L project more recently perceive this effect as even greater.

In terms of academic motivation, students scored higher in intrinsic motivation dimensions. No significant difference was found of the academic motivation between the four cohorts analyzed, which suggests that students were equally motivated, regardless of how long ago they enrolled in the university.

Finally, there is a very strong correlation between CDIO skills developed through the S-L project and all of the intrinsic motivation dimensions, as well as with the identified regulation, which is an external motivation dimension that's associated with higher levels of self-determination.

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