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Application of Microlearning Activities to Improve Engineering Students' Self-Awareness*

R. PASCUAL
Mechanical Engineering Department, Universidad de Chile, Chile. E-mail: rpascual@ing.uchile.cl

E. BLANCO
Mechanical Engineering Department, Universidad de Concepción, Chile.

P. VIVEROS
Industrial Engineering Department, Universidad Santa María, Chile.

F. KRISTJANPOLLER
Industrial Engineering Department, Universidad Santa María, Chile.

The development of skills for life and career (SLC) is a subject that has been extensively discussed in the literature. Yet, its implementation in the engineering curricula is only at a starting point. Accelerated technological advances and major changes in the future labor market are important drivers for the exploration of how to develop SLC. Such a context offers novel challenges for engineering education. This article describes an initiative in a Mechanical Engineering program. The methodology is centered in developing students' self-awareness using time-effective microlearning activities in a course at the end of the program. Results show a significant increase in self-awareness indicators. The approach can be easily extended to explore other SLC beyond self-awareness.

Keywords: self-awareness; skills for life and career; micro-learning

1. Introduction

The inevitable advance of science and technology is forever changing the labor landscape. In the following years, we will observe how many professions will be profoundly redefined [1, 2]. The job market will show accelerated changes in the set of skills to ensure employability. Universities are slowly evolving and curricular change is a global trend. For example, many Engineering Schools have designed and implemented a series of courses on innovation and entrepreneurship and have also promoted a general curricular alignment with Europe and North America [3, 4]. A crucial dimension in curricular change is centered on the development of Skills for Life and Career (SLC). Such skills are of high value in an economy more and more based on the service industry, which currently represents approximately three-quarters of the world's economy [5, 6]. Beyond economic reasons, and inspired by the well-known Delors report [7], there exists an increasing need to enhance strategies in at least two of the four pillars of an integral education process: *learning to be* and *learning to live together*. The above concepts set a rich, motivating context to develop efficient learning strategies, exploring activities that can occur inside and/or outside the classroom, and using diverse formats and platforms [8–11].

This work describes a time-effective microlearning approach that focuses on self-awareness development. To describe it, we organize the rest of the paper as follows. Section 2 presents a literature review related to the work focus. Section 3 describes the proposed methodology. Section 4 describes our case study. Finally, we evaluate the methodology in section 5.

2. Literature Review

Putting it simply, using SLC is the most frequent thing an engineer does [12, 13]. SLC will be difficult to handle by computers and robots and, thus, will be a bastion for humans in a world dominated by work for machines [1, 6, 4]. Nevertheless, there exist resistance to develop SLC in engineering education programs. Among other reasons, we find: (i) cultural prevalence of technical skills over non-technical skills [15], (ii) lack of knowledge of state-of-the-art educational frameworks by teachers [16], (iii) incentive schemes that strongly promote research [17], (iv) change resistance by the students themselves [18], (v) scarcity of space in the curricula to insert ad hoc courses [13]. No doubt, the existing barriers set a challenging scenario to propose innovative schemes to deliver SLC at program level.

SLC definition vary from source to source. As example, the Accreditation Board for Engineering and Technology of North America (ABET) [19]

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Table 1. Life skills according to the World Health Organization [23]. Highlighted, the focus of this work.

Critical thinking	**Effective communication**	**Self-awareness**
Decision making	**Interpersonal relationships**	Equanimity
Problem solving	**Assertiveness**	Coping with stress, trauma and loss
Creative thinking/lateral Thinking	**Empathy**	Resilience

propose, among others: (i) *an ability to function on multidisciplinary teams*, (ii) *an ability to communicate effectively*, *a recognition of the need for, and an ability to engage in life-long learning*. In (i) and (ii), interpersonal skills are highlighted. (iii) puts emphasis in self-awareness and openness to new experiences [20, 21]. Another source to guide SLC definition is the Partnership for the 21st Century Learning (P21) [15, 22]. It offers a framework that is an excellent framework to motivate the development of SLC. They summarize them under the '4Cs' umbrella: *Critical thinking, Communication, Collaboration, Creativity*. At the left side of the diagram, they highlight the education on SLC.

For years, the World Health Organization (WHO) [23], has promoted the so called *life skills*, among which we may find the ones which are the center of our study (Table 1). A complementary vision is offered by organizational psychology. As example, Bartram [24] promotes the set of roles that are necessary to excel in the engineering professional context, where autonomy, discretion and collaboration are sought. Table 2 offers a list of roles that an engineer must fulfill in a service oriented organization [25]. If such roles are not met by an engineer, it may hinder his/her professional development inside the organization. It is observed that among the seven roles, only one is related to technical expertise. More importantly, collaboration appears in a number of roles. It highlights what is the core of the methodology proposed in this paper: to design and implement ad hoc methodologies to enhance SLC of the future engineers.

In the next section, we describe a methodology to develop self-awareness. For that, we propose using a number of personality instruments. Other sources have used personality instruments to estimate changes after interventions related to specific aspects. For example, in Hess et al. [26], use the Engineering Ethical Reasoning Instrument and the Interpersonal Reactivity Index to measured changes in ethical reasoning.

3. Proposed Methodology

We summarize the proposed methodology in the concept map shown in Fig. 1. The main purpose is to introduce self-awareness to students during their final year of the program. The approach allows to improve an SLC that will play a part for their employability in future engineering job markets. We frame the methodology in a final year course as it assures student maturity and potential tendency to accept subjects which have historically been out of their program curriculum. Also a part of the research, is the use of scarce academic time, which is mainly occupied with professional engineering subjects. While developing the strategy, a number of potential areas of focus appeared.

We prefer to develop *self-awareness* as SLC as it is an area that may enhance collaboration and other SLC (Table 1) and also because it has not been well explored in the engineering education literature

Table 2. Expected roles of an engineer in a service company (adapted and extended from [25]).

Role	**Challenge**
1 Collaborator of his/her manager at superior level	Designing and implementing work plans according to guidelines and standards requested by the manager at the superior level, providing ideas and suggestions to help improve company results.
2 Member of the management team	Collaborating to achieve the proposed strategies. At the same time, must achieve the highest level of collaboration with its peers at the corporate level.
3 Internal provider	Providing ideas and resources that allow performance improvement of his/her clients inside the organization.
4 Technical expert	Guiding the development of his/her area of responsibility, according to the needs of the organization.
5 Responsible of the relationship with clients and suppliers (for commercial and procurement managers)	Consolidating relationships and information to allow project development, new lines of products and/or services, and supply schemes to add value for the company.
6 Team builder	Empowering collaborators with resources and skills to fulfill their function inside the organization.
7 Leader	Influencing on the values and beliefs of his/her collaborators, motivating them to develop themselves and assume organization's values and objectives as their own ones.

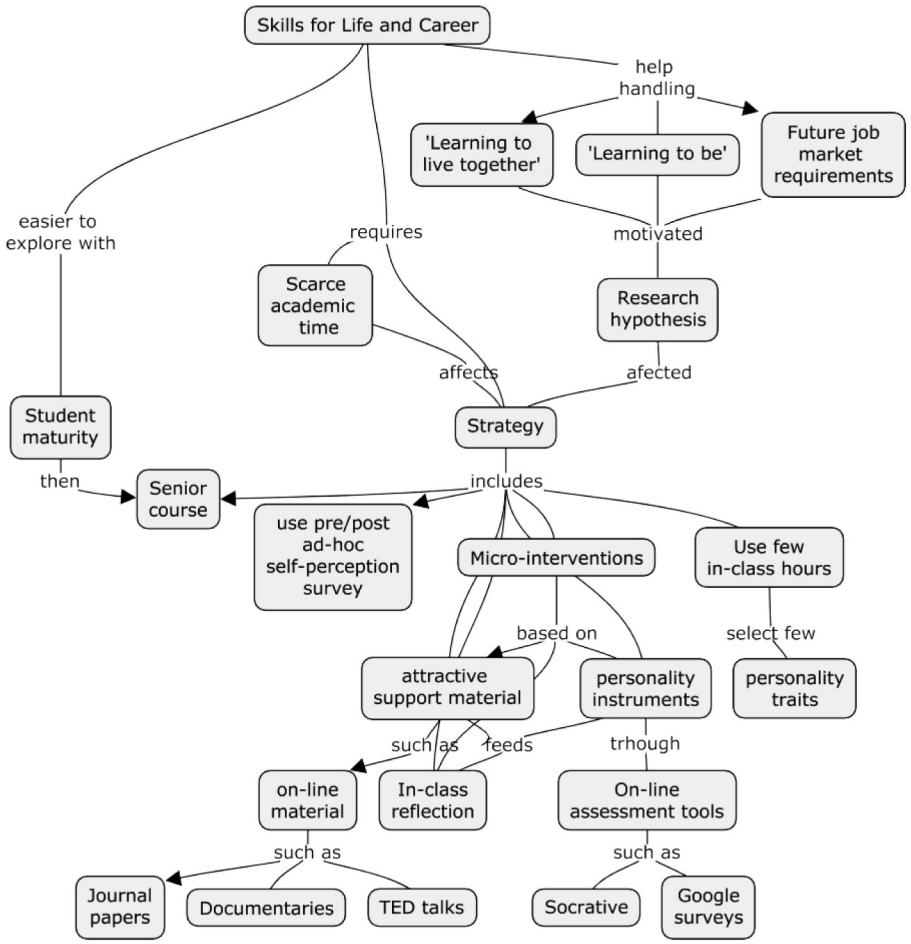

Fig. 1. Concept map of the proposed methodology.

[27]. The following hypothesis guided the strategy definition: *applying standard personality instruments, exploring appropriate support material and brief group reflections raises the self- perception levels regarding self-awareness*.

Once the research hypothesis was defined, the strategy development process was simplified. It is focused on sequential microlearning activities of three types: application of selected personality instruments (in the classroom), followed by exploration of attractive support material (at home), and a final in-class reflection of results from the instruments and the revised material (in the classroom). To assess the results, a pre/post test was designed. It is shown in the case study section.

A key aspect of the methodology consists in identifying, prioritizing and selecting a limited number of SLC instruments. This is so, as the allotted time to perform the microlearning activities is limited. Relatedness among the instruments is also desirable. The list of SLC candidates was selected from ABET [19], WHO [23] and P21 [15]. The final selection was chosen to cover an original and essential skill at the program level.

To address self-awareness development, several personality questionnaires are applied. The set used in the case study is shown in Table 3. The rationale to select the questionnaires is summarized in the concept map 3. For each instrument, three consecutive instances occur. First, each instrument is applied. After that, students check some support material associated to the main subject of the questionnaire (also in Table 3). Students have a week to revise/study it.

It must be observed that our intention using microlearning activities is to spark students' interest and self-propelled research into SLC. Additional material is advised to check for those who want to gain additional insight into each subject.

The support material was a mix of videos of TED talks [28, 29], journal papers [31], documentaries [32]. The support material must: (i) reinforce concepts treated by the instrument, (ii) belong to a validated source and, (iii) be considered as attractive material for millennials. For example, for the grit scale [30], we use a TED talk offered by the lead researcher on that subject [28] (Table 3).

The reflective situation starts with a quiz about

Table 3. Summary of SLC activities of the case study

Subject	Instrument	Source	Support material	Recommended material
Empathy	Read the mind in the eye	[33]	[31]	[44]
Big five personality traits	Ten Item Personality Inventory	[34]	[45]	–
Grit	Grit-S	[30]	[28]	[30]
Growth mindset	Implicit Self Theory	[20, 21]	[29]	[20]
Conflict management style	Thomas-Kilmann test	[36]	[46]	[47]
Macchiavellism	Mach-IV test	[48]	[32]	[49]

the support material. The quiz usually uses 5–10 minutes of in-class time. The average of such quizzes amounts to a small percentage of the final grade. After the quiz, results of the group and the rationale behind the questionnaire are explained by the instructor. A joint reflection of results is then carried on. This final instance usually takes 10–20 minutes.

The first instrument in the set is the Read-the-mind-in-the-eye (RME) test [33]. Studies have revealed that a main predictor of high performance of teams is related to high values empathy of its members, as estimated by the RME test. Empathy can be correlated to *agreeableness*, one of the five main traits [33].

The Big Five personality traits is a taxonomy that has been extensively described in a number of publications [34, 35]. The five factors are: Openness to experience, Conscientiousness, Extraversion, Agreeableness, Emotional stability. The initial model was proposed by Tupes and Christal [35]. There are several instruments associated to the taxonomy. As our objective is exploratory, we used a short version with 10 items [34].

Consciousness has been correlated to grit. We consider is the Grit-S scale [30]. Duckworth and Quinn studied personality attributes associated to professional success. A main predictor is grit, oriented to long term goals. People with high grit: know very well what they want, are tenacious, insistent to get their goals. We selected a short version of the instrument called Grit-S, which has 10 items. Grit scale is composed of two sub-scales. It allows to position an individual in a scatter diagram to compare him/her to others (fellow students in our case).

We explore static and growth mindsets using self-theories described in [20, 21] for example. Persons with static mindset believe their intelligence is fixed and tend to adopt performance goals. People with growth mindset believe their intelligence can be increased and tend to adopt learning goals. Consciousness has been correlated to growth mindset.

We also include conflict management style. We selected the well-known Thomas-Kilmann test [36]. Personal style to manage conflict can be understood in terms of assertiveness and cooperativeness. Assertiveness is associated to how an individual is worried about satisfying his/her own concerns. Cooperative- ness is associated on how individual concern to satisfy what worries the other(s). Five styles are described: competing, accommodating, avoiding, compromising and collaborating. The competitive style is dominated by high assertiveness and low cooperativeness. He/she wished to win at all costs and ensure that his/her position prevails. There exists a high risk of breaking relationships. The accommodating style shows high cooperativeness and low competitiveness. The individual is mainly worried about the others. For him/her it is important to keep friendly relationships. This attitude may activate changes on how the others behave. The avoidance style is low on both scales. He is nor collaborative nor assertive. She is probably postponing the conflict looking for a better bargaining position. The collaboration style is high in both assertiveness and cooperativeness. He looks for solutions which satisfy all parties even if it takes a longer time. This style promotes keeping good relationships. The compromising style promotes searching for intermediate solutions where all parties concede something.

To end the self-awareness exploration, we suggest the MACH-IV test [36, 37]. It estimates machiavellianism style. It correlates with *compromising* in the conflict management style. As engineers work in organizations, we hypothesize that understanding organization dynamics is a positive asset. Organizational power struggles occur and machiavellian behaviors are encountered.

4. Case Study

The methodology was tested in the course *Physical asset management* during the autumn term of 2019. The course is optative in the Mechanical-Engineering curriculum at Universidad de Concepción. The course is taken mostly by students in their final year of the program (Mode age is 22). The course has been used as testbed to explore teaching strategies based on self-determination theory [38], and also flow theory [39]. The course declares as learning

goals: (i) to optimize decision making related to equipment life cycle, (ii) to solve in an structured manner problems associated to physical asset management, (iii) to design strategies and ad-hoc methodologies to optimize engineering asset management. The above set of goals are set at the design/evaluate level in the revised Bloom taxonomy [40]. Additionally, an SLC goal was added: (iv) to recognize personality traits.

As described in the methodology section, several personality instruments were applied. For each instrument, additional support material was revised by the students at home. Finally, a group reflection was developed. Results of each inventory were published so that each student received his/her results and could compare herself to the rest of students (Figs. 2–8). For that we use an ad-hoc platform [41]. Their application was accelerated using well-known open-access digital survey platforms [42, 43]. Several students showed great interest in the subjects. Several supplementary sources were advised (also in Table 3).

At the end of the term, a wrap up session with a presentation of the results of the tests, reflection and a summarization using the concept map 3 helped the students understanding the why and the how of the initiative.

In what follows we show some student reflections at the end of the term:

> "I enjoyed this area of the course very much. I feel that all the material (on self-awareness) is beneficial to improve, not only as student or future engineer but also as a person . . ."
>
> "It made me reflect. I am already finishing my studies, yet there are gaps that I need to work on and advance . . ."
>
> "It was great input for me. It motivated me to face new challenges, search for new opportunities in every sense, reflect and investigate into extremely important subjects that I did not know about . . ."

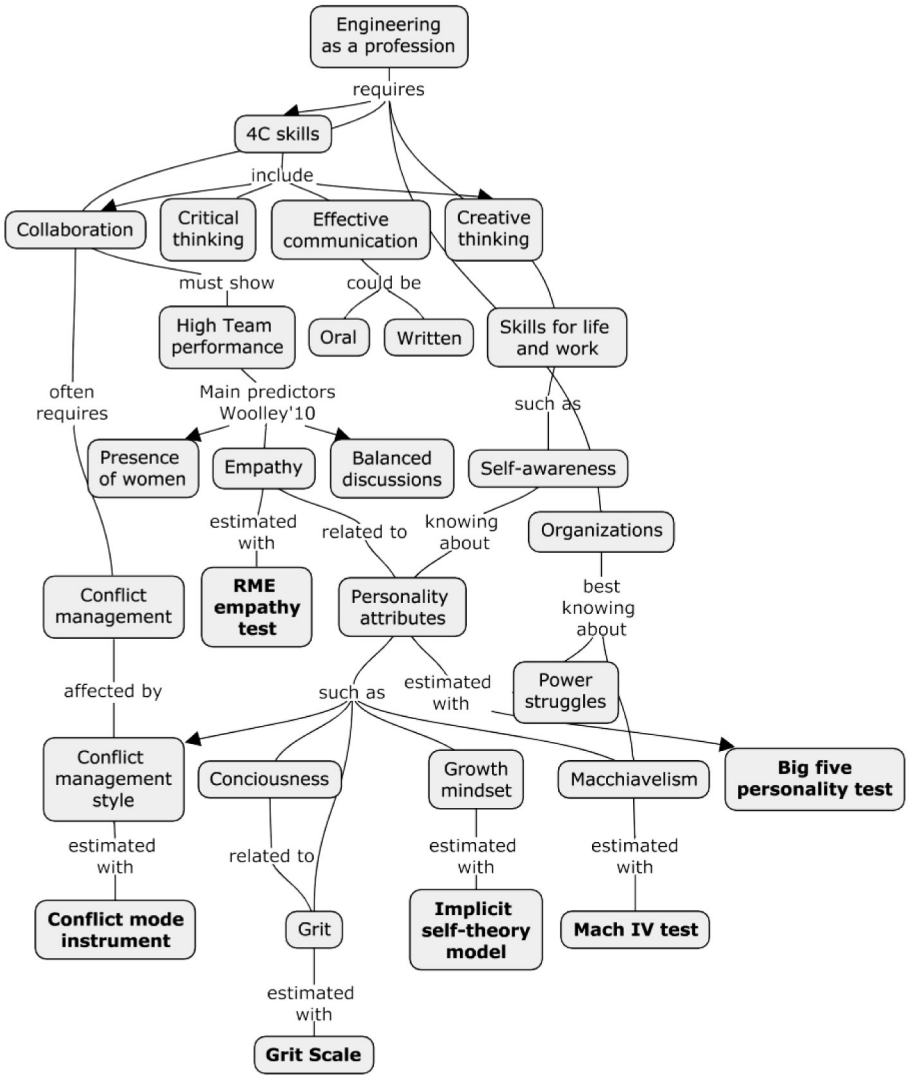

Fig. 2. Concept map for self-awareness instrument exploration. In boldface the instruments that were considered.

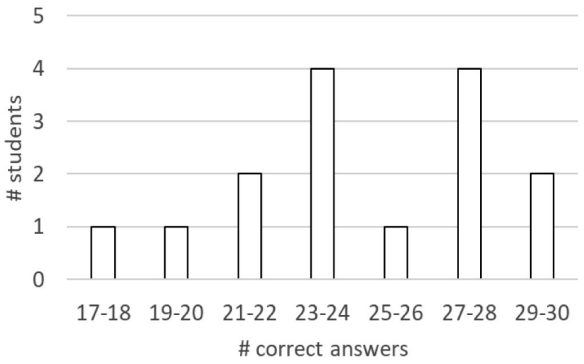

Fig. 3. Results of the Read-the-Mind in-the-Eye test (36 questions).

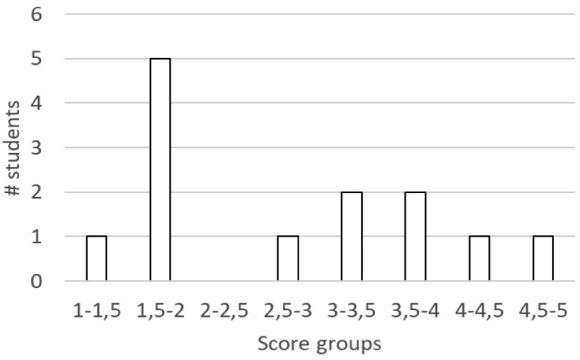

Fig. 6. Results of the growth mindset test (N = 13). Scale: 1–5. Lower values indicate a growth mindset.

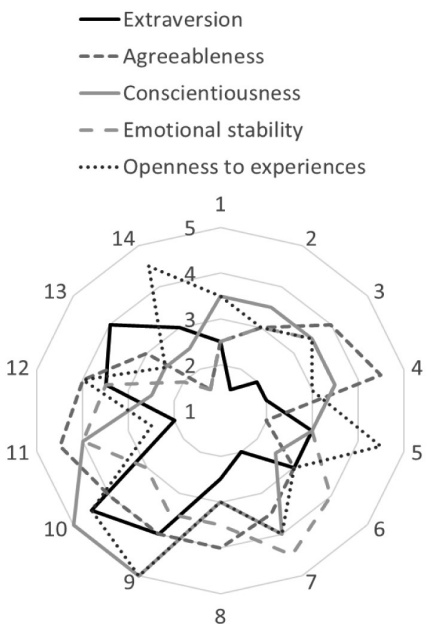

Fig. 4. Results of the Ten-Item Personality Inventory (N = 14). Scale: 1–5.

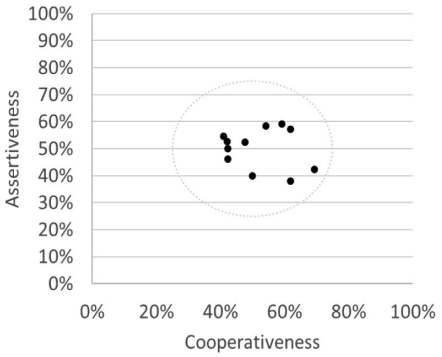

Fig. 7. Results of the conflict management style inventory (N = 11). The circle has a radius of 50%.

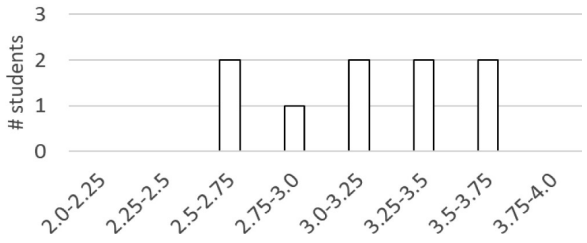

Fig. 8. Results of the Mach-IV test (N = 9).

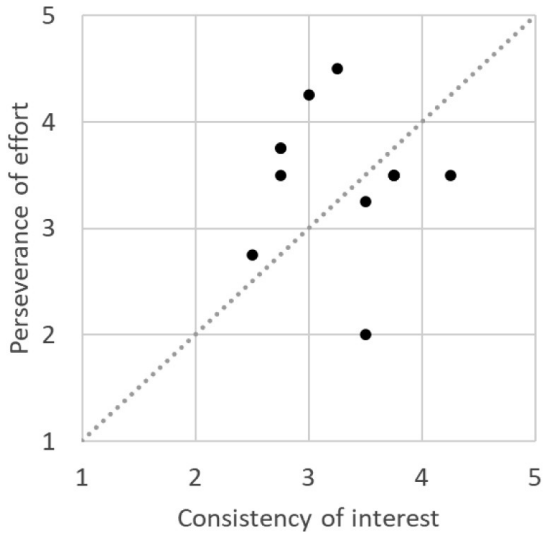

Fig. 5. Results of the GRIT-S (N = 15). Scale: 1–5.

"(This part of the course) was a starting point to analyze my personality. I have been able to identify areas of weakness. I will work on these traits and attitudes . . ."

4.1 Analysis

The results show a reasonable amount of heterogeneity in the group of students. Comments from them show interest in discovering and reflecting about its personality attributes and how they affect their life and work future.

Figs. 9 to 11 show the pre/post results of the questionnaire designed for the study. They show significative changes in self-perception in relation to: (i) self-awareness (Figs. 9–11), physical asset management, use of IT and evidence-based decision-making (Figs. 14–15), and effective communication (Figs. 12–13). Even if the number of

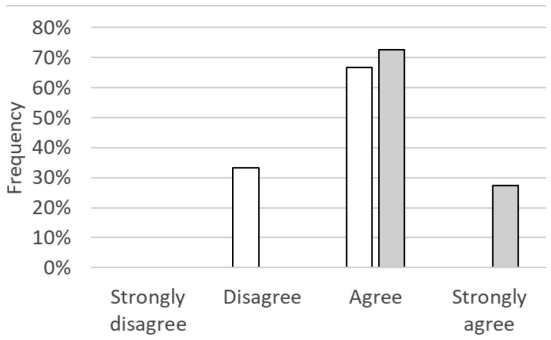

Fig. 9. Pretest (white) and posttest (grey) for proposition *I know my dominant personality traits.*

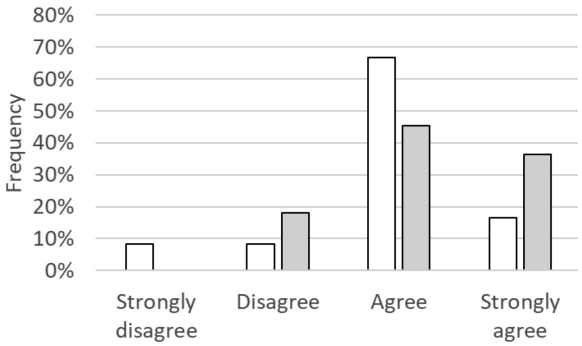

Fig. 10. Pretest (white) and posttest (grey) for proposition *I know and reflect frequently about my empathy to my peers, family and friends.*

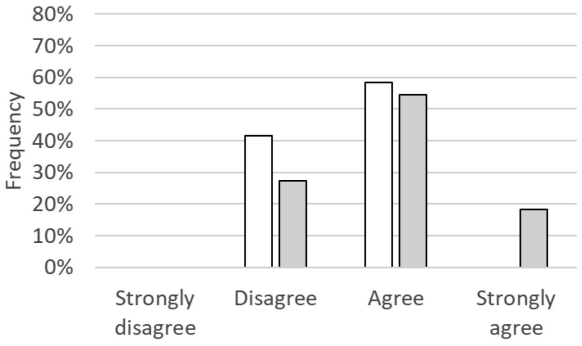

Fig. 11. Pretest (white) and posttest (grey) for proposition *I recognize my areas of strength and weakness to manage interpersonal conflicts.*

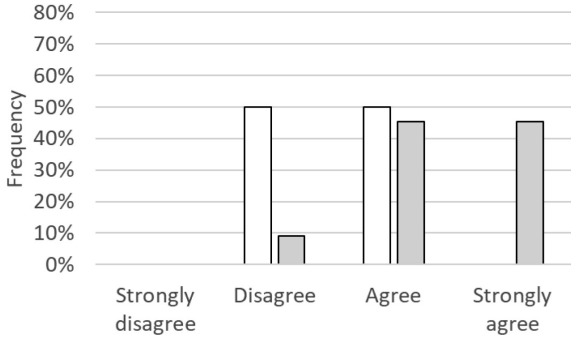

Fig. 12. Pretest (white) and posttest (grey) for proposition *I recognize my areas of strength and weakness for oral communication.*

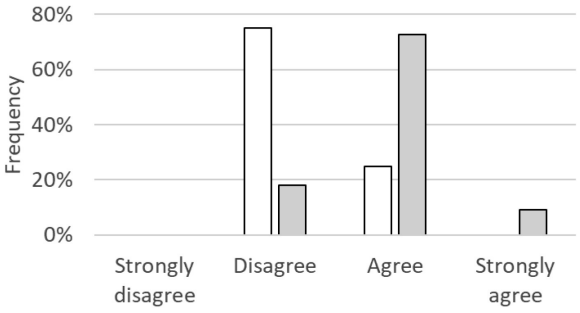

Fig. 13. Pretest (white) and posttest (grey) for proposition *I'm able to write a properly structured professional report* . Pre: white fill, Post: grey fill.

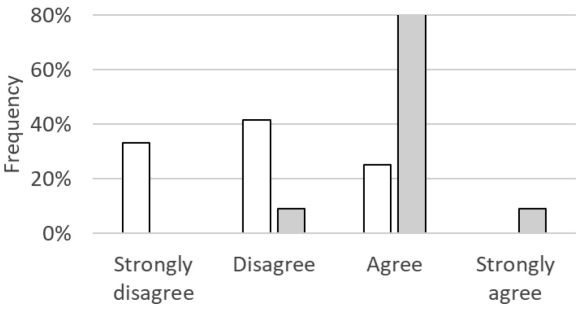

Fig. 14. Pretest (white) and posttest (grey) for the proposition *I'm able to identify and optimize processes related to engineering asset management*. Pre: white fill, Post: grey fill.

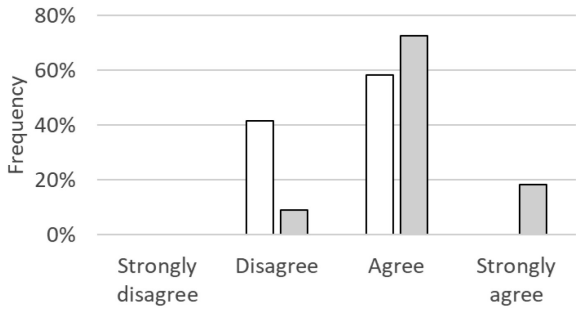

Fig. 15. Pretest (white) and posttest (grey) for proposition *I can apply IT tools (such as excel, python, etc.) to support operational decisions.*

samples is small, the positive change is very satisfactory and supports the validation of the research hypothesis. No doubt, insights gained in this work require further investigation, considering limitations and potential already reported in other contexts [8].

4.2 Discussion

With such a limited number of students involved, it is impossible to draw generalizations about the general success of the initiative to develop self-awareness using microlearning activities. Yet, the significant increase in self-awareness indicators is an excellent motivation for further inquiry. Evidence suggests that the proposed approach can be

used to enhance student learning in Engineering Education. The small amount of time and effort that the approach requires both from the teacher and the students serves as a lever to scale the initiative at the program-level and develop SLC at different courses and at different levels in the curriculum.

5. Conclusions

This work proposed an original methodology to develop SLC for the 21st century engineers using a micro-learning approach. We focused on self-awareness but the concept can be easily extended to other SLC. The rationale for our approach is the belief that any course in an engineering curriculum may be an excellent opportunity to develop SLC. Results from the case study suggest that the work hypotheses are reasonable and justify further work. The experiment allowed to detect an important interest of students to develop SLC and gain an understanding of how it might affect their personal and professional development.

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Rodrigo Pascual is currently an Associate Professor at the Mechanical Engineering Department of the University of Chile. He graduated in Mechanical Engineering at the University of Concepción, Chile, and obtained his PhD degree at the University of Liege, Belgium. He has worked in the academic world for more than 25 years in Belgium, Canada, and Chile. Since 2001 he has been researching Physical Asset Management, Reliability Modelling, and Engineering Education. He has an active level of involvement in several industrial and university-based projects.

Einara Blanco is a Mechanical Engineer graduated from the University of Pinar del Río in Cuba with a Master's degree from the same university. PhD in Mechanical Engineering from Sao Paulo State University, Brazil, and post-doctorate from the same institution. She is specialized in the development and implementation of technologies for energy management and valorization of biomass and waste, with emphasis on energy use, heat transmission, exergy, and combined cycles. She has been a lecturer in postgraduate programs in Cuba, Brazil, and Chile and has participated in several consultancies in thermal conversion of biomass and waste by pyrolysis, gasification, and combustion. She is the author of numerous publications in international journals and conferences. She works as a principal researcher in projects on energy recovery of MSW and agro-industrial waste. Einara is currently an assistant professor and researcher at the Department of Mechanical Engineering at the University of Concepción Chile.

Fredy Kristjanpoller is currently a Professor at the Industrial Engineering Department at Universidad Técnica Federico Santa María, Chile. He received his PhD in Mechanical Engineering and Industrial Organization at the University of Seville, Spain. His research and teaching interests are in operations, asset management, reliability, maintenance strategies and risk analysis. He has been published in several journals, including Reliability Engineering and System Safety, Complexity, Renewable Energy, Journal of Risk and Reliability and others.

Pablo Viveros received his PhD in Mechanical and Industrial Engineering from the University of Seville, Spain. He holds a Master in Asset Management and Maintenance from Universidad Técnica Federico Santa María (USM), Valparaíso, Chile. Since 2009, Pablo has been teaching courses in Operation Management, Reliability Engineering, and Engineering Asset Management. During 2016, he joined the Operation Management area of the Industrial Engineering Department at USM as a full-time faculty member. He has active participation in scientific research and industrial projects.