ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #37432

The Social Dimensions of Learning: facilitating social Dynamics for a more engaged student in a K12 Pre-Engineering Program [Work in Progress]

Andrea Ortiz

Andrea is an Engineering MSc student with a major in Engineering, Design & Innovation and a PE Diploma in Information Technologies at the Computer Sciences Department in the Pontificia Universidad Católica de Chile (UC). She entered university throught Talent and Inclusion Program. She is interested in STEM education, equal opportunities in STEM education (gender and social disparities) and engineering design related to computer sciences. She has worked as a researcher at the DILAB UC (Engineering Design Initiative) in Chile where she has also worked as a Teaching Assistant in Design Lab Studio (2019-1, 2, 2020-1), and Technology, Entrepreneurship and Design (2021).

Michelle Kang

Michelle "Mische" Kang (she/they; BA Wellesley; MA Stanford) is an educator and researcher who is deeply curious about making learning experiences compelling, inclusive, and accessible. She has partnered with communities around the world (South Africa, Chile, Rwanda, and the U.S.) and across sectors (K-12, nonprofit, government, and educational technology) on various educational initiatives aimed at honoring learners' backgrounds and the rich assets that they bring to the table. She currently works as a learning experience designer at a design thinking consultancy and explores the intersection of AR and education in her spare time.

Julian Goni

Iñaki Goñi is a psychologist specialized in interdisciplinary research. As a lecturer and researcher at the Engineering Design Initiative, Universidad Católica de Chile (DILAB UC), he researches the intersection between engineering design, social research and responsible innovation.

Constanza Miranda (Faculty)

Constanza is a multidisciplinary academic interested in the intersection between the creativity of design, the ethics of cultural anthropology and the tech aspects of engineering. Before Johns Hopkins, she was an assistant professor at PUC Chile's Engineering School where she founded and directed (with an amazing team!) the engineering design initiative (DILAB). She is the co-founder of the startup Simulmedic. Constanza holds a PhD in Design with a focus in anthropology from NC State University. While a Fulbright grantee, she worked as a visiting researcher at the CDR (Mech. Engineering) at Stanford. As an entrepreneur, a team player and researcher, her focus is on biomedical devices, engineering design & pre-engineering education. Past experiences involve work in industry such as Cooper San Francisco, Karl Storz Endoskope and Continuum Milan. Today, she constantly interacts with industry linking students to the conversations of the current practice. Her interest in creating tools for a hands-on education is embodied in the Anthro Design Crash Course book and the SaviaLab pre-engineering design program for rural schools in Chile. The latter was recognized by the 2018 Airbus GEDC (Global Engineering Deans Council) Diversity Award sponsored by UNESCO because of its aim to democratize technology. More of her over 15 years of teaching experience can be found at: www.constanzamiranda.cl

The Social Dimensions of Learning: facilitating social dynamics for a more engaged student in a K12 Pre-Engineering Program (Work in Progress)

Abstract

This is a Work in Progress: This qualitative-context sensitive study followed two cohorts of students (ages 14 to 18) undertaking a pre-engineering summer program at a selective university in Santiago de Chile. Participants were hosted in the FabLab belonging to the program in engineering design and innovation. The targeted participants of this program entailed diverse socio-economic backgrounds. Some middle and high schoolers belonged to families with no university professionals and some did. The program provided scholarships to all of those who were not able to submit a payment. Under a socio-constructivist theory, this study looked to understand the multiple social elements that played a role in learning. Elements involved teamwork and its related skills, co-regulation and collaborative learning processes, role models, and the formation and negotiation of identity in the learning process. This qualitative case study involved an exploratory phase where an ethnographic approach was undertaken, as well as a more structured qualitative research approach with participant observation and interviews. To identify salient themes, data collected was analyzed using Grounded Theory. Preliminary results showed how students perceive this program through comparing and reproducing the vocabulary and emotions of their past school-experiences. Additionally, role models were perceived through binary lenses in which some student monitors assumed the role of “equals” and others were perceived as traditional and strict teachers.

Introduction

This study describes a pre-engineering summer program at a selective university in Santiago de Chile. Concern for K-12 STEM education has been growing over the years due to the need for STEM professionals in the world's post-industrial economies [1], [2]. Universities have initiated programs at different levels to increase interest in STEM fields among young people to study these fields before the university entrance process [3] and create pipelines for groups that are traditionally underrepresented in these fields [4]. Within these programs, there are some focused on K-12 education that seek the integration of STEM disciplines through the use of engineering processes [5] which have been called "pre-engineering" programs.

The maker movement has gained traction in K-12 STEM education because of its ability to engage students in design and engineering practices [6], [7]. It has also been identified as a way to attract students to engage in STEM subjects and think creatively [8], [9]. Thus, makerspaces act as places of experimentation where learners construct artifacts that provide evidence for learning content, process, and identity [10]. Socio-constructivist learning theory asserts that learning is first constructed through a social medium before transferring onto an intra-psychological level [11]. Therefore, understanding social dimensions in the process of “making” learning can be critical in the success of K-12 STEM education contexts. Through this lens of socio-constructivist learning theory, we aim to understand multiple social elements of this specific educational program in the scope of this study: teamwork and its related skills [12], co-regulation and collaborative learning processes [13], the function of role models [14], and the formation and negotiation of identity in the learning process [15].

Currently, the concept of K-12 pre-engineering education has gained popularity in the United States, but not as much within Latin America. Pre-college engineering learning programs in Latin America span a wide variety of forms and have not yet reached mainstream popularity in educational institutions [16]. In Chile, there are several existing engineering education programs for high school students, but the concept of "pre-engineering" has not often been used to describe these programs. Examples of these programs include installations of FabLabs in schools and community centers, university-based summer programs for secondary school learners, and community-based engineering education camps.

This article presents the pre-engineering summer program, its participants, and their experiences. The purpose of this study is to explore how social dimensions of learning occur in the K12 extracurricular pre-engineering education context. We describe our ongoing research methodology proposed and the preliminary results obtained.

Our Case Study: Pre-Engineering Summer Program

This research is an exploratory and qualitative case study [17] that examines the case of a two-week summer pre-engineering program at the Pontificia Universidad Católica de Chile (UC) in Santiago, Chile called *Escuela Tecnológica de Verano* or Technological Summer School (TSS). This project has been carried out since January 2016 and has run eleven iterations to date. This study takes a deep look into the TSS of summer 2020, taking place during the first two weeks of January.

TSS is an engineering education program organized by an organization called FabIDI at UC where students work in groups to develop different projects and activities framed through the lens of digital fabrication [18]. It aims to expose children between 11 and 16 years of age to existing manufacturing technologies and bring them closer to newer FabLab-related technologies through attractive playful activities [18]. To participate, the students register with their parents via an online form and are then contacted by the organizers. Students who cannot afford the registration fee receive scholarships from FabIDI to ensure inclusive participation.

"Monitors" are volunteers who organize the TSS activities and are selected through an application process. Six monitors, all UC engineering students between 20 and 25 years old, took part in this iteration of the program. All the participants worked in groups of four or five and remained in those groups for the majority of program activities. The monitors designed the groups to include a variety of ages and at least two girls in each one. Table 1 presents topics and activities that were addressed through the program in detail. The activities included theoretical classes, practical labs, and games. In the last activity, all the students worked in different groups so that they could interact more with the rest of their peers.

Topic	2D design	3D design	Electronics 1	Replication	Electronics 2	Project	Exhibition
Days	1 and 2	3	4 and 5	6	7 and 8	9	10
Content	Basic concepts of dimensional design (color, typography, etc.) Use of vector design program Presentation of physical manufacturing machines in flat format (milling machine, vinyl plotter and laser cutter)	Bases for three-dimensional representation Use of 3D modeling program 3D replication techniques (scanner, photography and 3D printing)	Theory of electricity (voltage, intensity, and current) Presentation of electronic components Arduino board programming	Basis of mass replication Uses and techniques of rapid prototyping	Presentation of electronic components Connection between sound and electricity	Design methodology Recycling	Requirements presentation for the exhibition
Activity	Logo and icon design	Spinner design and scan of a sculpture	Preparation of circuit with LED and lamp	Mold making Manufacture of 3D replica in resin Rapid prototyping and design	Manufacture and use of water sensors Speaker construction	Challenge resolution; redesign of car garbage collector for recycling	Organization and presentation of a theme in groups

Table 1. Topics and activities by day.

Data Collection

The study included 32 students in total, all between the ages of 14 and 18. The qualitative interview portion of the data collection focused on 10 students in the program. Among these students, five identified as female and five as male. Six received grants through foundations or projects, three paid normal tuition, and one paid a discounted tuition. Although most of the participants lived within Santiago, of the 10 interviewed, four students came from other regions in Chile.

Multiple data collection methods, which included observations, field notes, and “semi-structured” interviews with participants [19] were used during the study. Afterward, researchers analyzed all transcripts and notes using grounded theory [20] (Strauss & Corbin, 1994), specifically open coding. This entails a coding process by which to make sense of the qualitative data—a method of selection, approach, simplification, abstraction, and transformation of the data that appear in the records [21] (Beebe, 2001).

Preliminary Findings

Preliminary analysis showed that students used the lens of previous schooling experiences to process and perceive their participation in this extracurricular pre-engineering program. Their vocabulary and affective associations of the program mirrored or contrasted with those of regular "school," with the former in constant comparison against the latter. Participants described the program in terms of their formal curricular schooling (i.e. what the school or teacher is "supposed" to be like), contrasting both models and valuing TSS in terms of the other.

Most students interviewed have been educated in Chilean public schools. This context reflects many formal education contexts where educators decide the goals and frames of learning, which are driven by traditional classroom activities [6]. This insight from the TSS raises larger questions surrounding the role of past schooling experiences in motivating participants to consider and even participate in extracurricular educational opportunities.

The data also illuminated another comparison made by the students, namely, that they perceived monitors as role models that either fulfilled their expectation of what a superior "should" be (a hierarchical, strict teacher) or eschewed that model entirely by being an "equal" (a kid, just like them). This raises questions about the role of teachers and facilitators in the pre-engineering education context, and how it may impact science identity development in students.

Future work involves continuing the codification process and contrasting literature to deepen our understanding of the study's results. Ultimately, we hope to understand how to facilitate social dynamics for future pre-engineering programs for more engaged student learning across diverse populations, as well as to enable its adoption across engineering and education practitioners across the region.

References

[1] K. Sadler, E. Eilam, S. W. Bigger, and F. Barry, "University-led STEM outreach programs: purposes, impacts, stakeholder needs and institutional support at nine Australian universities," *Stud. High. Educ.*, vol. 43, no. 3, pp. 586–599, 2018, doi: 10.1080/03075079.2016.1185775.

[2] L. D. English, "STEM education K-12: perspectives on integration," *Int. J. STEM Educ.*, vol. 3, no. 1, pp. 1–8, 2016, doi: 10.1186/s40594-016-0036-1.

[3] L. Gumaelius *et al.*, "Outreach initiatives operated by universities for increasing interest in science and technology," *Eur. J. Eng. Educ.*, vol. 41, no. 6, pp. 589–622, 2016, doi: 10.1080/03043797.2015.1121468.

[4] S. A. A. Allen-Ramdial and A. G. Campbell, "Reimagining the pipeline: Advancing STEM diversity, persistence, and success," *Bioscience*, vol. 64, no. 7, pp. 612–618, 2014, doi: 10.1093/biosci/biu076.

[5] R. L. Carr, L. D. Bennett IV, and J. Strobel, "Engineering in the K-12 STEM standards of the 50 U.S. States: An analysis of presence and extent," *J. Eng. Educ.*, vol. 101, no. 3, pp. 539–564, 2012, doi: 10.1002/j.2168-9830.2012.tb00061.x.

[6] L. Martin, "The promise of the maker movement for education," *J. Pre-College Eng. Educ. Res.*, vol. 5, no. 1, pp. 30–39, 2015, doi: 10.7771/2157-9288.1099.

[7] B. K. Litts, Y. B. Kafai, D. A. Lui, J. T. Walker, and S. A. Widman, "Stitching Codeable Circuits: High School Students' Learning About Circuitry and Coding with Electronic Textiles," *J. Sci. Educ. Technol.*, vol. 26, no. 5, pp. 494–507, 2017, doi: 10.1007/s10956-017-9694-0.

[8] Y. C. Hsu, S. Baldwin, and Y. H. Ching, "Learning through Making and Maker Education," *TechTrends*, vol. 61, no. 6, pp. 589–594, 2017, doi: 10.1007/s11528-017-0172-6.

[9] K. Bevan, B., Petrich, M., Wilkinson, "TInkER ING Is Serious Play," no. June, 2014.

[10] B. K. Litts, "Making learning: Leverage makerspaces as learning environments," *Proc. Int. Conf. Learn. Sci. ICLS* , vol. 3, no. January, p. 1726, 2014.

[11] L. S. Vygotsky and M. Cole, *Mind in society: Development of higher psychological processes*. Harvard University Press, 1978.

[12] M. Borrego, J. Karlin, L. D. Mcnair, and K. Beddoes, "Team effectiveness theory from industrial and organizational psychology applied to engineering student project teams: A research review," *J. Eng. Educ.*, vol. 102, no. 4, pp. 472–512, 2013, doi: 10.1002/jee.20023.

[13] E. G. Cohen, "Restructuring the Classroom: Conditions for Productive Small Groups," *Rev. Educ. Res.*, vol. 64, no. 1, pp. 1–35, 1994, doi: 10.3102/00346543064001001.

[14] J. R. Gladstone and A. Cimpian, "Which role models are effective for which students? A systematic review and four recommendations for maximizing the effectiveness of role models in STEM," *Int. J. STEM Educ.*, vol. 8, no. 1, 2021, doi: 10.1186/s40594-021-00315-x.

[15] W. Fasso and B. A. Knight, "Identity development in school makerspaces: intentional design," *Int. J. Technol. Des. Educ.*, vol. 30, no. 2, pp. 275–294, 2020, doi: 10.1007/s10798-019-09501-z.

[16] C. Miranda, J. I. Goñi, and M. H. M. Fuenzalida Hellen Fuenzalida, "Board 119: Pre-engineering programs and the instillment of empowering abilities for minorities: The case of the savialab program," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2019, doi: 10.18260/1-2--32206.

[17] R. K. Yin, *Case Study Research: Design and Methods*, 4th ed. Los Angeles, California: Sage, 2009.

[18] FABIDI, "Escuela de Fabricación: una guía sobre el qué, cómo y por qué," Santiago, Chile, 2019.

[19] U. Flick, *An introduction to qualitative research*. sage, 2018.

[20] A. Strauss and J. Corbin, "Grounded theory methodology: An overview.," 1994.

[21] J. Beebe, *Rapid assessment process: An introduction*. Rowman Altamira, 2001.