DESIGNING AN INTRODUCTORY FIRST-YEAR COURSE FOR AN ELECTRONICS ENGINEERING PROGRAM

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ABSTRACT

We present the design and evolution of our current first-year introductory course for the Electronics Engineering program of the School of Engineering at the University of Concepción, Chile based on CDIO Standard 4. For the last eight years, we have gathered student reactions and opinions about the course, recording how its different activities have impacted both their interest in and knowledge of their chosen field of study. These activities have changed throughout the years and have included, in no particular order, talks by faculty members about their research, presentations by practicing electronics engineers about their day-to-day jobs, visits to local industries, individual and small-group programming projects, latter-year student presentations about their internships, junior and senior engineers and alumni talking about their first jobs, and others. Evidence gathered through yearly surveys show that students appreciate the course as they enjoy working in small-group programming projects and hands-on laboratories and also because it gives them the chance to meet and work with their classmates. This was particularly important for the 2020 and 2021 cohorts, when all class activities migrated to virtual platforms. Thus, we have designed a three-part 17-week long course. A six-week college induction course is followed by lab sessions where students work in small groups on electronics programming projects using microcontroller boards such as Arduino Uno, BBC Microbit and/or Raspberry Pi. These lab sessions are interspersed with presentations by practicing junior and senior electronics engineers, mostly alumni, talking about their first jobs and current work. Finally, the course's last weeks are reserved for student poster presentations about the electronics engineering field. Student opinions about this new course design have been encouraging, as it has been well received by the incoming student class.

KEYWORDS

Introductory course, Student satisfaction, Electronics Engineering, Standards 2, 4.

INTRODUCTION

As most Chilean engineering programs (Vial, 2005), the Electronics Engineering program of the School of Engineering of the University of Concepción is six years in length, divided into three two-year cycles. The first cycle is aimed at building strong foundations in math and sciences: first-year students take rigorous courses on algebra, calculus, physics and chemistry. During the second two-year cycle, students take mandatory courses covering several topics in electronics engineering, such as semiconductors, digital systems, electronics, process control systems, etc. Finally, in their last two-year cycle, students choose their elective courses both to specialise their technical knowledge and to broaden their horizons. The program's last term is wholly dedicated to a semester-long individual project that tests students' skills and

knowledge by conceiving, designing, implementing and evaluating their solution to an electronics engineering problem of their choosing.

In recent years, there has been a nationwide concerted effort to shorten engineering programs. Therefore, since 2020 all engineering programs at the School of Engineering of the University of Concepción are 5 1/2-year programs. Student feedback gathered via surveys and focus groups showed us that student motivation and enthusiasm were negatively affected by the math- and science-heavy courses, especially during the first two-year cycle. These courses are taught by the School of Math and Physics and follow a scientific curricular approach rather than an engineering-oriented approach. Another revealing insight was that many students did not become properly acquainted with their chosen field of study until the second two-year cycle, and did not fully understand their future role as engineers until the last two-year cycle. Both these factors resulted in most engineering programs having a relatively high attrition rate: on average, 1 out of 4 first-year engineering students left their chosen program either by quitting, changing their majors or being dismissed because of their low grades (Higher Education Information Service, 2021).

How to encourage student interest in their field of study? The Electronics Engineering program has been using the CDIO Standard 4 as a guideline to design its Introduction to Electronics Engineering course, aimed at introducing students to the practice of engineering and to the electronics engineering field. The course, which has undergone several iterations, also focuses on the development of those personal and interpersonal skills and attitudes needed for their academic and professional development. We found several works in the CDIO Knowledge Library to be useful references, such as Roslöf (2008), Loyer et al. (2011), Muñoz, Martínez, Cárdenas, and Cepeda (2012), Vega, Morales, and Muñoz (2013), Vargas (2014), Correal *et al.* (2016), and Schrey-Niemenmaa and Piironen (2017). This introductory course was initially offered as a first-year voluntary-enrolment course for extra credit, and was used as a pilot test bed to try out different activities on first-year students and thus find out the best format for the course. In the following section, we describe the different versions of this course in more detail.

THE INTRODUCTION TO ELECTRONICS ENGINEERING COURSE

2015-2018 course versions

The Introduction to Electronics Engineering course has gone through several iterations since its conception. Its first version was offered in 2015 as a semester-long voluntary enrolment course for first year students only. The course met once a week for two hours and was graded based on class attendance as pass/fail. Student activities typically involved small-group development activities, topical lectures by their future teachers, current research presentations by professors, alumni talks about their future career prospects, among others. Not all first-year students enrolled in the course: only 33 of the 48 students in the freshman class of 2015 signed up for it. Even though the course was graded pass/fail based on attendance, 5 students failed the course. As course enrolment was voluntary, these students were not required to take the course again. The 2016 version of the course was similar. Enrolment was 42 students out of a cohort of 55, of which only 3 students failed the course. For the 2017 version of the course, 37 students out of a possible 48 enrolled in the course. Course requirements were made stricter, so 12 students failed the course.

2019 course version

The four versions of the Introduction to Electronics Engineering course described above were very helpful for determining topics that both interested and motivated students, as well as to

identify lecturers who could successfully engage with first-year students and stimulate their interest in the field. However, the logistics of coordinating a 17-week semester-long course alongside the rest of the first-year 12-week trimester courses proved to be a major problem, creating calendar conflicts and confusion among students and teachers. Thus, for 2019 a 12-week trimester course was planned, which included fewer talks and lectures so as to fit the course material into 12 weeks. As a result, many small-group development activities were removed. This trimester-long voluntary course had an enrolment of 39 students out of the 2019 cohort of 51.

2020 course version

From 2017 to 2019, all School of Engineering programs went through a curricular redesign process to shorten program duration to 11 semesters. As a result of this process, all programs now include an introductory course to the program's discipline. This mandatory course meets for two hours a week and is graded as all other program courses. Student feedback about their experiences with the voluntary enrolment course from 2015 to 2019 had shown us the usefulness of our Introduction to Engineering course and its effects on first-year student motivation and overall satisfaction with the program. At the same time, feedback from the trimester-long 2019 version of the course indicated that first-year students missed the small-group development projects of the Introduction to Engineering course: these activities improved morale and motivation, and helped build camaraderie and esprit de corps among them. Consequently, a second course was designed for the second trimester of 2020. In this course, students would work in groups to develop electronics prototypes based on Arduino boards. Unfortunately, the COVID-19 pandemic derailed these plans, as classes were cancelled nationwide. In-class group activities and lectures were suspended and replaced by virtual classes and meetings via Microsoft Teams. An Introduction to Electronics Engineering course was taught during the first trimester of 2020, consisting mainly of virtual lectures via Microsoft Teams, while we studied ways in which students could work remotely in small-group projects and still be able to develop their personal and interpersonal skills. So, we designed a second trimester-long course in which students worked in small groups to develop Android apps using AppInventor (http://www.appinventor.mit.edu), an online web-based integrated development environment that uses intuitive visual programming where students can build fully functional apps for smartphones and tablets (Wolber, Abelson, Spertus, & Looney, 2014), (Patton, Tissenbaum, & Harunani, 2019). Both these courses were mandatory and had full enrolment. As with most courses, student grades are at an all-time high, as are overall student retention rates. These courses had an enrolment of 53 students, of which 43 are still active program members.

2021 course version

In 2021, all School of Engineering programs modified their first year of study so as to do away with its division into three trimesters and revert to a two-semester year. In accordance to this change, the 2010 Introduction to Electronics Engineering trimester courses were successfully merged into one semester-length course, during which students again worked in small groups to develop simple Android apps. Given the restrictions placed on in-person activities by the COVID-19 pandemic, this course was taught online via Microsoft Teams.

COURSE ACTIVITIES

In the previous section, we briefly presented six versions of our Introduction to Electronics Engineering course, without going into detail of the student activities for each one. As mentioned before, the exploratory nature of these courses allowed us to experiment with course contents and activities, and to try different approaches every year. This section describes many of these activities. Not all students engaged in all the activities mentioned

below: in particular, the peculiar nature of university activities during the COVID-19 pandemic these last two years has precluded many of them.

Introduction to University life University staff talk to students about the opportunities and challenges associated to leaving their homes and adapting to university life, covering topics such as common computer software, University computing resources, etc.

Introduction to the University Library system: Students visit the library for the first time. During the pandemic, University Library staff reviewed access to online books and databases.

The Electronics Engineering field: The program head goes over the Electronics Engineering field reviewing future prospects and fielding questions from students.

University rules and regulations: The program head reviews relevant university rules and regulations, covering everything from the credit system to the university's grievance reporting system.

Student wellness: Staff from the University's Student Wellness Centre talk to students about how to face the physical and mental challenges of living away from home

Student inclusion and diversity: Staff from the University's Inclusion Program talk to students about equal access to opportunities and resources for people having physical or mental disabilities and members of minority groups.

Student relationships: Staff from the University's Gender and Diversity Centre talk to students about healthy student relationships and the University's rules and regulation regarding these matters

Professional ethics: Lecturers talk to students about professional ethics and its implications, discussing recent case studies

Alumni talks: Alumni are invited to talk to students about their experiences as a student in the Electronics Engineering program, and to describe their day-to-day jobs as electronics engineers

Recent graduates' talks: Recently graduated students come back to school to talk to students about their job-seeking experiences, their first jobs and to reflect on the program

Talks by summer interns: Students who enrol on summer internships are encouraged to talk about their experiences to first-year students, showing them photographs and videos of their workplace and activities

Faculty research talks: Many faculty members are eager to showcase their work and talk about their research to first-year students. This also gives students an overview of the field's state of the art.

Field trips: Students tour nearby industrial plants and gain in situ knowledge of the role of the electronics engineer in that particular business

Group research projects: Students work in groups to research topics of interest in electronics engineering, presenting their work to the class

Student group essays: Students work in groups to research topics of interest in electronics engineering and collaboratively write essays about them

Android app development: In 2020 and 2021 students worked collaboratively to design and develop apps for Android using a web-based integrated development environment

DATA GATHERING METHODS

To evaluate the effectiveness and usefulness to students of the above-mentioned activities, we have periodically surveyed all active program members who took the Introduction to Electronics Engineering course in any of its seven versions. Of this universe of 272 students, 146 answered the survey. Figure 1 shows our preliminary survey results. It should be noted that not all students had the opportunity to do every activity: for example, only two of the seven courses included a field trip. Thus, results are given as a percentage of the total number of students who engaged in a certain activity and then answered the corresponding survey question.

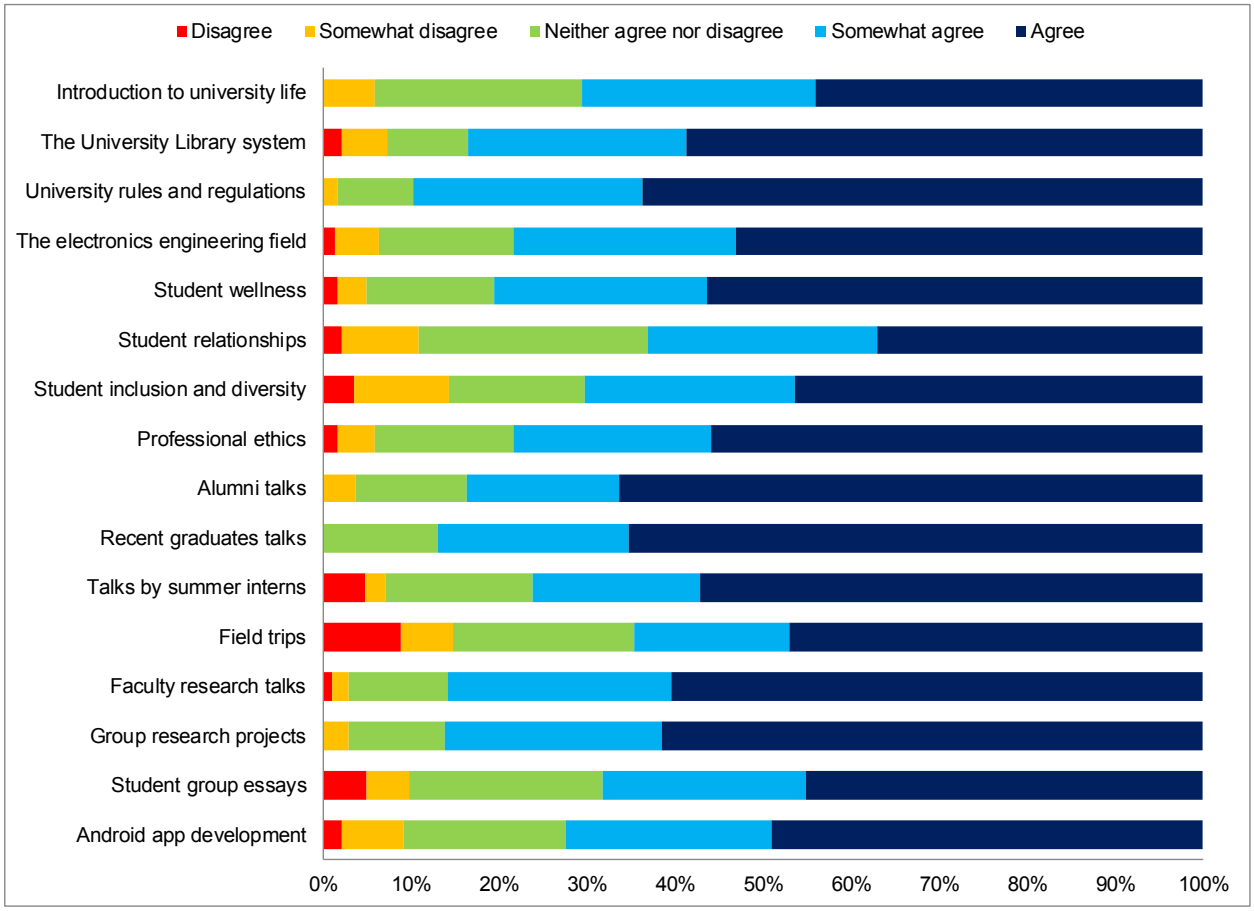

Figure 1. Student perception of introductory course activity usefulness

As can be seen in Figure 1, students in general consider those course activities they engaged in as useful and informative. Most students highly value induction activities such as the University rules and regulations review, the Introduction to University Life presentation and the overview of the electronics engineering field. Likewise, first-year students find that faculty research talks, alumni talks and recent graduates' talks are interesting and topical. On the other hand, most talks about student relationships, student wellness, inclusion and diversity given to first-year students by University personnel were not as well received. Hence, we are working with the corresponding University units to design more interesting and relevant presentations. Finally, those few activities that were graded (student group projects, student research projects and the development of Android apps) were considered somewhat less useful and enjoyable.

Regarding the course workload, any first-year students report problems with time and resource management, and with teamwork and work distribution among their classmates. However, these problems are usually associated with the math- and science-heavy course: this introductory course is seen by students as a lighter-load course. Both the University and the School of Engineering have long-standing student support programs to help those students that struggle with their transition from high school to university.

Students were also asked to report on their perception of the effects of the Introduction to Electronics Engineering course via a follow-up survey taken after the course is finished. Figure 2 shows some of our aggregated preliminary results.

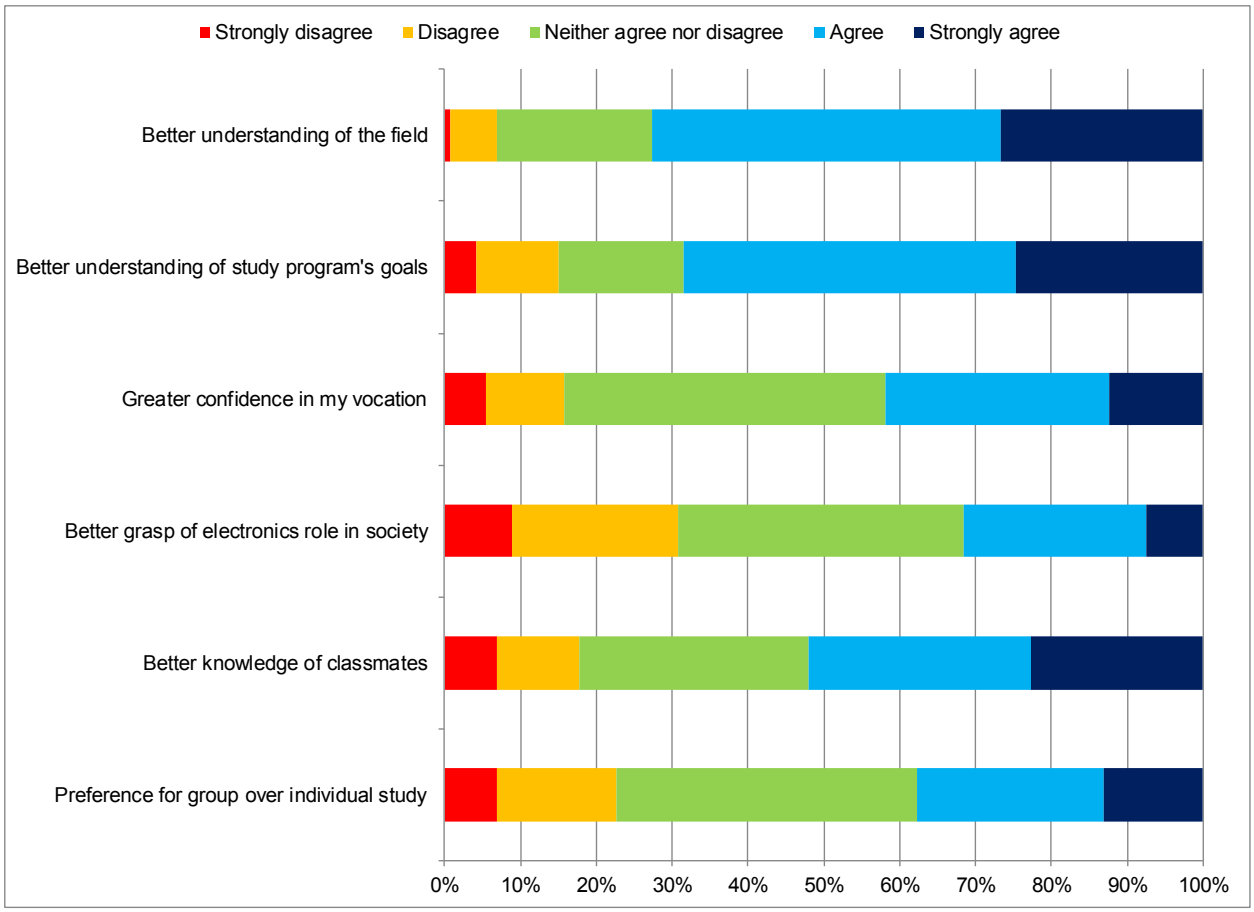

Figure 2. Student perception of introduction to Electronics Engineering course

On the whole, as can be seen in Figure 2, students perceive their Introduction to Electronics Engineering course as a pathway to a better understanding not only of the Electronics Engineering study program which they have just joined, but also of the electronics engineering field itself. However, they still do not have a firm grasp on the role of the electronics engineer in society and industry. This uncertainty does not help them identify and define their skilful vocation yet. While this course may have not convinced many of our students that electronics engineering is their vocation, this new understanding of the field might yet help them fall in love with their chosen field of study.

Also, from Figure 2, it can be seen that through this course our students have met their classmates, worked together on some simple projects and are starting to appreciate the value of teamwork. This has been especially important for the 2020 and 2021 cohorts, who, because of the COVID19 pandemic, were not able to meet their classmates in person until March of 2022, after in-person restrictions were lifted. Even so, in-class facemask use was mandatory until the second semester of 2022. Thus, our Introduction to Electronics Engineering course allowed for student engagement, interaction and teamwork in a lower-pressure environment than the other math- and science-heavy first year courses.

DESIGN OF AN INTRODUCTORY FIRST-YEAR COURSE

Throughout this paper, we have presented the design and implementation of an introductory Electronics Engineering course for first-year students and its different versions, from 2015 to date. The optional nature of these courses has allowed us to experiment with different formats and activities. The effectiveness and usefulness of these modifications have been assessed

via student satisfaction surveys not only at the end of the course, but lately also through a retrospective survey given to latter-year students.

The current version of the course is now a mandatory semester-long course divided into roughly three parts. The course starts with a six-week college induction section including a series of lectures introducing the university and its services, the electronics engineering study program and the electronics engineer's role in industry and society. Additionally, some University-mandated lectures on student relationships, inclusion and diversity are included.

The second part of the course aims to give students a taste of the hands-on lab work they will experience in later years. These lab sessions are interspersed with presentations by practicing junior and senior electronics engineers, many of them alumni, talking about their first jobs and their current work. The University's cautious return to normal activities after the pandemic meant that facemasks had to be worn in class at all times by professors and students, and that in-person laboratory work was severely limited. Likewise, all field trips were cancelled. Therefore, in 2022 the hands-on lab work was replaced by Android app development using Kodular (Kodular, 2022), an improved version of the AppInventor development environment.

Finally, the course's last weeks are reserved for student poster presentations about the electronics engineering field and for talks and presentations by faculty, alumni and engineering practitioners aimed at giving students food for thought about the field's promise and their professional future. Additionally, we have older students act as role models to younger students by having them give poster presentations about their internships, as hopefully these may help first-year students' motivation and interest in the field. Furthermore, we have embraced the latest new-fangled technologies to have engineers talk to students from their place of work and to build a video repository in the cloud for future reference.

Student opinions about this new course design have been encouraging, as it has been well received by the incoming student class. The renewed focus on presentations, either in person or via video, by practicing engineers and alumni talking about their work history has been appreciated and commented upon by our first-year students. At the same time, this year's students have been critical of the Android app development focus, clamouring for more electronics and less programming. We aim to do that in the 2023 version of the course by focusing this year's lab work on using the Micro:bit microcontroller card. Likewise, we intend to bring back the yearly field trips to nearby industries, another common request we hear from our students.

CONCLUSIONS AND FUTURE WORK

Throughout this paper, we have presented the design and implementation of an introductory Electronics Engineering course for first-year students. We have also presented preliminary survey results for all students that have enrolled in the different versions of this course since 2015. The current version of the course is now a mandatory semester-long course divided into roughly three parts: a series of lectures that serve as an induction to the university, the program and the field of study, talks and presentations by faculty, alumni and engineering practitioners aimed at giving students food for thought about the field's promise and their professional future, and a series of graded group activities for students to work together, thus developing their personal, interpersonal and teamwork skills. This course runs parallel to their math- and science-heavy first year courses and is their first introduction to the practice of engineering.

For 2023, we will replace the Android app programming experiences, which were appropriate for online classes, with lab sessions where students work in small groups on electronics programming projects using microcontroller boards. For 2023, we have chosen to use the Micro:bit v2 board, an open source hardware ARM-based embedded system designed by the

BBC for use in computer education in the United Kingdom. This board was chosen for its versatility, robustness and low cost, and it has an ARM Cortex-M4 processor, several sensors such as an accelerometer, a magnetometer, and a touch sensor button, and includes a microphone and speaker, programmable buttons, USB and Bluetooth connectivity and a 25-LED display. The Micro:bit board is programmable via Microsoft MakeCode, a graphical blocks language, and via MicroPython.

Furthermore, starting in 2022, during their second semester students enrol in a School of Engineering-wide Innovation course, where they will work in teams with students of other engineering disciplines on problem solving using Design Thinking. There they work on devising simple engineering solutions to multidisciplinary problems and it is expected they will use the Micro:bit board as a microcontroller in their designs.

Our survey results also show that students' perception of the Introduction to Electronics Engineering course change with the years since the course was taken. First-year students get the most out of the induction part of the course, as they lack familiarity with university life, the campus, the study program and the university's rules and regulations. At the same time, older students who now understand the field better may look back and now appreciate the faculty research lectures, and the alumni and practicing engineers' talks. More work is needed to explore these topics and we intend to continue evaluating the course's effectiveness and usefulness to students in the future, so as to adapt it as needed. We are currently using these and other results to inform syllabus design for the 2023 version of this course, which we hope will incorporate both in-person lectures and video talks.

Finally, we feel that through the process described above we have designed an introductory Electronics Engineering course that provides the framework for the student's future engineering practice, while aiding the development of students' essential personal and interpersonal skills such as teamwork and collaboration (CDIO Standard 4). As future work, we intend to update the course by adding discussion of the rationale of sustainability in the context of engineering, as discussed in Malmqvist, Edström, and Rosén (2020). Finally, the School of Engineering is working with the School of Math and Physics to improve horizontal coordination and further contextualize their first-year course.

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