UNIVERSIDADE FEDERAL DE SANTA MARIA

DOCUMENTATION

CDIO INITIATIVE

October 2020

Institutional Officers

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Dean

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Pro-rectory of graduation

SUMMARY

1 General Presentation

1.1 Federal University of Santa Maria - UFSM

Founded in 1960, the Federal University of Santa Maria was the first federal university created in the countryside, outside a Brazilian capital. The University currently has 28210 students in 270 Undergraduate and Graduate Programs. In the Engineering area area, the University has two centers:

- Center of Technology - CT (Santa Maria, RS) with 12 Undergraduate Engineering Programs:
    - Started in 1960 decade: Civil, Electrical, Mechanical, Chemical.
    - Started in 2009: Control and Automation, Sanitary and Environmental, Computer and Production Engineering.
    - Started in 2015: Aerospace, and Telecommunications Engineering.
- Cachoeira do Sul Campus - CACS (Cachoeira do Sul, RS) with 4 Undergraduate Engineering Programs: Electrical, Mechanical, Transport and Logistics, and Agricultural Engineering. The programs in Cachoeira do Sul Campus started in 2014.

The university currently has Stricto Sensu Graduate Programs (Master/PHD) in 6 Engineering Areas: Civil, Electrical, Mechanical, Chemical, Production, and Environmental.

1.2 Alumni Profile

The desired alumni profile of each engineering program is defined in their Pedagogical Program. Currently all programs are changing the curriculum and Pedagogical Program in order to consider the profile defined in the new Brazilian Engineering Education Guidelines, which is aligned with CDIO Syllabus.

Some data considering alumni profile:

- According to the Center for World University Rankings (CWUR) World University Rankings (2020-21), UFSM is the 891th in the World, and 8th in Brazil, in the “Alumni Employment Indicator”, measured by the number of a university's alumni who have held top executive positions at the world's largest companies relative to the university's size.
- Entrepreneurship of Engineering students is stimulated by the University. The UFSM Innovation and Technology Transfer Agency (AGITTEC) aims to intensify the institutional initiatives to develop entrepreneurship, with frequent events and programs of business development and company incubation.

2 CDIO Initiative

The first contact with the CDIO framework was with the Embraer Professional Master Program, attended by professor André Luiz da Silva, coordinator of the Aerospace Engineering Program from 2017 to 2020.

In 2017 the Aerospace Engineering Program has included CDIO-based courses throughout the curriculum. The CDIO-based courses are detailed in Section 2.5.1.

Since 2018, integrative works have been developed and consolidated in specific courses of the Acoustic Engineering Program, such as: signal processing, psychoacoustics, auralization and subjective acoustics, in order to ensure the assessment of the sound quality of spaces and products. Formalization as an integrating project program is being worked on by the structuring teaching group of the course.

In 2019 program coordinators contacted professor Sérgio Mazini from UNITOLEDO, member of the Brazilian CDIO Initiative. He came to our university to lecture in our 1st CDIO UFSM Workshop, which occurred in October 2019.

In 2020 the Electrical Engineering Program (CT) started the experimental course named “Integrated Project I”, based on UNITOLEDO experiences with curriculum integration in design-implement courses. This experience was important to sensitize students and faculty about the necessity of implementing CDIO standards.

In 2020, the UFSM Committee for the New Brazilian Engineering Guidelines was created in order to develop the curricular reform methodologies and advise the curricular reform of Engineering Programs. Also, the CDIO UFSM was created within the New Brazilian Engineering Guidelines Committee to conciliate the CDIO framework with the New Brazilian Engineering Guidelines and the Public Outreach Projects regulations. Due to COVID 19 pandemic and the time consuming preparation of remote education, the committees have started more actively in the second semester of 2020. The meetings are being planned at least monthly. Currently a methodology for curricular reform is being finished, based on CDIO Standards and the New Brazilian Engineering Education Guidelines support documentation.

Figure 2.0.1 shows the steps for the curricular reform of Engineering Programs, considering the CDIO framework. The conceiving stage is being currently developed. The Sections 2.1 to 2.13 present the actions taken by the institution that strengthen the CDIO Standards.

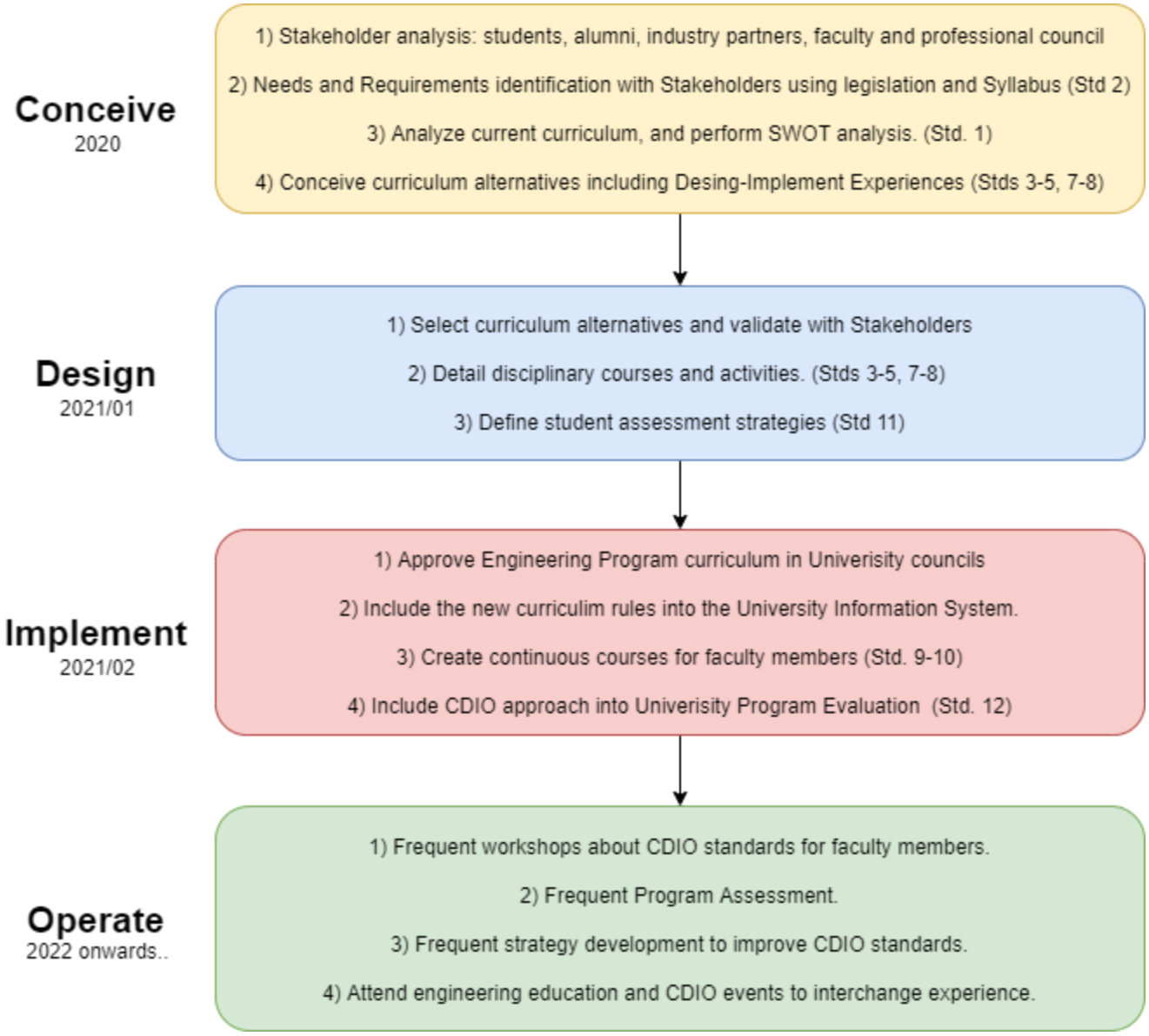


Figure 2.0.1. Methodology to design the curriculum based on CDIO and New Brazilian Engineering Guidelines.

2.1 Standard 1 - Context

2.1.1 Letter of Institutional Support

MINISTÉRIO DA EDUCAÇÃO

UNIVERSIDADE FEDERAL DE SANTA MARIA

Santa Maria, October 30th, 2020

To: CDIO INITIATIVE

I declare that the Universidade Federal de Santa Maria supports, encourages and invests in the development of standards established by the CDIO initiative within the Engineering Programs of this institution.

Paulo Afonso Burmann

Dean

Universidade Federal de Santa Maria

Figure 2.1.1. Institutional Letter of Support.

2.1.2 1st Workshop CDIO UFSM

After contacts with professor Sérgio Mazini from UNITOLEDO, the 1st Workshop CDIO UFSM occurred in october 2019, aiming to sensibilize faculty and students about the CDIO Standards and plan actions to adopt the CDIO framework.

The Workshop Program can be found on https://www.ufsm.br/unidades-universitarias/ct/eventos/i-workshop-cdio/ .

The transmitted speeches can be found on https://www.ufsm.br/unidades-universitarias/ct/2019/10/09/i-workshop-cdio/.

The following Figures 2.1.2 and 2.1.3 show the presentation of CDIO results and a meeting with Program Coordinators, respectively.

Figure 2.1.2. 1st Workshop CDIO UFSM. Presentation of prof. Andre Luiz da Silva, showing the results of CDIO courses in the Aerospace Engineering program.

Fig. 2.1.3. 1st CDIO UFSM Workshop. Meeting with program coordinators.

2.1.2 Creation of the New Brazilian Engineering Guidelines Committee

A commission has been created to help Engineering Programs to implement the New Brazilian Engineering Guidelines. Fig. 2.1.4 shows the designation of the commission. The commission has planned monthly meetings and will advise the Engineering Programs to implement the New Brazilian Engineering Guidelines in Engineering Programs, aligning with the CDIO framework.

Brazilian Engineering Guidelines support documentation can be found on http://www.abenge.org.br/file/DocumentoApoioImplantacaoDCNs.pdf .

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DE SANTA MARIA

PORTARIA N. 98.118, DE 14 DE MAIO DE 2020.

O REITOR DA UNIVERSIDADE FEDERAL DE SANTA MARIA, no uso de suas atribuições legais e estatutárias e tendo em vista o que consta na Resolução n. 011/2020-UFSM e do Ofício n. 002/2020-CT, resolve:

DESIGNAR os servidores abaixo relacionados, como membros da Comissão Permanente de Implantação das Novas Diretrizes Curriculares Nacionais de Engenharias (CODCNEng),vinculada ao Centro de Tecnologia:
- Prof. **Tiago Bandeira Marchesan**, SIAPE 2571147;
- Téc. Adm. **Rita de Cacia Borges Liberalesso**, SIAPE 3555206, Representante da PROGRAD;
- Profª **Candice Muller**, SIAPE 3011961;
- Profª **Damaris Kirsch Pinheiro**, SIAPE 7987010;
- Prof. **João Francisco Carlexo Horn**, SIAPE 1964955;
- Prof. **Lucas Vizzotto Bellinaso**, SIAPE 1222134;
- Prof. **William D'Andrea Fonseca**, SIAPE 2044425;
- Prof. **André Luis da Silva**, SIAPE 1908193, Suplente.

PAULO AFONSO BURMANN

Figure 2.1.4 - Designation of New Brazilian Engineering Guidelines Commission.

2.1.3 Creation of the CDIO Committee

Currently, a group of 22 professors and program coordinators, the pedagogue of the Pedagogical Support Unit and the vice director of the Center of Technology are directly engaged with the CDIO adoption in the University. From this group, a CDIO Committee has been established with 5 professors:

- Lucas Vizzotto Bellinaso (designated CDIO representative): Electrical Engineering (CT) Program Coordinator.
- André Luiz da Silva: former Aerospace Engineering Program Coordinator and pioneer of the CDIO approach in the university.
- Carlos Henrique Barriquello: Computer Engineering Program Coordinator.
- Cristiane Cauduro Gastaldini: Cachoeira do Sul Campus representative. Former Electrical Engineering Program Coordinator.
- Marcelo Serrano Zanetti: vice coordinator of the program in Telecommunications Engineering.

Figure 2.1.5 shows a meeting with professor Sergio Mazini (UNITOLEDO), where the UFSM CDIO Commission solved doubts about the documentation for the application to the CDIO Initiative.

In order to engage other faculty members and program coordinators, the committee can be changed annually.

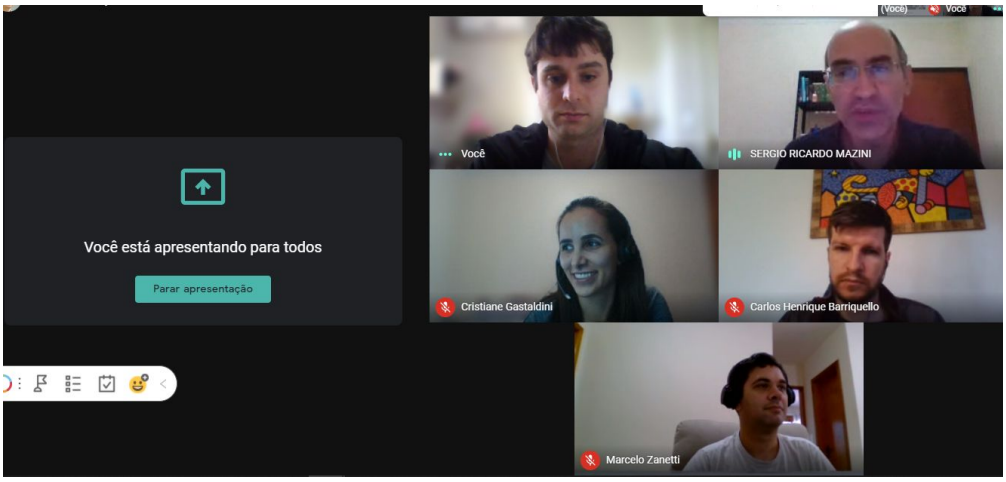


Figure 2.1.5. UFSM CDIO Committee meeting with professor Sérgio Mazini (UNITOLEDO).

2.2 Standard 2 - Learning Outcomes

Currently, all engineering programs have a Pedagogical Program listing all learning outcomes as well as the expected qualifications profile the student will possess upon graduation. With the New Brazilian Engineering Guidelines in Engineering Programs, the qualifications profile will step forward towards the CDIO standards. To enforce this, the translation of CDIO Syllabus was made with the aim of applying it as a survey for students, professors, alumni and representatives of industry and productive sectors. This information is being collected using the “google forms” platform and will be used to evaluate the actions and promote changes. The syllabus evaluation form that will be used for conceiving the curricular reforms can be found on

https://docs.google.com/forms/d/1acue_jBxoky5wt2KltGkvxcaX7a42KYC3QJPeQU1L2c .

2.3 Standard 3 - Integrated Curriculum

The necessity of an Integrated Curriculum, with mutually supporting disciplinary courses, is recognized by all Engineering Programs. Section 2.3.1 describes the Electrical Engineering Program experience with a pilot project for a course to sensitize students and faculty about this integration. The Aerospace Engineering Program already performs this integration with CDIO courses. These experiences will be considered in the curricular reforms of all Engineering Programs.

2.3.1 Electrical Engineering (CT) - The Integrated Design Project Experience

After the 1st Workshop CDIO UFSM, the Electrical Engineering program organized the experimental course named “Integrated Project I”, in order for faculty and students to experience the use of planned engineering projects as a way to integrate the curriculum with mutually supporting disciplinary courses. The course was aimed at students enrolled in the 5th semester of Electrical Engineering. In this course, the class was challenged with the task of designing a smart energy meter. The choice for this project was made by the professors of the 5th semester of Electrical Engineering so all the class would work together to design the same smart meter. The students were divided in 5 groups, each of which was responsible to design a different block of the meter, where different engineering knowledge, mainly learned in 5th semester of Electrical Engineering, were required to design each block: analog signal conditioning; digital signal conditioning; communication and interface; layout; and security and quality control. Furthermore, a hierarchy formed by a general manager for the project and group managers was established, to organize communications among different groups and between the groups and the professors. The final project designed by the class was evaluated by a board formed by the professors of the disciplines present in 5th semester. The evaluation was done based on technical criteria, including how the students integrated the knowledge acquired in the disciplines of 5th semester into the project. The final layout of the meter designed by the layout group is shown in Figure 2.3.1.

Since the course Integrated Project I was in the experimental phase, the students were invited to evaluate the course regarding many aspects, some of which are shown in Figure 2.3.2. For example: its contribution in understanding other subjects of the 5th semester; the importance of the knowledge acquired in other disciplines to carry out the project; and the contribution of the course Integrated Project I to students engineering skills.

The complete evaluation, in Portuguese, can be seen at:
https://www.ufsm.br/app/uploads/sites/426/2020/07/EE202001-Enquete-discentes-Projeto-Integrado-I-1.pdf.

Course program, objectives and methodology (in Portuguese) can be found on:
https://www.ufsm.br/ementario/disciplinas/eng1019/

The course was also covered by the UFSM news department, and the respective article can be found on:

https://www.ufsm.br/cursos/graduacao/santa-maria/engenharia-eletrica/2020/07/23/disciplina-projeto-integrado-i/

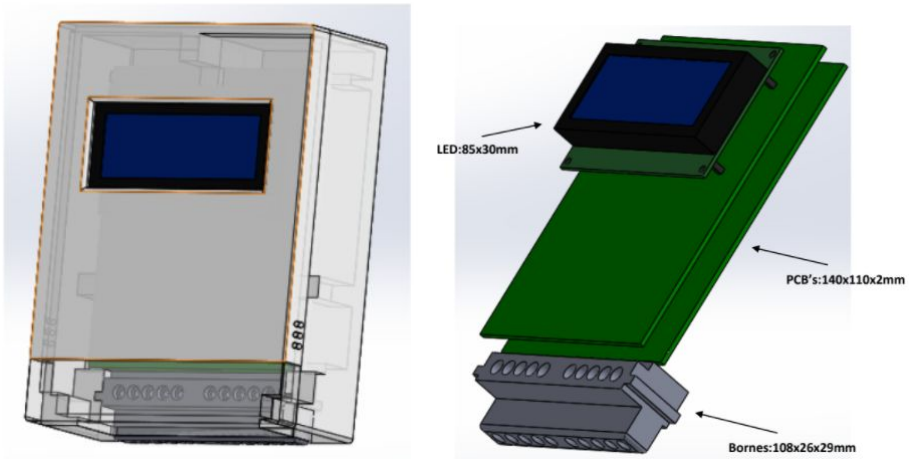


Figure 2.3.1. Smart meter designed by the students.

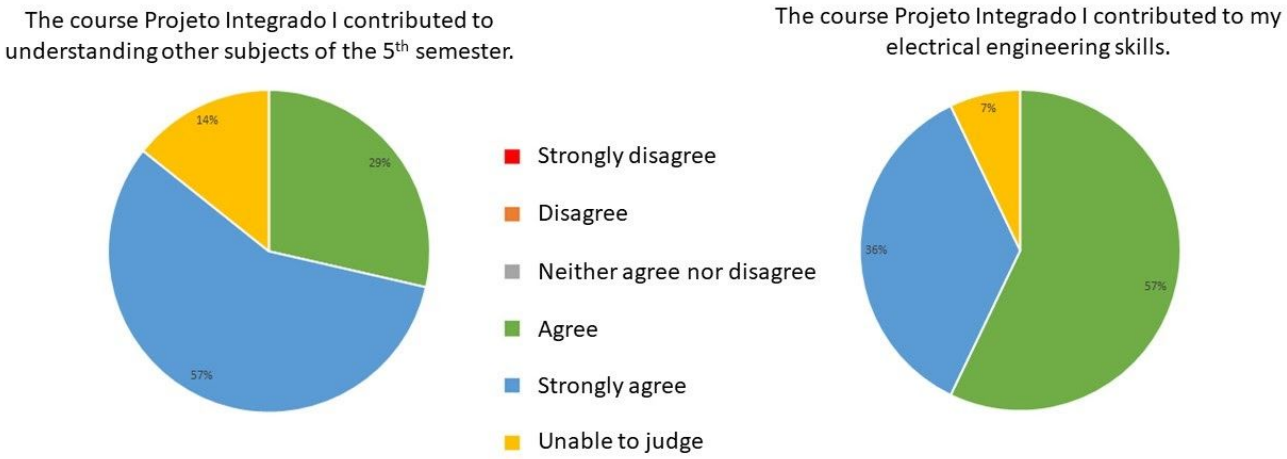


Figure 2.3.2. Evaluation of Integrated Project I by the students.

2.3.2. Aerospace CDIO courses

The Aerospace CDIO courses are being used to integrate disciplinary courses in design-implement experiences. The course methodology is shown in Section 2.5.1.

2.4 Standard 4 - Introduction to Engineering

All Engineering Programs have the introductory course “Introduction to Engineering”, where the students are presented to the main aspects of engineering, visit companies and are presented to the opportunities that they have as engineering students, including student groups, projects and R&D laboratories. Some examples are shown below.

2.4.1 Electrical and Computer Engineering (CT) - Entrepreneurship in Introduction to Engineering

The Introduction to Engineering course in Electrical Engineering (CT) and Computer Engineering has for 20 years introduced entrepreneurship for the beginner students, focusing on developing skills and competences necessary for a leading engineer and questioner, able to use his training to develop new ideas and escape the conventional, aiming to foster innovation and technical-scientific development of society. Through the project-based teaching methodology, we sought to show students the role of the electrical engineer in society, including both social and environmental aspects, working in the private or public sectors, mainly as an entrepreneurial agent. The course focuses on three aspects:

- knowledge of the Electrical Engineering Area and legislation;
- visitation to research groups and student groups inside the university and companies outside. Figure 2.4.1 shows the visitation of 2017 beginner students to the PET Electrical Engineering group, described in Section 2.7.5.
- a final design-implement project applying engineering concepts, where the students are free to define the scope and are challenged to write and present a business plan.

Figure 2.4.1. Electrical Engineering (CT). Students visiting PET Electrical Engineering group.

The Introductory course is frequently evaluated and improved. A paper showing course methodology, results and evaluation was published in COBENGE 2018. Avalailable at http://www.abenge.org.br/cobenge/arquivos/2/LivroSD2018.pdf (page 59).

2.4.2 Transport and Logistics Engineering - Gamification in Education

Transport and Logistics Engineering has promoted activities to engage new students in pursuing basic technical knowledge in Introduction to Engineering Course. Main developed activities:

Creation of a board game: besides getting familiar with technical terms of transport, logistics and infrastructure, students experience several concepts to be used throughout their professional life, such as: time and resource management, communication techniques, teamwork and creativity.

Figure 2.4.2. Transport and Logistics Engineering - Creation of board game.

Marshmallow Challenge: based on teamwork methodologies, students have to build the highest structure able to support the weight of a single marshmallow at its top. Students experience several concepts to be used throughout their professional life, such as: project management, especially time and resource management, communication techniques and team effort.

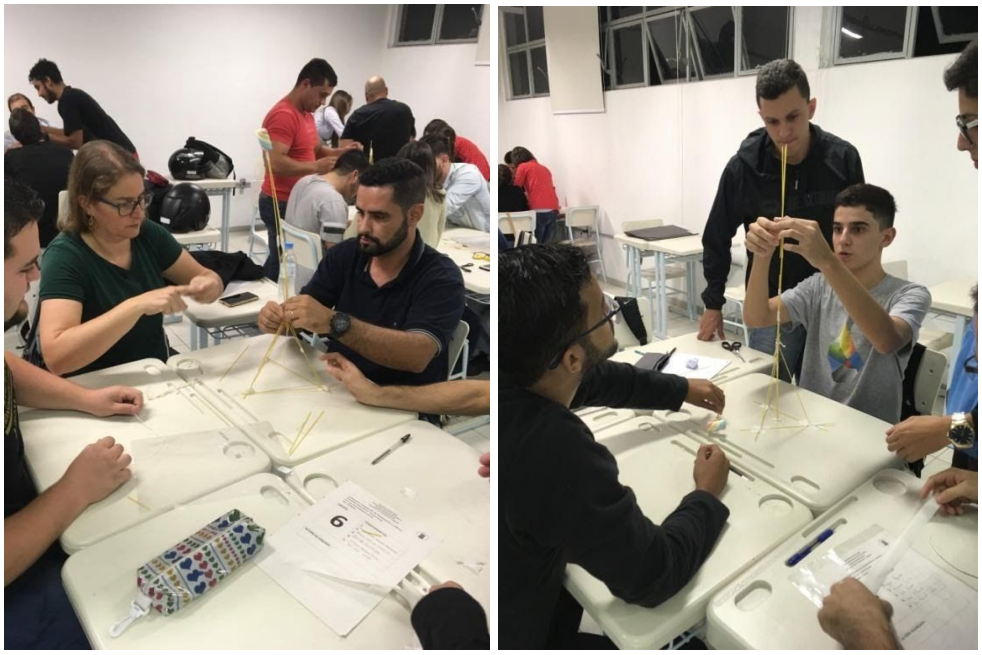


Figure 2.4.3. Transport and Logistics Engineering - Marshmallow challenge.

Site visitation: the early introduction to professional practices and experiences may retain and engage them to a better performance along the engineering program. Transport and Logistic Engineering students are usually exposed to several opportunities to participate in field visits.

Figure 2.4.4. Transport and Logistics Engineering - Site Visitation.

2.4.3 Control and Automation Engineering - Lab Tour and Motivation

The most important goal of the Introduction to Engineering Course is to present program specifics, motivate by presenting students the program skills, and share experiences of graduated Control and Automation Engineers. This is firstly accomplished by presenting and demonstrating the institution laboratory equipment and didactical experiments. Secondly, by presenting student competition teams/groups, such as: Formula SAE, Baja SAE, Aerodesign SAE and RoboCup teams. Thirdly, by presenting the entrepreneur activities of the institution, such as the business incubator, the startup companies and cases of success. And finally, promoting talks with recently graduated students that can easily communicate with students and share graduation experiences. Figure 2.4.5 illustrates some of these activities. All course goals are frequently updated and evaluated by students and alumni feedback.

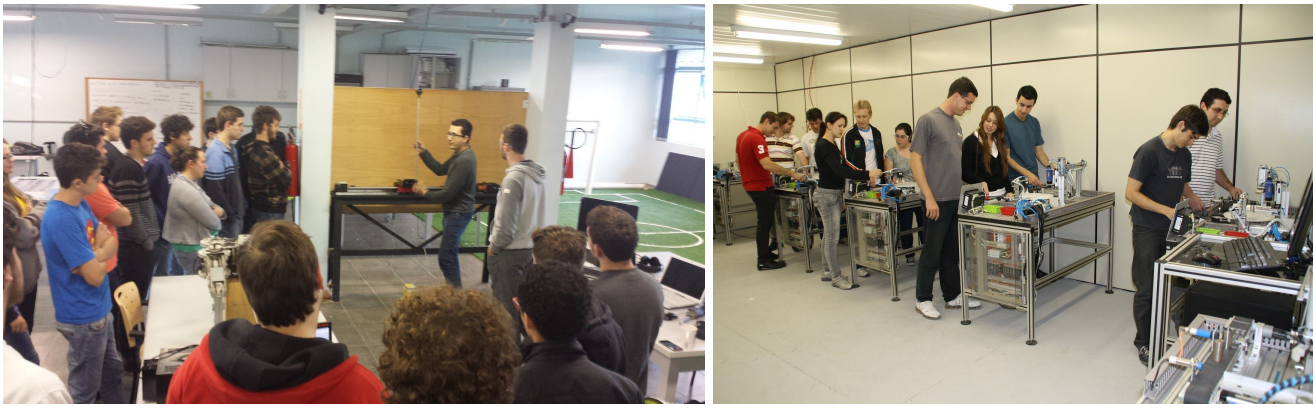


Figure 2.4.5. Control and Automation - Lab Tour and Student Presentations.

2.4.4 Aerospace Engineering - Introduction to Engineering Activities

The Introduction to Aerospace Engineering course has promoted several activities to motivate and engage new students in the aerospace technology area, to prepare them for the Program and to show them the possibilities of their future profession. This is made in two ways: in class, learning the foundations of aerospace technology and through several visits and lectures. The visits introduce students to the Aerospace engineering related laboratories, competition teams, entrepreneurship initiatives and other important partners such as the Brazilian Air Force Air Base. Within class, beyond the technical fundamentals of aerospace engineering, students learn and prepare themselves for the following CDIO courses.

Some of these Introduction to Aerospace Engineering initiatives are shown from Figure 2.4.6 to Figure 2.4.13.

Figure 2.4.6. Aerospace Engineering - Students visiting the competition teams.

Figure 2.4.7. Aerospace Engineering - Group work regarding CDIO method.

Figure 2.4.8. Aerospace Engineering - Students visiting the nanosatellite NANOSATC-BR Project ground station.

Figure 2.4.9. Aerospace Engineering - Students visiting AGITTEC (Innovation and technology transfer agency) and attending a lecture about entrepreneurship.

Figure 2.4.10. Aerospace Engineering - Students visiting a start-up (AUSTER) developed by former engineering students.

Figure 2.4.11. Aerospace Engineering - Students visiting the Brazilian Air Force Air Base, attending a lecture about UAVs.

Figure 2.4.12. Aerospace Engineering - Students visiting the Brazilian Air Force Air Base, having a introduction to the Black Hawk helicopter.

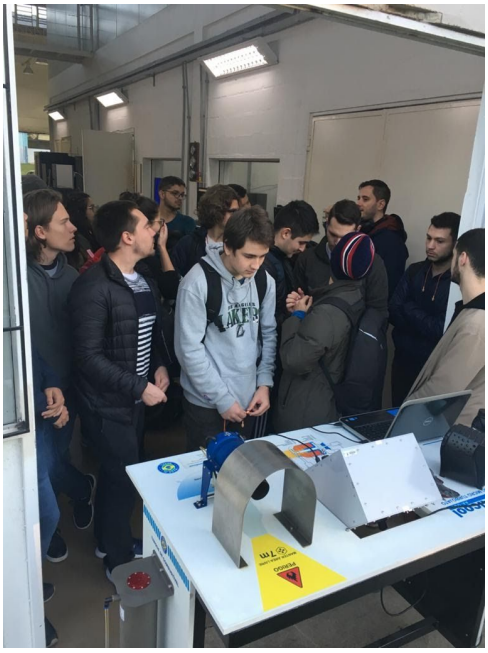


Figure 2.4.13. Aerospace Engineering - Students visiting the Motors Laboratory - LABMOT, watching a propulsion educational bench experiment.

2.5 Standard 5 - Design and Implementation Experiences

All Engineering Programs have the completion of program assignment, where the advanced engineering students usually perform a project with experience in design and implementation, but can also conduct theoretical research. The projects usually have one year duration. The Engineering programs incentivize the students to perform practical engineering projects when possible.

In the new Brazilian Engineering Education Guidelines, it is mandatory to have an engineering project experience at an advanced level.

From basic to advanced engineering level, Aerospace Engineering has CDIO courses, which will be considered for other Engineering Programs in the curricular reform.

2.5.1 Aerospace Engineering - Conceive, Design, Implement and Operate courses

The Aerospace Engineering Program has four CDIO courses distributed throughout the 5 years, at the 2nd, 4th, 6th and 8th semesters (of a 10 semesters Program).

The CDIO courses introduce students, since the first year of higher education, to the professional practice of Aerospace Engineering, via extra-class research and the development projects under the supervision and guidance of a Professor. These activities qualify as a pedagogical practice centered on the student, where the Professor is a mediator. The students enrolled in the CDIO courses meet in groups focused on different Projects. The research and development topics of each group can be proposed either by the Professor or by the students themselves. The book “Rethinking Engineering Education: The CDIO Approach (Crawley, E. F. et al, 2014)” is used as a primary reference for all courses, guiding the method both for students and Professors.

The four CDIO courses integrate the four dimensions of conception, design, implementation and operation, in different degrees for each course. The depth and relevance of each dimension are defined in the corresponding course objectives, since the four courses are organized in an evolutionary approach over each following semester, through projects of increasing complexity.

It is the responsibility of the CDIO professor to define the criteria, abilities, concepts and results to evaluate students according to the course level. Beyond guiding technical, managerial, personal and interpersonal skills, the advisors also motivate groups to publish their CDIO work through Workshops, congresses, articles and other means.

Some CDIO course project reports are available here:

https://www.ufsm.br/cursos/graduacao/santa-maria/engenharia-aeroespacial/trabalhos-concluidos-de-cpio/

Results of the implementation of the CDIO approach in Aerospace Engineering have been published in the First Brazilian Aerospace Conference:

André Luis da Silva, Marcelo Serrano Zanetti. Implementação do Método de Ensino CPIO no Curso de Engenharia Aeroespacial da UFSM. Anais do 1° Congresso Aeroespacial Brasileiro. Available at: https://www.ufsm.br/app/uploads/sites/426/2020/10/Artigo-CAB-Implementacao-do-Metodo-de-Ensino-CPIO-no-Curso-de-Engenharia-Aeroespacial-da-UFSM.pdf

Some examples of successful results of CDIO courses are depicted in Figures 2.5.1 to 2.5.5.

Figure 2.5.1. A CDIO Group designed a wind tunnel for the Aerospace Engineering Program.

Figure 2.5.2. A CDIO group designed and operated a CanSat model (nanosatellite) and won 1st Place in a Brazilian nanosatellite national competition.

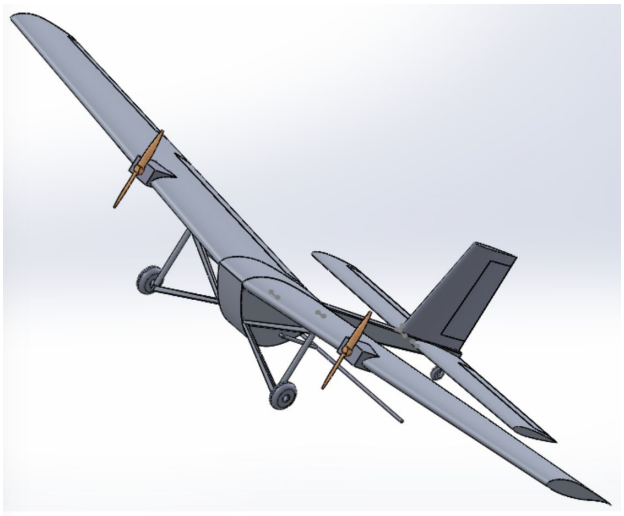


Figure 2.5.3. A CDIO Group designed an UAV for agricultural spraying.

Figure 2.5.4. CDIO group performing experiments on the optimization of solid propellant for rockets.

Figure 2.5.5. CDIO group designed and implemented a quadcopter.

2.5.2 Electrical Engineering (CT and Cachoeira do Sul Campus) - Electricity and Electronics Workshop

The Electrical Engineering program has the optional introductory course called “Electricity and Electronics Workshop” (Oficina de Eletricidade e Eletrônica), offered as an optional course for beginner students. The aim of the course is to introduce laboratory equipment and develop a design-implement project of a regulated DC Power Source. In the last semester, the course project was integrated with the Chemistry course, applying Chemistry principles to manufacture a Printed Circuit Board for the DC Power Source.

Figure 2.5.6 shows some photographic records of 2017 on Cachoeira do Sul Campus.

Figure 2.5.6. Electricity and Electronics Workshop on Cachoeira do Sul Campus.

2.5.3. Design-Build Competitions for Beginner Engineering Students

The university has the annual design-build competition “Spaghetti Bridges” for beginner engineering students. The objective is to make students apply concepts acquired in the classroom about material resistance and structural theory to represent small-scale bridges. The competition is open to all Engineering students and is usually considered part of the grade of Strength of Materials courses.

News about the competition can be found on:

https://www.ufsm.br/2019/06/18/competicao-de-pontes-de-espaguete-movimenta-o-ct/

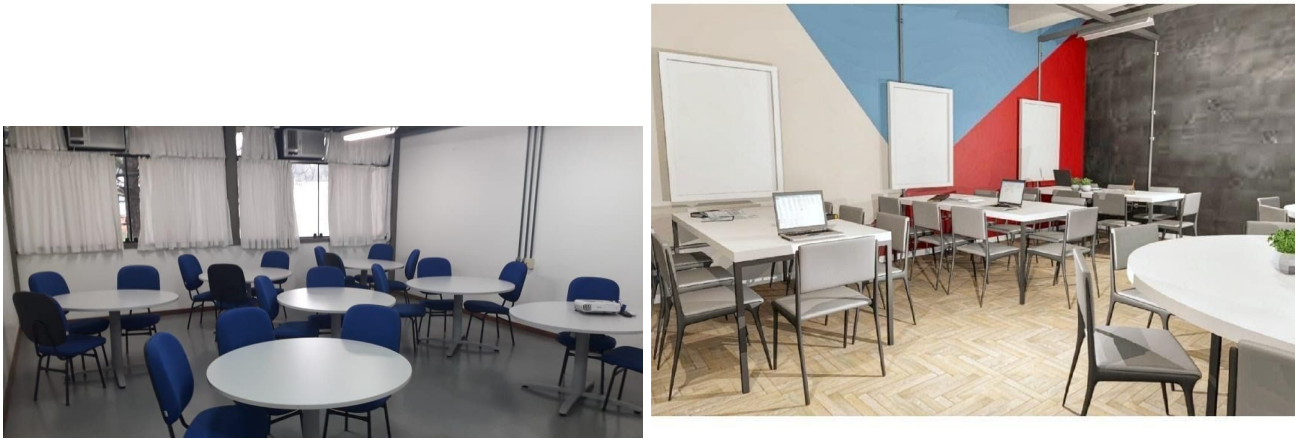
2.6 Standard 6 - Engineering Workspaces

The University has engineering workspaces and laboratories which are continuously evaluated. The workspaces are not only for the engineering classes, but also for the student groups and R&D laboratories, where the undergraduate students have access to develop engineering projects, with design-implement experiences. The following subsections show some of these spaces.

2.6.1 Coworking and study rooms

The Center of Technology features a coworking space, a sectorial library with two study rooms (one for individual studies and another for group studies), in addition to the central library of the institution that also has spaces for study. Engineering students can access e-books, as well as printed books, both through the Library Portal (https://portal.ufsm.br/biblioteca/pesquisa/index.html) and through the Discovery Service (https: // www. ufsm.br/orgaos-suplementares/biblioteca/servico-de-descoberta/). The Portal has an “electronic resources” tab, and there are included the main bases that UFSM signs, with Wiley being one of the most accessed in the engineering area at the moment. Figures 2.6.1 to 2.6.12 show photographs of some of these spaces.

Figure 2.6.1 - Coworking Room in CT.



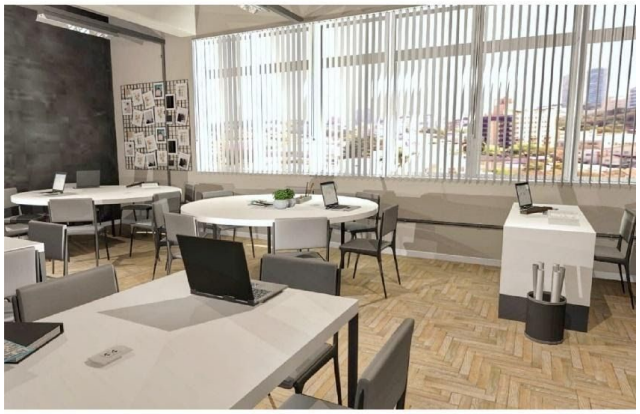


Figure 2.6.2 - CT Classrooms designed for active learning (flipped classroom).

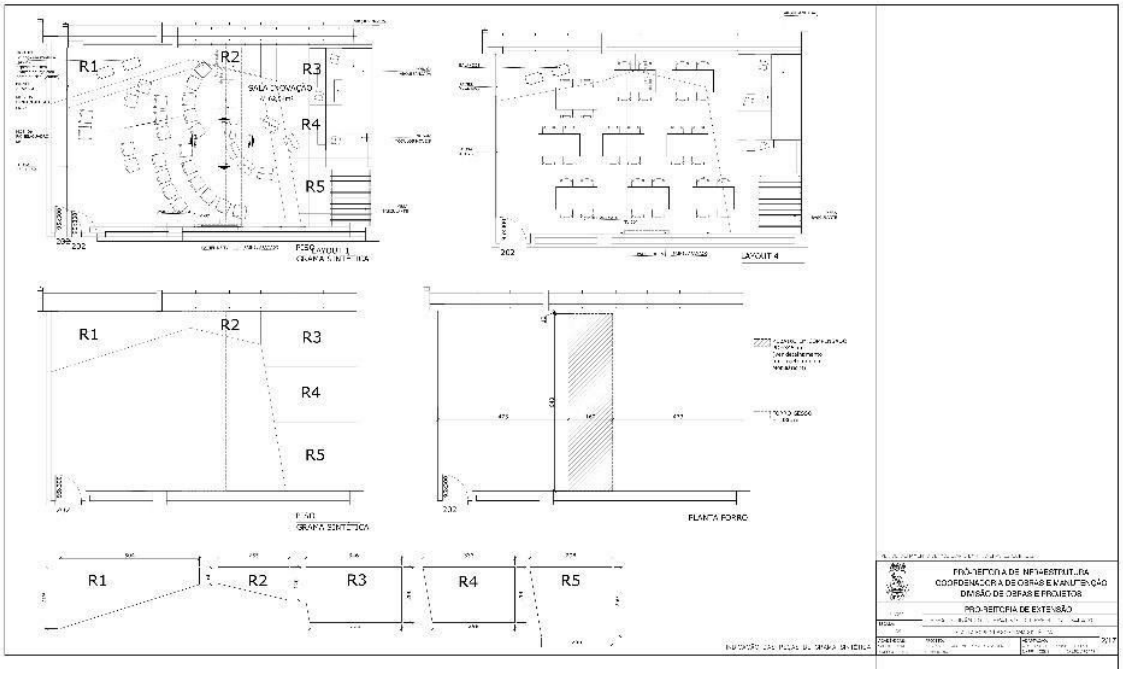


Figure 2.6.3 – Innovative Classroom that will be opened in 2021. Project is being implemented.

Figure 2.6.4 - Libraries at UFSM.

The Innovation and Technology Transfer Agency (AGITTEC) has a Coworking Room where the course “Entrepreneur Attitude” is developed: an interdisciplinary course opened to all students in the university, aiming to create new business and start-ups.

Figure 2.6.5 - Coworking room AGITTEC - “Entrepreneur Attitude” course

2.6.2 Laboratories

The Center of Technology has many Engineering laboratories opened for classes and for development of undergraduate engineering projects. Production, Automation, Electrical, Electronics, Telecommunications and Aerospace Engineering laboratory courses are developed in the Electrical Engineering Research and Development Nucleus (NUPEDEE), which currently has 16 laboratory and project development rooms. The NUPEDEE workspaces have dedicated staff to offer total support for students and faculty for laboratory activities and project development. Also, the spaces of NUPEDEE are

frequently evaluated and redesigned considering occupation data and equipment use. Room and equipment booking, laboratory schedule and evaluation reports are available at NUPEDEE website (nupedee.ufsm.br).

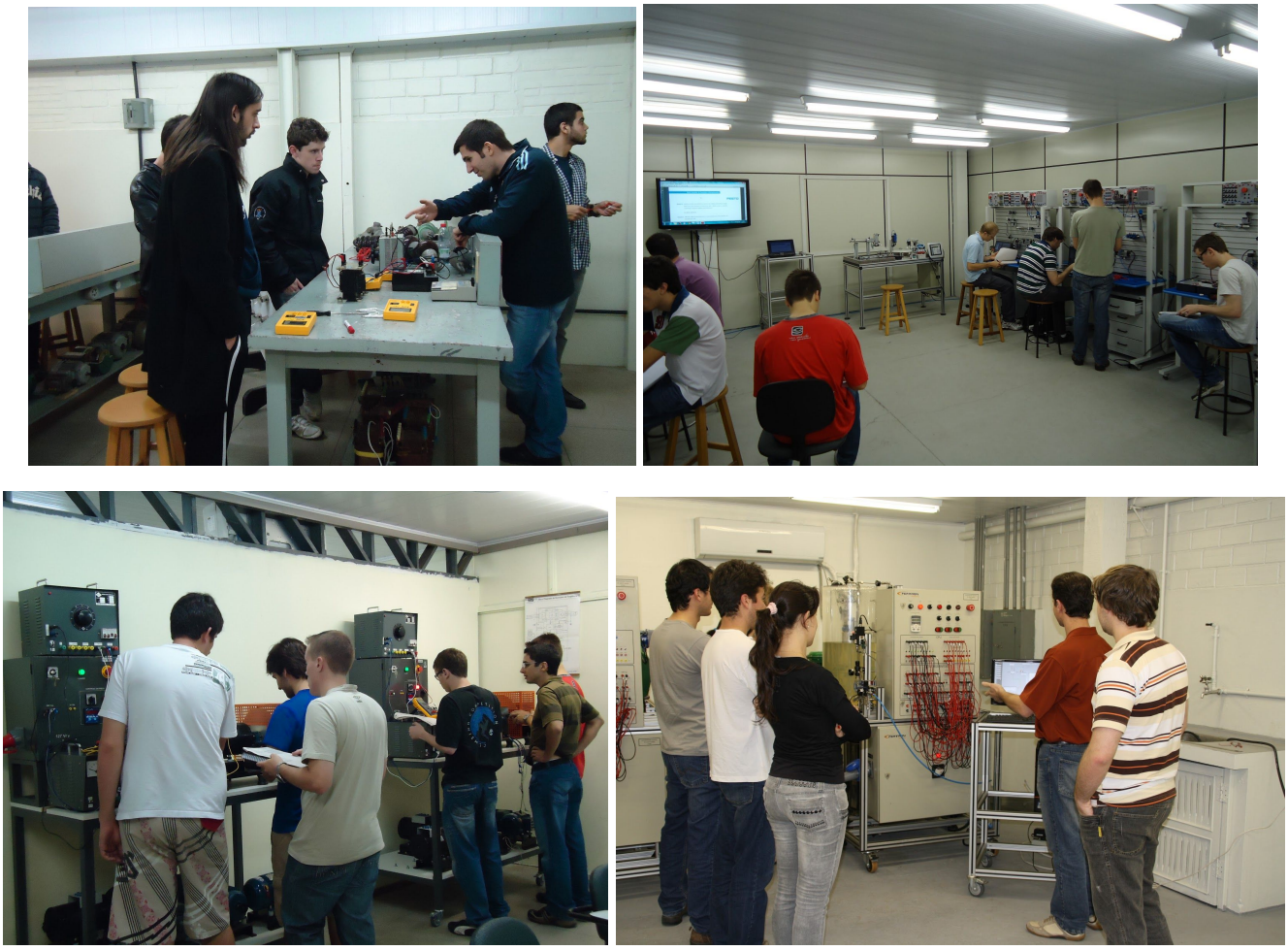


Fig. 2.6.6 - Some NUPEDEE Laboratories.

In addition to NUPEDEE the Acoustics and Vibrations Lab., belonging to the Civil Construction Materials Lab. (LMCC), supports all practical activities developed in projects and disciplines of the undergraduate program on Acoustic Engineering, in addition to collaborating with undergraduate and graduate program in Civil Engineering.

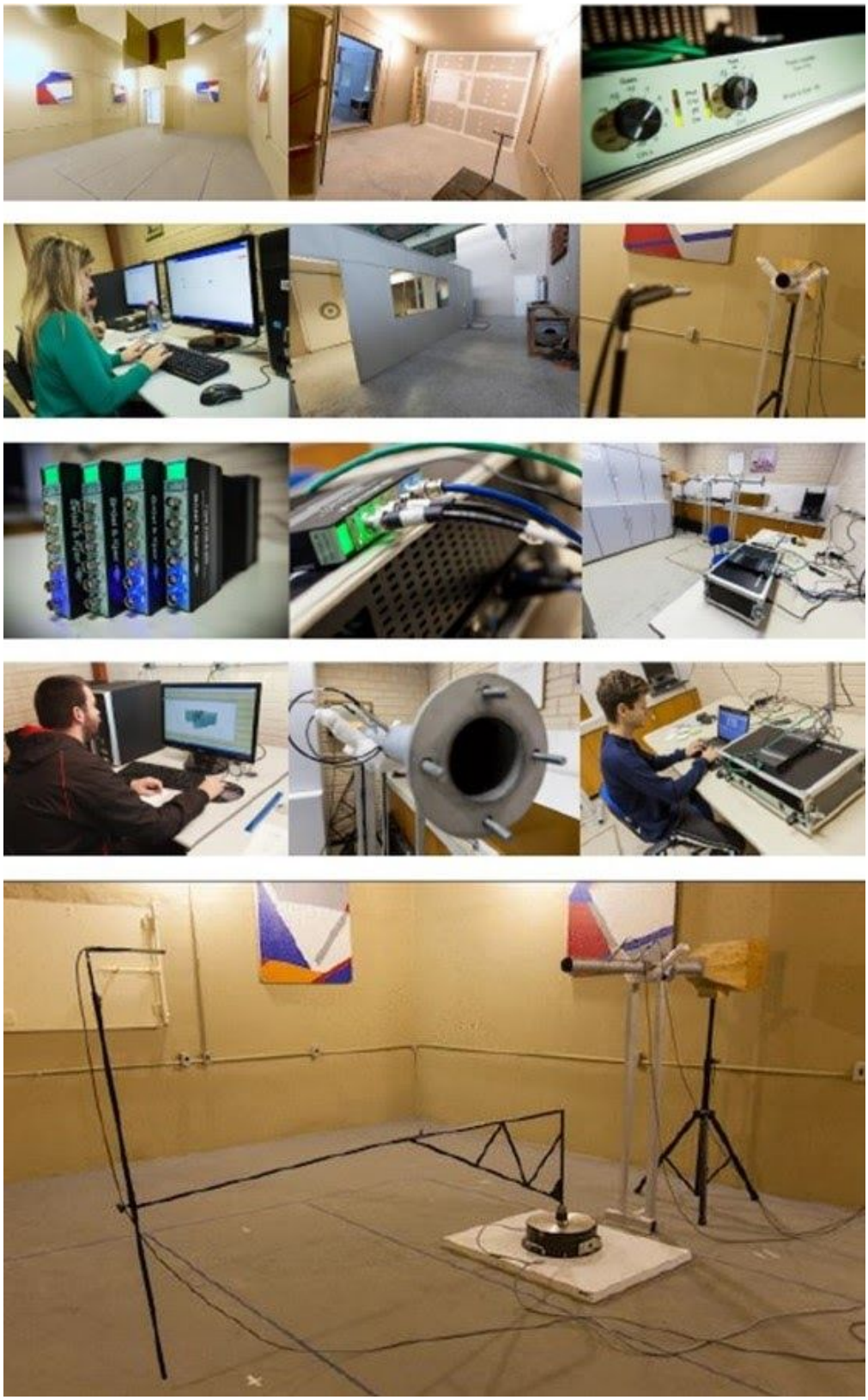


Fig. 2.6.7 - Tests performed in the Acoustics and Vibrations Lab.

2.7 Standard 7 - Integrated Learning Experiences

The engineering students have dozens of opportunities with integrated learning experiences. Some opportunities are shown in the subsections below.

2.7.1 Competition Teams

The Center of Technology has competition teams that integrate students from multiple Engineering Programs. The current competition teams are described in the following:

Rocket Design Team: by the initiative of the students themselves, a rocket design team was formed to foster activities aiming participation in rocket design competitions. The team is called RocketLab, and it is composed of students from different programs in engineering and exact sciences, including aerospace, automation and control, electrical, mechanical and physics. The students receive faculty support, in terms of supervision and financial means for the development of systems and prototypes. As a recommendation of its supervisor, the team is adopting methodology for Systems Engineering and Project Management in order to improve performance and to speed up prototype development cycle. This includes adopting the CDIO as a guideline for development, and the use of project management software to allow for delegation and to keep track of tasks and activities. Figure 2.7.1 depicts the students preparing for the testing of a rocket engine.

Figure 2.7.1. Students preparing a rocket engine for a static test.

The team is getting ready to fly its first prototype, and it is formally registered within the faculty. Therefore this initiative is an ongoing project and it shall remain active as long as there are students and supervisors interested in rocket design.

- Is related to courses taught: yes (many courses from the program in Aerospace Engineering program are directly related)
- Is related to outreaching activities: yes (we are planning activities to introduce the subject to primary and secondary school students)

The students are closely followed by the faculty supervisors in order to enforce considering safety as a number one priority, and are encouraged to work out personal differences within the team, besides being taught to adopt best practices in project management.

Carancho Aerodesign Team: the Carancho Aerodesign Team has 16 years of experience representing UFSM in the SAE BRASIL Aerodesign competition. Throughout the year, the members set up teams to develop, design and construct an Unmanned Aerial Vehicle (UAV), according to the limitations imposed by the competition rules for the year, aiming to carry as much cargo weight as possible. The team has 50 members that are divided in 7 sectors; Aerodynamics, Stability and Control, Performance, Electrical project, Loads and aeroelasticity, Structures and structural tests and computer aided design (CAD). The competition teams, formed by undergraduate students, gather in São José dos Campos, to present their techniques, development and research in reports and presentations, as well as to put the built UAVs to the test in the flight competition.

Some figures below illustrate the project. Figure 2.7.2 presents some student members during the flight test in the UFSM main campus. Figure 2.7.3 presents the Carancho team and their two model airplanes in the competition of 2019. Figure 2.7.4 presents a student during the assembling of a wing.

Figure 2.7.2: Preparation for a flight test.

Figure 2.7.3: Carancho team at the SAE Aerodesign competition of 2019 in São José dos Campos – SP.

Figure 2.7.4: Student assembling a wing.

The Project receives students from many Engineering Programs, especially Aerospace and Mechanical Engineering. Partnerships with other competition teams from the university, as Formula and Baja, are common, with the share of materials, tools and knowledge. A partnership has also been made with the Jr. company Projep Jr. in 2018, to improve and professionalize the internal structure and culture of the team. Internal feedback is constant during the year and the development of the project, specially between integration and sector managers, with individual meetings and conversations. Participants are not graded by the team, corrections and suggestions are communicated through constructive criticism. After the competition, lessons learned forms are fulfilled by all participants and debated in community, guiding the changes and corrections necessary for the next year project success.

Fórmula Team: is recognized as one of the best in the country in the Formula SAE Brasil competition. The team represents UFSM designing, developing, building, testing and competing with open-wheel single-seater vehicles.

Website: https://formulaufsm.wordpress.com/

Bombaja SAE Team: this team participates in the Baja SAE competition. The team started its activities on April 4, 2003. Despite its focus being Mechanical Engineering, students from other programs participate: Production Engineering, Electrical Engineering, Computer Science, Computer Engineering, Business and Public Relations. The team is configured as a company and is based on three principles: develop pride in being a student and represent UFSM, develop entrepreneurship and the ability to work as a team. Bombaja defines itself as a parallel training program in the UFSM environment.

News: https://www.ufsm.br/2019/12/09/equipe-bombaja-conquista-o-1o-lugar-em-competicao-baja-sul-2019/

SpaceLab Team: With the growing demand for qualified professionals to work in the Brazilian Space Sector, as well as the growing use of nanosatellites for various applications and the great potential of this class of satellites for the Brazilian Space Program, national student nanosatellites competitions were created. In these competitions, engineering students go through all phases of the development cycle of space systems until they obtain the system that will be used in the competition. The Federal University of Santa Maria started its activities with competition nanosatellites in the 2nd Semester of 2019, through the CDIO course, and obtained the 1st Place in the CanSat category of the CubeDesign competition, organized by the post-graduation school of the National Institute for Space Research (INPE). This competition team objective is to centralize and consolidate UFSM's initiatives to participate in the main national nanosatellites competitions, promoting aerospace engineering theoretical and practical experiences through nanosatellites projects, spreading the aerospace culture to UFSM students and professors. The figure 2.7.5 shows the SpaceLab team building a CanSat and presenting the project to the competition judges.

Figure 2.7.5: Students assembling a CanSat (left) and presenting to competition judges (right).

2.7.4 Junior Companies

The University has several junior companies for Engineering Students. The junior companies aim to develop personal and interpersonal skills in the students and learn in practice about business and project management.

UFSM Junior companies are listed here: https://www.ufsm.br/pro-reitorias/pre/empresas-juniores/

Main Engineering Junior companies:

Motora Jr: works together with companies from Santa Maria and region offering consultancies in the most diverse mechanical areas, such as Machine Development, Industrial Automation, Industrial Exhaustion and Digital Modeling / Technical Design.

Projep Jr: is a junior company in the production engineering sector which mainly operates in the segments Quality Company, Layout and Safety. In addition to carrying out projects under the tutelage of several specialist teachers in the aforementioned areas, it also carries out open scope projects linked to the management of production lines for products and services

Automatiza Jr: works in the area of automation projects such as access control, intelligent lighting and automation consulting. The junior company accepts student members from all areas, aiming to provide experience on projects, management and entrepreneurial culture.

Website: https://www.automatizajunior.com.br/

Base Jr: junior company of civil engineering and architecture that performs branch projects: architectural design, electrical design, sanitary, estate settlement, residential and commercial interior design. Our members receive training to develop and sell projects. Internal management activities are entirely carried out by the members, who are assisted by construction industry professionals.

Compact Jr: aims to develop solutions in computer systems, having students of Computer Sciences, Information Systems and Computer Engineering. The company develops websites, web or desktop systems and applications to optimize processes. Founded in 2015, it

ITEP-Jr: develops solutions in the areas of Strategic Management, Production Management and Economic-Financial Management. It is linked to the Production Engineering Program.

Meta+: Junior company created by students of the Mechanical Engineering course of Cachoeira do Sul Campus that aims to apply the concepts through providing services to the city and region community. It is currently registered as an extension project linked to the course. Among the services offered by the company are: CAD drawing; Project development; Maintenance Management; Organizational Management; People management; Industrial management; Stock Organization; Process optimization; Production costs; Areas related and related to Mechanical Engineering.

Acústica Jr. : Junior company in the process of creation, comes to unify and assist existing projects, promoting greater union and dissemination of knowledge, in addition to seeking the constant realization of more projects focused on the acoustic industry. *Acústica Jr*, a junior company in acoustic services, fits into the concept of junior companies and, since 2018, when the proposal came up, an initiative of the students of the Acoustic Engineering Course (EAC), has been working on its formation and consolidation, seeking student and teacher support and winning stages for legal approval of its existence to open in 2020, considered the international year of sound and the year in which the Technology Center and the UFSM complete 60 years. Among the main skills and competences developed by the company's activities are empathy, technical responsibility, research, coordination, direction, supervision, and guidance in the business administrative sphere. In the professional field, the company seeks to develop in its associates the study and improvement of knowledge and techniques through the practice of projects aimed at raising awareness about acoustic comfort, acoustic comfort of mechanical, electrical and electronic equipment, acoustics and sound in indoor and outdoor environments. To accomplish acoustic consultancy, insulation quality, building acoustics in general, importance of using PPE's, acoustic projects for institutions such as UFSM, acoustics vehicles, acoustic materials and devices, acoustic recording, emission and recording equipment, works related to acoustic standards, promotion of lectures, short courses and industry events, sound pressure level measurements and insulation and acoustic comfort assessments. Among the activities developed until then, *Acústica Jr* has invested in the training and development of the team and investigated the feasibility of offering courses and events to the academic community. The promotion of knowledge in the area of acoustics and vibrations, combining theory and practice, benefiting the training of students and serving the community, has received support from UFSM, the EAC Course and the Nucleus of Junior Companies of Santa Maria (NEJSM). The *Acústica Jr* has as main objectives: dissemination of the EAC; promoting the integration and expansion of the contact network; combating the evasion rate; gain experience with the market in the area; and promoting learning and practical realization of what is seen in the classroom.

Results already achieved by *Acústica Jr*:

1. Acoustic meetings: support and lecture by Eng. Renato Cipriano; complementation and exemplification; and practical experience.
2. Lecture of *Acústica Jr* in the 3rd Academic Week of EAC.
3. NEJSM “most participative” award.
4. First sale and realization of the project: reduction of household noise at low cost.
5. First selection process: entry of new members.
6. Live on the Special Home Exercise Regime (REDE). of UFSM; welcoming new students; and assistance to veteran students.

Lecture of *Acústica Jr* in the III Academic Week of EAC (2019).

Participation of members of *Acústica Jr* in NEJSM event (2019).

Live welcome, with the coordination and secretariat of EAC, for new students of EAC (2020).

Lecture by engineer Renato Cipriano.

2.7.5 Tutorial Education Programs

The Center of Technology has two Tutorial Education Programs (PET): PET Electrical Engineering and PET Civil Engineering. The PET is a governmental program to improve education of the students members of the PET and create projects to improve all the Engineering Program. A PET group

is composed of a tutor professor and 12 to 18 undergraduate students, who develop research, education and outreach projects. Many current faculty members are alumni of the PET groups. One of the most importants PET activities is to evaluate possible difficulties of undergraduate students and promote short duration courses to help all undergraduate students to overcome these difficulties.

Figure - Tutorial Education Program Electrical Engineering: students and advisor - 2020 Group.

Figure . Some PET courses.

Available at the PET Youtube channel:

https://www.youtube.com/channel/UCBEYpCQ4ruNVIHnAUV5Gmug

2.7.7 IEEE Student Branch UFSM

The IEEE (Institute of Electrical and Electronic Engineers) is the largest professional organization in the world, covering professionals from all areas of Electrical Engineering. UFSM has an IEEE Student Branch (IEEE-SB) with 4 groups: Industry Applications Society (IAS) Chapter; Power and Energy Society (PES) Chapter; Robotics and Automation Society (RAS) Chapter; and Women in Engineering (WIE) group.

The student branch promotes projects aiming to disseminate knowledge among students of electrical engineering areas (Electrical Engineering, Control and Automation, Telecommunications, and Computer Engineering Programs), also opened to other areas. Some of the initiatives that are carried out are lectures and software workshops, such as Altium, Matlab and Proteus. Besides, technical/cultural exchanges were promoted between students from Germany and Brazil, an educational model was also developed with focus in Smart City, in which undergraduate students developed their knowledge in renewable energy, electronics and energy storage.

During the conference ISGT 2019, the student branch organized an IEEE Humanitarian Event, the IEEE PES Lighting for Humanity, based on several panel sessions and on a practical training provided by the Liter of Light. The Liter of Light organization develops poles and lampions in a sustainable way, utilizing plastic bottles, solar panels and LED lamps, applying it in communities with a restricted or non-access to electrical energy. The Liter of Light idea has gained strength through its characteristic of being cheap, sustainable and clean solution for these locals that have not access to electrical energy, a very common reality in Brazil, due to its long extension. During this humanitarian training, kits of poles and lampions will be built by the STA students, as well they will be able to understand the impact that the light can provide to a community that has no access to energy.

In 2020, due to the coronavirus pandemic, the branch has migrated its activities to virtual environments, thus, lives were made aiming to inform students on several subjects, such as mental health, photography, professional skills and home office. A week of virtual workshops was also held, in which the focus was to spread knowledge in several technical areas of electrical engineering, with lectures that address the handling of various software that are used in engineering courses.

IEEE-SB UFSM Youtube Channel:

https://www.youtube.com/channel/UCNvOJBRP7k6qP6SgP-mWKrw

Fig. 2.7.iu. IEEE Student Branch UFSM during IEEE Day 2018.

Fig. 2.7.d - IEEE PES Lightning for Humanity Event during ISGT LA 2019.

Source: https://site.ieee.org/pes-enews/2019/10/29/ieee-pes-lighting-for-humanity/

2.7.8 Transport and Logistics Engineering - Public outreach and community engagement in Design-Implement experience

The Transport and Logistic Engineering program has developed the project “PEDALA KIDS - Developing cities through kids perception”, fostering the interaction of children with urban mobility and the urban space, thus contributing to their citizen formation through playful activities in the schools and also practical activities based on the use of bicycles. From the public outreach perspective, local communities have been invited to participate in events that promote cycling among children. The project aims to raise the discussion on sustainable urban mobility and prepare future generations for safe cycling.

Figure 2.7.e . Pedala Kids project.

Following a framework for product design, the undergraduate Mechanical and Transport and Logistics students were challenged to design and build a lightweight balance bicycle using recycled materials. Best design considering technical requirements were evaluated by a set of specialists, but aesthetics and handling were also evaluated by final consumers: kids. In total, nine prototypes for balance bicycles were presented.

Figure . Pedala Kids Project: the Conceiving, Designing, Implementing and Operating approach.

2.8 Standard 8 - Active Learning

The active learning is incentivized with frequent workshops and faculty training, described in Section 10. Some actions are shown in the subsections below.

2.8.1 Publication of disciplinary course assignments - “Space Exploration”

As part of the grading for the elective course "Space Exploration", within the Aerospace Engineering undergrad program, the students were required to form groups and to work on a paper in a topic related to the syllabus of the course. Additionally, with no impact on grading, the students were encouraged to format the respective paper according to the submission guidelines of the II Brazilian Aerospace Conference (II CAB) in order to allow for a submission. Many groups had their papers accepted for publication and presented the work during the event that took place between 16-19 September in 2019, as shown in Figure 2.8.1.

Figure 2.8.1. Students presenting a work during the II CAB. Oral communication (left), poster (right).

As the first offering of the course took place in 2019, and with the covid-19 pandemic impacting on events worldwide, this initiative was implemented only once. However, it should take place at every subsequent offering of the course, and should not be restricted to other editions of the CAB: we will point to different conferences and journals as well.

- Is related to courses taught: yes (Space Exploration)
- Is related to outreaching activities: no

Besides the grading for the class work, the students submitting a paper to a conference or a journal receive invaluable extra feedback from the peer-reviewing process, and also from the audience

when performing oral or poster presentations. This allows for improvement in technicalities of the project, and how it is presented.

2.8.2 Project Based Learning and Gamification in Programming course

Algorithms and Programming is a course taught to the first semester students in many engineering programs. Being the first contact in computing for most of the students, it is a challenging subject. The course has as objectives teaching computational thinking and “C” as the first programming language the students must learn. At the beginning of the course the students are shown all the potential related to learning this technology, and one example that appeals to most of them is computer gaming. Therefore, at the end of the semester the students are asked, as part of the grading, to develop a computer game, including sound reproduction and a graphical interface, while the programming logics must encompass most of the syllabus of the course. Besides the interest in game programming, the integrative project also promotes gamification strategies through the establishment of a “Hall of Fame” conceived to stimulate students in achieving their best performance. Figure 4 presents screenshots from a computer game developed by students.

Hall da Fama: Algoritmos e Programação

Hall da Fama dos **jogos** criados pelos alunos que cursaram as minhas turmas da disciplina **ELC1022 Algoritmos e Programação** na UFSM. As turmas são de **primeiro semestre**, enquanto que os jogos foram escritos em **C**, utilizam a biblioteca Allegro e rodam no **Windows**.

2016.1 Eng. Aeroespacial	Tank Football	Bruno, Christian e Daniel
2016.1 Eng. Telecomunicações	Air Combat Training	Fabiano e Leonardo
2016.1 Eng. Telecomunicações	Pong Wars	Adrion, Angelyca, Christian, João e Marcelo
2016.2 Eng. Elétrica	Jogo da Velha	Chrystian
2016.2 Eng. Elétrica	Aluno	Kenedy e Rodrigo
2017.1 Eng. Aeroespacial	Mexicnyan	João Pedro e Kaique

Figure 2.8.2. A game created by first semester students of an introductory programming course (top row). The hall of fame listing the best projects done by the students, since 2016 (bottom row).

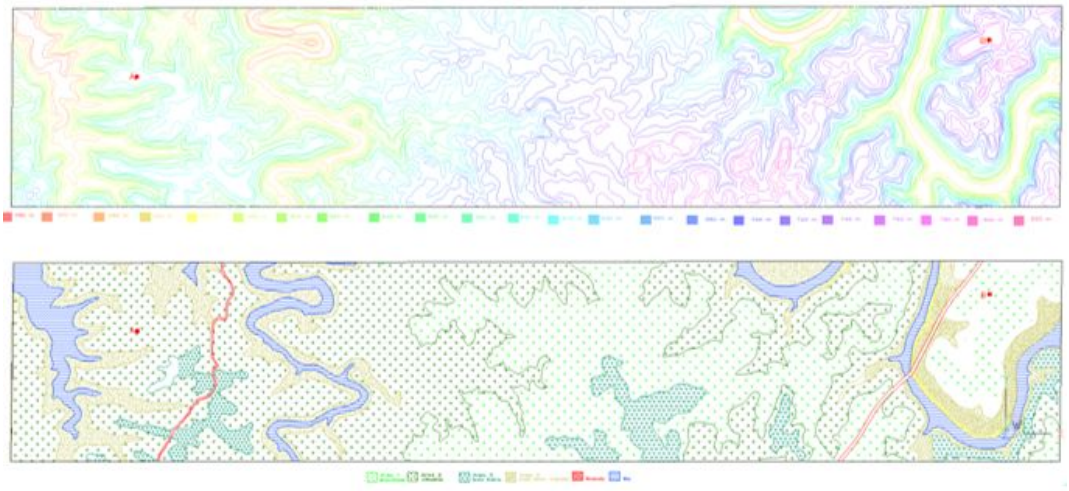
This initiative was initiated in 2016, and it is successfully repeated every subsequent semester.

- Is related to courses taught: yes (Algorithms and Programming)
- Is related to outreaching activities: yes (the students could organize outreaching course in programming and computer gaming)

The focus on computer gaming is just the means to reach an end: having a solid base in programming. With the knowledge and good command of a computer language the students can achieve much more along the duration of their programs. As an example, an Aerospace Engineering student that attended the course, using the same libraries that were employed in game programming, could develop the graphical interface of a glass cockpit from scratch. Finally, the integrative project is done in a group and must be presented to the lecturer: therefore they practice team working and presentation skills.

2.8.3 Project based learning - Power Transmission Line Project

Executed within the course “Power Transmission Lines” of the Electrical Engineering program, this project involves multiple CDIO syllabus. The objective of the project is to conceive and design a power transmission line of about 30 km, in a team of 4 students, evaluating characteristics of the terrain, types of towers, conductors and hardware. It is necessary to conceive the allocation of the towers, cable traction, and material costs, foundations, right-of-way, line capacities, etc. Environmental impacts must also be assessed, considering the vegetation map. A complete budget must be submitted, with due justification for the choices made, including the energy losses in a 30 years period. The students are assessed not only by the design, but also by their written and oral skills and interpersonal skills within the team.



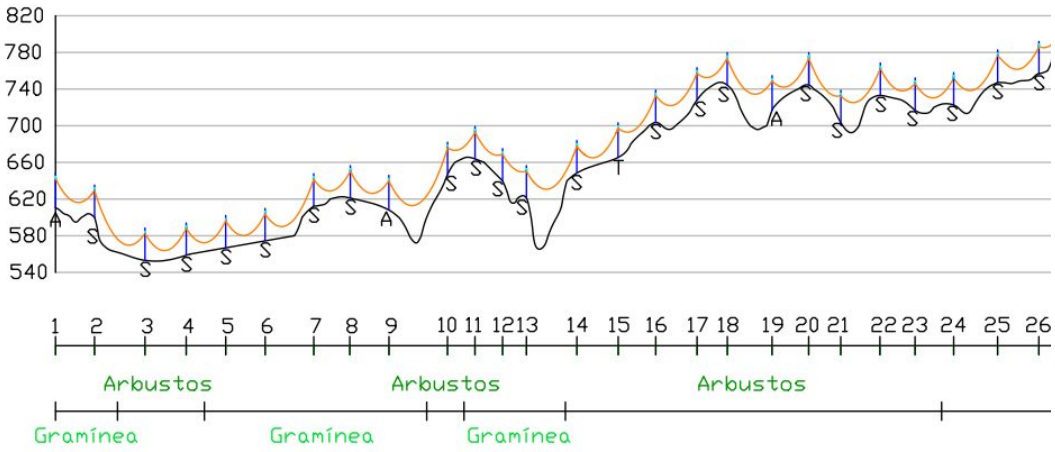


Figure 2.8.3. Power Transmission Line Project

2.8.4 Numerical methods course in acoustics and vibrations

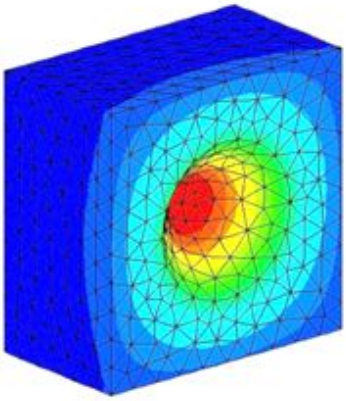
Acquire theoretical and practical knowledge for modeling vibroacoustic problems in general. Be able to develop computational tools in finite elements, boundary elements and statistical methods. This is a course that serves as the basis for several other courses in the acoustic engineering program, such as the subject “speakers box”. It also serves to establish the knowledge acquired in room acoustics, noise control, vibration control, buildings acoustics. The acquired concepts can be used widely for introduction to the job market, as in aeronautics, automobiles or buildings. Students are instructed to build their own numerical codes and tools (from start to end) and thus analyze a real vibroacoustic problem (an acoustic room, the internal cavity of an automobile), or any situation of interest. The course includes Finite Elements Methods for acoustics and vibrations, Boundary Element Method for vibroacoustic, Geometrical Acoustics and Energy Statistical Analysis. The students are required to program the computer to obtain desired responses for each technique. They can use a programming language of their choice (such as Matlab and Python).

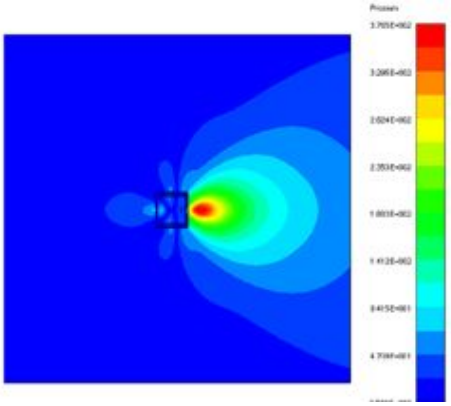
The basis of other subjects in the Engineering Acoustics program (such as room acoustics, noise and vibration control, experimental methods in acoustics and vibrations) are explored and reinforced in numerical methods for acoustics and vibration. During the course students have to develop small or great pieces of computer program to perform vibroacoustic analysis of real problems or theoretical aspects of the course (rectangular or complex rooms, vibrations of plates and beams, porous absorbers etc.). This comprises a good complement to the theoretical part, which is very complex and abstract.

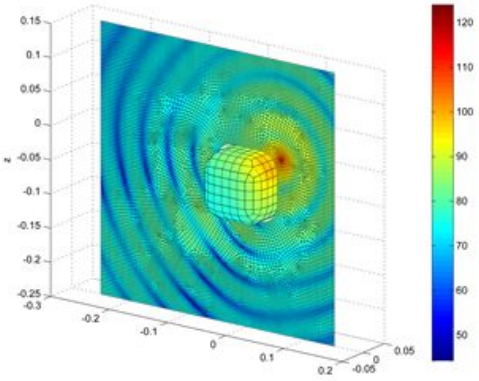
Complex mathematical derivations are made with the help of the professor with focus on arriving at important parts that will actually be used in the coding problem. Each student has the arbitrariness to

program in the way that is most convenient, allowing for creativity. Important programming steps are instructed by the professor with the use of open software for CAD and mesh generation.

Each semester the professor always looks for computational news and new possibilities of simulation related to acoustics and vibrations. In addition, there is a growing demand and the emergence of new simulation software (free of charge), which allows much greater freedom for the teacher, the student or the university to establish knowledge in the area and even later use it as a daily work tool without relying on high-cost commercial software in times of crisis. New computational techniques for vibroacoustics simulation have been studied and presented to students. Students' learning is assessed through theoretical tests and projects. The feedback is given through the evaluation of the results of the reports presented, always in comparison with some experimental or theoretical aspect, for validation. Every semester the professor is evaluated by the students, so new ideas and suggestions are put in practice next semester. Every semester the professor is evaluated by the students, so new ideas and suggestions are put in practice next semester.







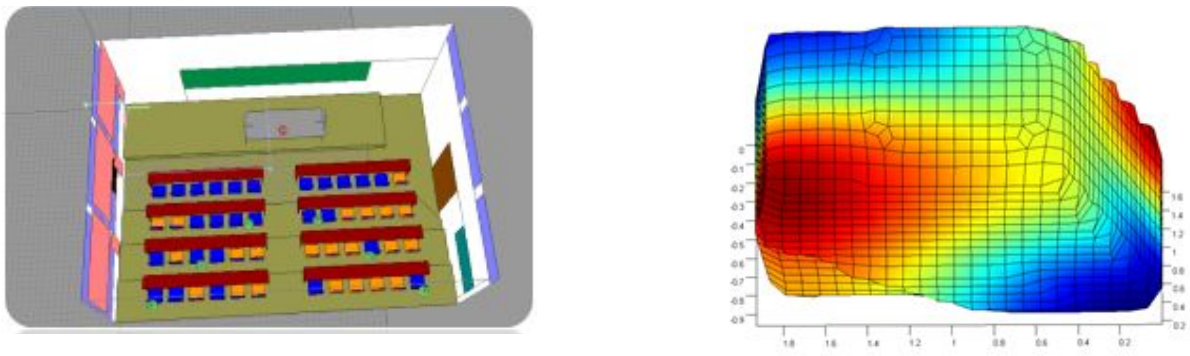


Figure 2.8.4. Examples of vibroacoustic simulations performed in the course of numerical methods in acoustics and vibrations.

2.8.5 Room Acoustics course

To acquire theoretical and practical knowledge on the sound propagation inside rooms. To be able to design spaces with adequate acoustics. We develop the basis used in other subjects that come later in our program, such as in Auralization and Psychoacoustics. The course consists of the theoretical lectures and a final large project. Students must apply knowledge of each unit in the development of each project phase.

The design of a non-existing room is a task accomplished by research and computer modelling. In that regard, part of the work on this course is accomplished through programming languages (this includes some computer modelling of room acoustics, the behavior of sound absorbers and post processing of computer simulation done in a commercial software). Also, the course uses ODEON, a commercial software for 3D simulation of the sound field using geometrical acoustics. As a research institution we also developed our own geometrical acoustics code, which can be seen at https://journals.sagepub.com/doi/abs/10.1177/1351010X20964758.

We develop the basis used in other subjects that come later in our program, such as in Auralization and Psychoacoustics. Also, students are encouraged to contact design offices in order to acquire knowledge from acoustical consultants on the final project they are supposed to do.

During the course students have to develop the acoustical design for a room of their choice. They receive general guidelines such as room type, volume, floor area and/or number of attendants. The final project is comprised of 5 phases: 1) research on what are the relevant parameters and their target values for the chosen room; 2) Design of computer models to predict the behavior of sound absorbers (students must program their own routines); 3) Calculations and design targeting the low frequency behavior of the room; 4) Calculations and design considering a statistical behavior of the room (reverberation time with

and without acoustic treatment; 5) Calculations and design using geometrical acoustics and 3D modelling (industry standard). Finally, experiments are also carried out in integration with other courses (e.g. Auralization).

Students' learning is assessed through theoretical tests and at each stage of the final project. Feedback is given on the main errors of the theoretical tests, so that their cause is corrected. Also, the feedback given at each stage of the final project usually leads to improvements shown in the next stage.

2.8.6 Digital signal processing course

To acquire theoretical and practical knowledge on signal processing applied to audio, sound and vibration. To be able to develop signal analysis tools. This is a course that serves as a base for several other courses in the acoustical engineering program.

The course consists of several small projects. Students must apply knowledge of a unit in the analysis of real signals and linear time invariant system measurements. The projects in this course are related to: 1) Waveform manipulation; 2) Continuous spectral calculation of fundamental signals; 3) Understanding sampling and quantization; 4) Understanding the use of the Fourier transform in realistic signals; 5) Using statistical signal processing for analysis and system estimation. All projects are small, but students are required to program the computer to obtain desired responses. They can use a programming language of their choice (such as Python). We develop the basis used in other subjects in the Engineering Acoustics program.

During the course students have to develop small pieces of computer program to perform signal analysis of each of the theoretical aspects of the course. This comprises a good complement to the theoretical part, which is very complex and abstract. The lectures are a mix of expositive, but with a sequence of questions that force the students to deduce, on their own, the most important concepts. In the most important parts, they are also required to produce mathematical derivations of important concepts. In this way, the professor acts as a helper and the students have more control on their own learning experience.

Students' learning is assessed through theoretical tests and at each small project. Feedback is given on the main errors of the theoretical tests and small, so that their cause is corrected.

2.9 Standard 9 - Enhancement of Faculty Competence

The faculty enhances its competence in personal and interpersonal skills, and product, process, and system building skills by participating in public outreach projects and R&D projects. Some opportunities are shown below.

2.9.1 Research groups and Post Graduation Programs

The faculty staff at UFSM has several available options for competence enhancement, such as the participation in research groups, post graduation program activities (teaching, advisoring, researching, etc.) and working on research and development projects in partnership with the industry. Those activities are not only encouraged and supported by the university, but also taken into account for career promotion.

Indeed, at Center of Technology, the academic staff is highly involved in research and development projects with the industry. The Center of Technology has currently 28 projects financed by Industry Partners (https://www.ufsm.br/orgaos-executivos/agittec/empresas-parceiras-da-ufsm/). There are eight post graduation programs: four masters (Mechanical Engineering, Production Engineering, Architecture/Urbanism and Computer Science) and four with masters and doctorates (Civil, Electrical, Chemical and Environmental Engineering) - https://www.ufsm.br/unidades-universitarias/ct/pos-graduacao. And, there are over 650 research groups at the university, being more than 100 research groups at the Center of Technology (https://www.ufsm.br/pro-reitorias/prpgp/grupos-de-pesquisa/).

2.9.2 Institutional support for university-industry partnership

At UFSM, the academic staff receives support for the engagement into research and development projects in partnership with the industry. The Innovation and Technology Transfer Agency (AGITTEC) seeks to expand and intensify institutional initiatives aimed at the dissemination of entrepreneurial culture and education; strengthen technology transfer with a focus on university-business relationships and protect the knowledge and technologies generated by the university community (https://www.ufsm.br/orgaos-executivos/agittec/).

Also, recently, the Institute of Smart Grids (INRI) of UFSM has been included as a R&D unit of EMBRAPII (Brazilian Industrial Research and Innovation Company - https://embrapii.org.br/en). Founded in 2017 by researchers associated with the Graduate Program in Electrical Engineering, INRI

aims to act in research, extension, technological development and innovation. It has a strong presence in the area of R, D & I in the electrical and industrial sector, acting on the themes of generation, transmission and distribution and energy management

https://embrapii.org.br/unidades/unidade-embrapii-em-recursos-energeticos-distribuidosinri-ufsm-instituto-de-redes-inteligentes-da-universidade-federal-de-santa-maria

2.10 Standard 10 - Improvement of Teaching Competence

Some actions to improve teaching competence are described below.

2.10.1 Center of Technology - Pedagogical Support Unit projects

The Technology Center Pedagogical Support Unit (UAP) has the objective to support faculty members, administration staff and students to improve teaching/learning processes. The UAP advises faculty members and proposes innovative education programs to the disciplinary courses. In 2016 and 2017, UAP has promoted the “Conversation with the Teacher”' project, with monthly meetings for the continuous training of professors. The project worked with themes such as entrepreneurship in the classroom, the inclusion of students with disabilities in the university context, the active learning methods, the flipped classroom, bringing experienced professors to promote the mediation of pedagogical meetings. In 2017, the UAP/CT promoted the following meetings: “Teacher Conversation: Innovative Education and the Value of Spontaneity”, with Bruno Feldens Queiroz from POINT - Creative Facilitation; “Teacher Conversation: What is it like to be at the head of a Group / Team?” with professors Cezar Beltrame (Pilot School of Chemical Engineering), Geomar Martins (Team Mulita), Gilmar Vogel (Carancho Aerodesign and Bombaja), Luiz Antônio Righi (Team Torena), Mário Martins (Formula) and Rodrigo Guerra (Taura Bots), students and administrative technicians in education who are part of the groups / teams; “Teacher Conversation: REFORMA Course”, with the mediator Bruno Feldens Queiroz from POINT - Creative Facilitation; “Teacher Conversation: Popular Engineering: how and why?”, With Professor Fernanda Santos Araújo, from the Federal Center for Technological Education Celso Suckow da Fonseca (CEFET-RJ), Nova Iguaçu Educational Unit; “Teacher Conversation: Interculturality and Education of Ethnic-Racial Relations”, with the presentation by speakers Rosane Brum Mello and Maria Rita Py Dutra from the Affirmative, Ethnic-Racial and Indigenous Actions Center, from the Coordination of Educational Actions, UFSM.

From 2018, UAP/CT is coordinating the project named “From the voice of experience to implementation” aiming to organize strategies to implement pedagogical methods. The project is based on the interchange of best practices between professors. The paper available at https://revistas.unicentro.br/index.php/aproximacao/article/view/6368/4337 (in portuguese) reports some results of this project.

News about the project:

https://www.ufsm.br/unidades-universitarias/ct/2018/12/05/primeira-professora-a-participar-do-projeto-experimentar-recebe-homenagem/

https://www.ufsm.br/unidades-universitarias/ct/2018/11/27/iniciativa-da-uap-acolhe-e-incentiva-professores-do-ct-a-testarem-novos-modelos-de-aula/

Events transmitted by web:

https://farol.ufsm.br/transmissao/transmissao-aula-prof-fatima-squizani

https://farol.ufsm.br/transmissao/transmissao-aula-prof-fatima-squizani-1

Fig. 2.10.1 - UAP/CT Staff: Celita Simões (left), administration assistant, and Simoni Hermes (right), pedagogue, Doctor in Pedagogy.

2.10.3 Institutional Actions for Improving Teaching Competence

The Pro-rectory of Graduation (PROGRAD), the Pro-rectory of People Management (PROGEP) and the Office of Educational Affairs (CAED) offer frequent training courses for all university staff.

Examples of courses:

https://www.ufsm.br/2020/08/27/ufsm-promove-curso-de-introducao-ao-uso-de-ferramentas-de-webconferencia-e-edicao-de-videos-aplicacoes-para-reunioes-e-aulas-remotas/

https://www.ufsm.br/pro-reitorias/prograd/2020/10/20/curso-para-docentes-sobre-o-uso-da-ferramenta-digital-padlet-inscreve-ate-23-10/

https://www.ufsm.br/pro-reitorias/prograd/2020/09/22/segunda-turma-do-curso-de-organizacao-e-planejamento-de-aulas-remotas-inscreve-ate-25-9/

https://www.ufsm.br/orgaos-executivos/caed/minicursos/

The statistics of training courses promoted by the University can be seen here: https://portal.ufsm.br/ufsm-em-numeros/publico/painel.html?categoria=503

2.10.4 Teaching competence assessment

The teaching competence is evaluated every semester by the students in the “Teacher assessment by the student”. The results of the evaluation are being used by the professors to improve their teaching competence. A good assessment result is an incentive for the professor's career. The

Number	Question	Related CDIO Standards
1	The course program and objectives were presented by the teacher.	2
2	The teacher fulfilled the course program.	2
3	The teacher demonstrates mastery over the content presented, treating it with clarity and objectivity.	9, 10
4	The teacher establishes relationships between the contents of his course with the contents of the other courses, contributing to professional training.	3, 9, 10
5	The teacher attends the classes and follows the start and end times.	10
6	The teacher is available to answer questions about the course subject.	10
7	The teacher uses adequate teaching techniques for learning.	8
8	The teacher uses the didactic resources available, favoring learning.	8
9	The teacher encourages the use of supplementary materials (books, websites, online journals, audio, videos, among others).	8, 7
10	The teacher prepares assessments compatible with the course content.	11
11	After assessments, the teacher discusses the questions and clarifies the grade assigned.	10, 11
12	The teacher listens to criticisms, opinions and suggestions regarding his classes, showing himself open to dialogue.	10
13	Do you have any suggestions, praise or criticisms about the teacher's performance? Your opinion is important and will be read by the teacher and his / her boss.	10

2.11 Standard 11 - Learning Assessment

It is already recognized the need of assessing not only the disciplinary knowledge, but also personal and interpersonal skills, and product, process, and system building skills. The Aerospace Engineering strategy in CDIO courses is planned to be adopted in other Engineering Programs for the curricular reforms. The Electrical Engineering (CT) course introduced the same approach in the Integrated Project course (Section 2.3.1).

2.11.1 CDIO courses of Aerospace Engineering

In the CDIO courses of Aerospace Engineering (Section 2.5.1), the evaluation covers all course programs, which includes personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge. As defined in art. 14th of CDIO course rules, weighing and detailed assessment criteria should be defined by the professor.

CDIO course rules:

https://www.ufsm.br/app/uploads/sites/428/2018/11/Norma_CPIO_V4_Maio_2018.pdf

Course Program with CDIO Syllabus:

https://www.ufsm.br/ementario/disciplinas/dem1106/

2.12 Standard 12 - Program Evaluation

There are several evaluation mechanisms currently in use at UFSM, which mainly relies on a evaluation model standard widely used in Brazil: The National System for Evaluation of Higher Education (SINAES). Basically, this evaluation model is structured into three axes: institution, programs and students. While the institution is responsible for its own evaluations, programs and students are evaluated externally. This is an interesting model on its own, as the students and programs are compared against the same standards, enabling an overview of the higher education quality across the country. However, the periodicity of these nationwide evaluations is small and this impairs the ability of the institution to adapt to short term trends.

As stated above, UFSM conducts annually a self-evaluation, where everyone involved with the institution takes part, answering a survey, including faculty, administrative staff and the students. The results are used by the institution and its members to take measures for its own improvement. Figure 2.12.1 presents the overview of the results obtained for the period of 2019/2020.

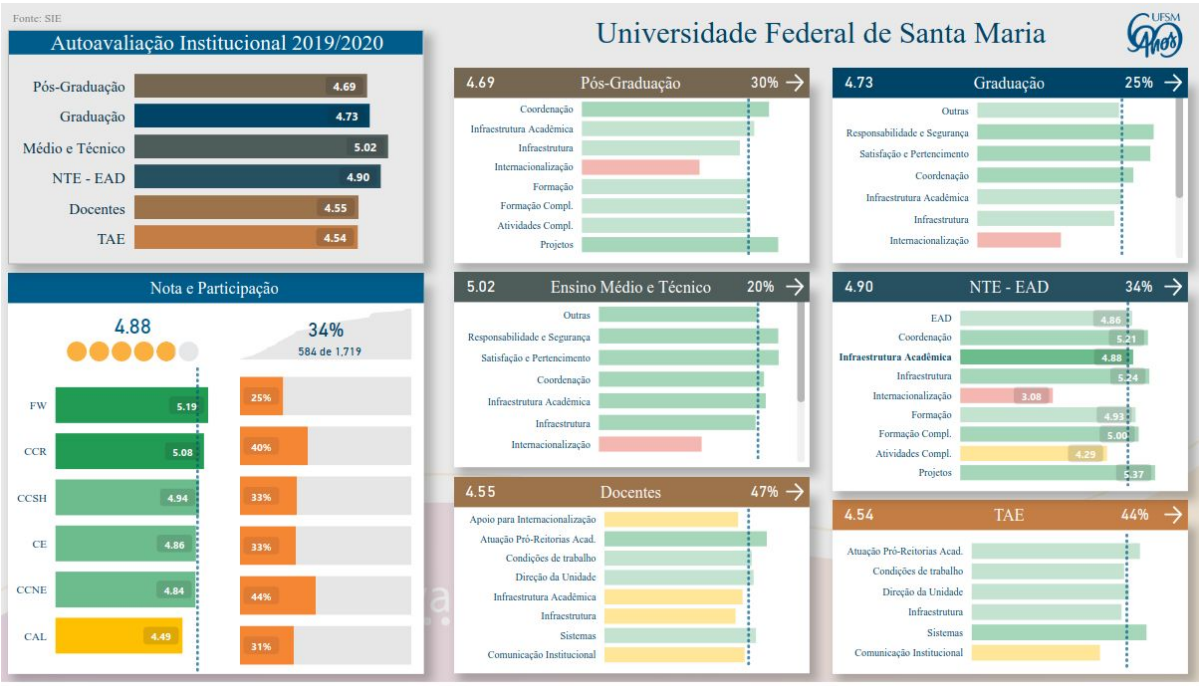


Fig. 2.12.1 - UFSM Institutional self-evaluation results 2019/2020.

Although covering many aspects of university life, the institutional self-evaluation does not evaluate its programs directly. It only does some indirect analysis of the departments. Nevertheless, the program in Aerospace Engineering, being in a recently created program, and expecting the visit of the

external program evaluation national committee, did implement a pioneering program evaluation model raising awareness about its importance and frequency. Therefore this model could be considered or adapted to the particularities of other programs.

In order to remediate the lack of institutional program evaluation, and to address the needs of this CDIO proposal, an evaluation of the UFSM engineering programs was performed. It consisted of a survey, answered by faculty members, that measured how well each program already fulfills the expectations of each of the 12 CDIO standards in a scale from 0 (not at all) up to 5 (fulfilled). Figure 2.12.2 depicts the results. It can be observed that there are plenty of opportunities for improvement. Since the CDIO standards and its whole concept is new for many faculty members and students, future surveys need to clarify what is meant and expected for each standard.

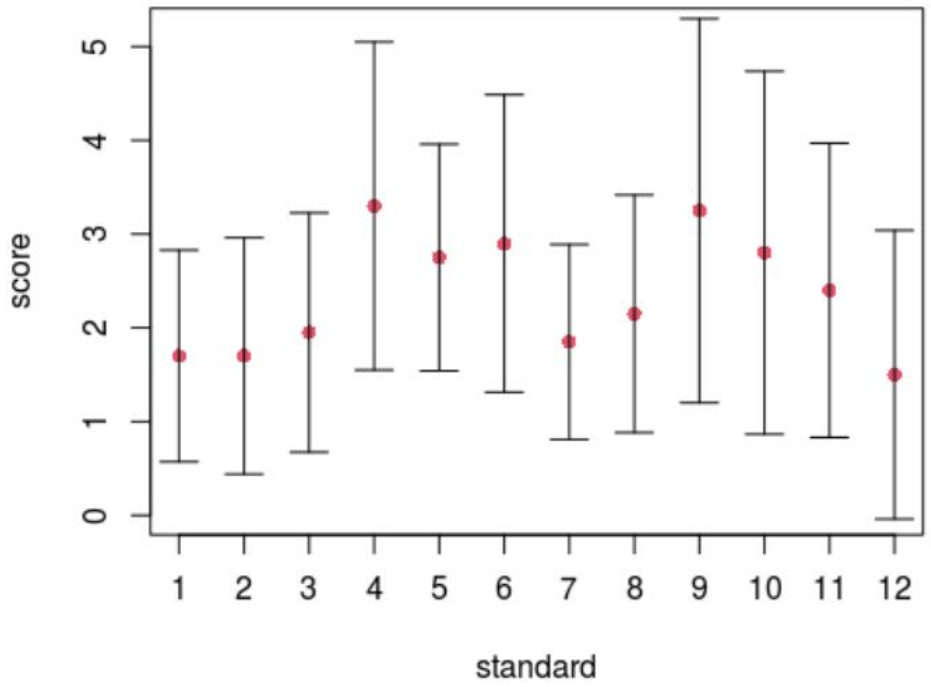


Figure 2.12.2 - Evaluation of Engineering Programs by the CDIO standard, and the mean program score (red dots), together with the standard deviation (vertical lines).

2.13 Other actions

2.13.1 Optional Standard 3 - Engineering entrepreneurship

An interdisciplinary course named “Entrepreneur Attitude” is offered to all students in the University. This course began with the Curriculum of Control and Automation Engineering and later spread to all programs, including engineering, statistics, physics, business, rural sciences, industrial design etc.

The course's main objective is entrepreneurial training, developing creativity, innovation, personal and interpersonal skills, and technical entrepreneurship aspects. The course activities take place in the coworking room at AGITTEC. The students talk with invited entrepreneurs and speakers, and work with group dynamics. Interdisciplinary groups are stimulated to create an innovative product or service and a business model. Possible business can later apply to the incubation program at the AGITTEC business incubator. Figure 2.13.1 shows some photos of the course.

The course program is available here: https://www.ufsm.br/ementario/disciplinas/dpee1084/

Fig. 2.13.1. Entrepreneur attitude course debate.

Figure 2.13.2. Entrepreneur attitude course.

2.13.3 Research project: Study of the dispersion of aeronautical materials characterization parameters for noise control

In the aeronautic market, mainly in the executive segment, the cabin noise level is considered an important competitive differential for product success. One of the main strategies for controlling cabin noise is the design of the thermo-acoustic treatment system. This system is composed of a set of materials, which have different functions in noise control, the main ones being:

- Vibrational damping materials for structures;
- Sound-absorbing materials;
- Sound barrier materials.

The determination of the efficiency of these materials in their respective functions is defined through data obtained experimentally, and like any experiment, the results have a dispersion of results. In a design environment, the initial sizing estimate for each system should be as accurate as possible so that design changes are avoided or minimized. In this context, the determination of the dispersion of the results of characterization of the materials that make up the thermo-acoustic treatment system is important so that it is taken into account when dimensioning the system.

Acquire theoretical and practical knowledge on measuring acoustic and mechanical properties of porous materials. From data processing, understand the dispersion and variability of these parameters. Four students were involved in this research project as interns (scholarship holders) over 2 years. They learned basic and in-depth concepts about porous materials, sound insulation, material selection,

probability and statistics and computational modeling. These concepts are integrated with the subjects of Fundamentals of Acoustics, Room Acoustics, Noise Control, Signal Processing, Vibration Control and Experimental Methods in Acoustics and Vibrations.

Students and professors were introduced to the engineering techniques used by the company (Embraer). The tools used by the company, the experimental and numerical techniques and the reasoning used to select materials on the aircraft were understood, with the objective of controlling noise and vibration. The professors and students had to plan the design CAD geometries, development and follow the manufacturing process of all the experimental benches of the project (impedance tube, air flow resistivity tube, tortuosity etc.) with external mechanical machining companies. After the benches were ready, the students were able to test and experiment the materials to verify if the equipment was adequate.

Basically, two workspaces were remodeled at the university to attend the demand for research. Room 1105 was structured in such a way that it could receive these students as well as the experimental benches. The UFSM acoustic and vibration laboratory (LEAC) was also selected to carry out part of the experiments. Some experiments can be seen in the links below:

1. https://www.eac.ufsm.br/ensaios/ensaios-acusticos; and
2. https://www.eac.ufsm.br/laboratorio-e-estrutura.

The project itself was fully integrated with the company. Weekly or biweekly meetings took place with Embraer's chief engineer. There was a great exchange of experiences and learning of different concepts that can be applied to aeronautics, vehicle acoustics, buildings acoustics and room acoustics, which are the main areas that the graduate student finds work in his professional life.

Throughout the project the students developed their own tools for acquisition, signal processing and statistical analysis of the results of the experimental benches. These tools were all made of open source codes (Matlab, ITAtoolbox - www.ita-toolbox.org) based on the learning they obtained in different disciplines of the Acoustic Engineering course. This knowledge and the tools are devices that can be used in the future in professional life (public, private or consulting company).

Many experiment benches were built and for this reason they serve as a support for study and acoustic measurements that are performed in activities of subjects such as noise control, room acoustics and vibration control. Even not participating in the project, other students have the possibility to learn the most important concepts seen throughout the project.

New knowledge, mainly about statistical analysis and parameter measurements (e.g.: Mechanical – Elastic and Poisson coefficient), was acquired by the professors. These concepts have been applied in other disciplines and research that seek to understand the dispersion of any acoustic parameters (like

transmission loss of mufflers, reverberation time in rooms, speaker parameters, subjective parameters etc.).

The assessment of understanding and learning throughout the project was carried out through the evaluation of experimental or numerical results of comparison with analytical models sent by the students. In addition, the presentation of experimental reports. All students were involved with undergraduate final work related to the research project theme with Embraer and the learning could be evaluated in this way as well.

The project occurred within the expected timeframe (2 years) and two technical visits took place at the company (São José dos Campos-SP) during this time. The results obtained were beyond satisfactory. The entire work team was praised by Embraer's engineers. The database obtained from the characterization of porous materials has been widely used by the company in the statistical energy modeling of internal aircraft noise for the development of new products. In all, four complete reports were presented to the company, on the other hand, many equipment and benches developed remain as a laboratory structure for UFSM / Acoustic Engineering.

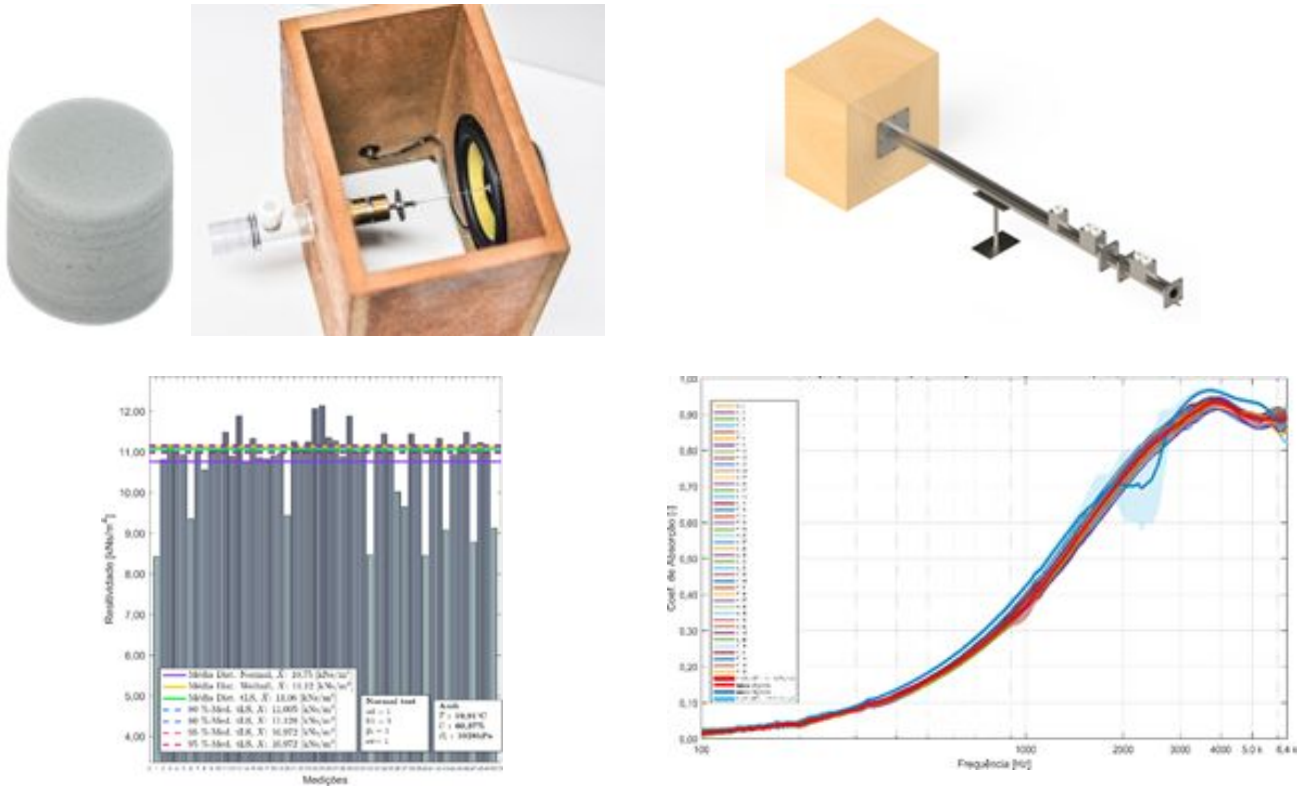


Figure 2.13.3. Examples of benches and statistical results of parameters.

3 Conclusion and next steps

UFSM has many Engineering Programs and respective faculty members engaged with the adoption of the CDIO Framework. The SWOT analysis shown in Figure 3.0.1 has been carried out to highlight our Strengths, Weaknesses, Opportunities and Threats for improving the CDIO standards in the Engineering Programs.

Figure 3.0.1. SWOT analysis for improving the CDIO standards in the UFSM Engineering Programs.

To improve the CDIO standards in the UFSM Engineering Programs, we intend to use our strengths and opportunities to overcome our weaknesses and threats. Some strategies are already being planned:

Weaknesses and Threats: the main weaknesses in Brazilian public universities are the slowness to purchase material and infrastructure with public funding. Also, public resources for material and investment are becoming increasingly scarce. To overcome these problems it is necessary to obtain funding with industry partners. The competition teams (Bombaja, Carancho, Formula) obtain funding

through donations of industry sponsors. Also, R&D projects are important to obtain industry funding. The Center of Technology has obtained around R$5 milion in 2019 in projects with the Industry (source: Agittec). Part of this budget goes to infrastructure and material for the project in which the undergraduate Engineering Students participate. Therefore, one possible solution to overcome the public funding slowness and scarcity is to have more R&D projects funded by the industry. These projects are very important to enhance the faculty competence on conceive, design, implement and operate skills (Std. 9).

Another current weakness is the faculty's low knowledge of CDIO standards. This will be overcome with the offering of courses by the Pedagogical Support Unit and the offering of a continuous training course within our virtual learning environment (Moodle).

Opportunities: the inclusion of UFSM in the CDIO Initiative is an opportunity to interchange experience with other institutions, and help new Universities and Programs in improving their engineering education. This moment coincides with the need to reform the Engineering Curricula due to the New Brazilian Engineering Education Guidelines and the National Public Outreach Projects guidelines. The CDIO approach is a way to comply with these legislations.

Another opportunity is the large adoption of Active Learning by the faculty due to remote education during the COVID 19 pandemic. Remote education has enforced the adoption of active learning methods such as the flipped classroom to better engage students. In the flipped classroom strategy, the professor makes study material and videos available, and uses the webconference time to develop other activities such as quizzes, exercises, projects. After the remote education experience, the use of active learning strategies will be more easily adopted, impacting on the improvement Standard 8.

Strengths: one important strength of the University is the Institutional Evaluation System, which already evaluates faculty competence. Following the planning shown in Figure 2.0.1, it is expected to include the CDIO standards as assessment criteria for the Engineering Programs.

However, the most important strength of UFSM is to offer dozens of opportunities to undergraduate students in student groups, public outreach and educational projects, and the possibility to work with graduate students in R&D projects. The main possible strategies to improve standards 3, 5, 7, 8 and 11 is to adopt the Aerospace Engineering approach with CDIO courses (Section 2.5.1). The CDIO course projects can be vinculated to the project or group in which the student participates, creating a mutual benefit between the projects, groups and Engineering Programs. An strategy to better integrate the disciplinary courses is to adopt planned projects to beginner students, such as the Electrical Engineering experience with the smart meter (Section 2.3.1), and consider projects with free scope for students in the last engineering years, where the free scope can be defined by the student or group or project in which the students participates.

The next intended steps to improve the CDIO standards at UFSM:

- participate in CDIO events;
- create the 2nd CDIO UFSM Workshop, inciting the participation of faculty and students;
- follow the planning shown in Figure 2.0.1 to reform the curriculum, with the work of faculty, the New Brazilian Engineering Education Guidelines committee and the CDIO UFSM committee;
- inciting other Engineering Programs to adopt the CDIO approach.