Academic Minor and Research Stay: Senior Undergraduate Courses in Mexico with International Experience in North America

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Abstract

Senior courses in higher education represent an important opportunity for students to apply their academic skills and explore their post-graduate plans. Here, technical engineering expertise needs to be balanced with “soft skills” associated with teamwork relationships. In addition, students can increase their employability skills and competencies by incorporating international experience. This is possible at Tecnologico de Monterrey in Mexico, where the Tec21 educational model is designed to provide a high-impact practical experience in students by developing solid and integral competencies while solving challenges linked to real world problems.

In this context, the four-year undergraduate program of the faculty of Engineering and Sciences is divided into the following phases: exploration, focus and specialization. Fundamental knowledge is acquired by the student in exploration stage, while core competencies are evaluated by Professors in focus stage. Moreover, during specialization phase, students select from a wide range of research stays and academic minors based on their personal interests and passions. In this stage, students under international exposure enhance their expertise and develop greater professional self-efficacy within a specialized engineering domain. Thus, considering that the implementation of research stays and academic minors with international experience for undergraduate students are not encountered in literature, this work presents two senior-level course options: 1) the research stay named “Implementation of Advanced Control Strategy for UAVs”, and 2) the academic minor titled “Autonomy of Unmanned Aerial Vehicles (UAVs)”. These programs are implemented in collaboration with a private University in United States and a Canadian company.

If students choose the research stay, the student designs and implements a hierarchical model predictive control (MPC) for three-dimensional trajectory tracking using a quadrotor of Quanser®. Experimental tests were performed in real-time at the laboratory of University of the Incarnate Word in San Antonio, Texas, with support from the U. S. Army Research Laboratory and the U. S. Army Research Office; this enhances fruitful research discussions between Professors and undergraduate students, which foster a sense of belonging to the research community. Hence, in collaboration of undergraduate mechatronics and robotics students, outcomes are: one paper published and another manuscript currently under review in Q1-indexed journals, in 2024 and 2025, respectively; this initiative led to the enrollment of two students in Master program and one student in Doctoral program, enabling them to advance in their research careers.

If students select the academic minor, they visit top Universities in Toronto, Canada. Here, learners explore UAVs labs and understand how university labs are used for academic and research purposes. Additionally, they participate in an immersive experience at Quanser®, which is a worldwide leader company in educative technology products. The Canadian

company awards an official certificate to teams that successfully solve a real-world challenge posed by R&D Manager in charge of Academic Applications of the organization. The outcome of this academic minor includes the publication of a conference paper in 2025.

Introduction

Higher education institutions heavily invest in undergraduate engineering curricula that center on experiential learning [1]. Hence, educational approaches such as internships, cooperative education, undergraduate research and international learning experiences are widely recognized as effective experiential learning models, linking theoretical knowledge with professional practice [2][3]. Furthermore, as described in [4][5], students improve problem-solving strategies, higher intrinsic motivation and resilience while they are involved in complex real-world scenarios.

Although experiential learning in engineering education offers many advantages, most of them vary considerably in structure, depth, and alignment with curricular goals [1]. Studying abroad is often focused on cultural exposure and limited in technical depth. Then, research internships lack sustained industry engagement or global collaboration [6]. Similarly, internships and co-op programs prioritize professional practice, operating independently from academic coursework or structured faculty mentorship [7]. Thus, the educational impact of these experiences vanishes when technical rigor, industry experience and faculty mentorship are not considered in the corresponding program design [8][9].

Accordingly, prior studies in engineering education highlight the importance of program models that integrate experiential learning within the curricula of senior undergraduate engineering students. Research suggests that structured experiential models, characterized by technical rigor, professional skill development and guided reflection, are associated with improved student learning outcomes, increasing retention and enhancing professional self-efficacy [7][10][11].

This paper presents a senior-level curricular model that integrates international experiential learning within formal academic minor pathways. The proposed structure takes into account technical coursework, applied research, and international collaboration with academic and industry partners, while providing sustained faculty mentorship throughout the experience.

Background and Institution Context

In Tecnologico de Monterrey at Mexico, the faculty of Engineering and Sciences offers a four-year undergraduate program, which is organized in three phases: exploration, focus and specialization. In the exploration phase, students acquire foundational knowledge in science and engineering, identify their areas of interest and develop key skills. Then, during the focus phase, core disciplinary competencies are consolidated and assessed through advanced academic blocks, hands-on practice and projects. Finally, in the last year of the program, the specialization phase supports advanced technical development while fostering student autonomy, professional identity formation and readiness for post-graduation transitions. Here, according to his main interests, the student solidifies his impact on the world by choosing among different programs, such as: i) Studying abroad, ii) Professional stay, iii) Research stay and iv) Academic minor. The research stay and the academic minor programs are defined as follows:

> **Research stay.** Students carry out a project proposed by a professor, aligned with the research lines of the faculty. The experience gained by applying the scientific method to a research project within their disciplinary area enables students to enhance their competencies.
>
> **Academic minor.** It is designed to provide students with knowledge and skills in a discipline that complements their primary field of study or, alternatively, deepens their expertise within their own area of specialization.

The specialization semester starts with the call for students to do a preliminary selection among the programs mentioned above. Then, when the call is closed, and the students are confirmed in which program they are accepted, they can be enrolled.

Materials and Methods

This article focuses on the improvement of the design and implementation of senior undergraduate programs: research stay named "Implementation of Advanced Control Strategy for UAVs" and academic minor titled "Autonomy of Unmanned Aerial Vehicles".

Research Stay

The research stay is offered to Bachelor's in Mechatronics Engineering (BME). The overall objective is to combine control engineering theoretical content with immersive international academic and laboratory experiments that produce cutting-edge research.

Students of seventh semester attend theoretical content of control engineering during the first instructional period. The sessions additionally incorporate recommended activities, formal mathematical proofs, and paper-based exams. Then, in the second and third periods, learners visit a prestigious international research laboratory, offering students real-world professional and scholarly experience. In Figure 1, the structure of the research stay program is illustrated as a flow diagram.

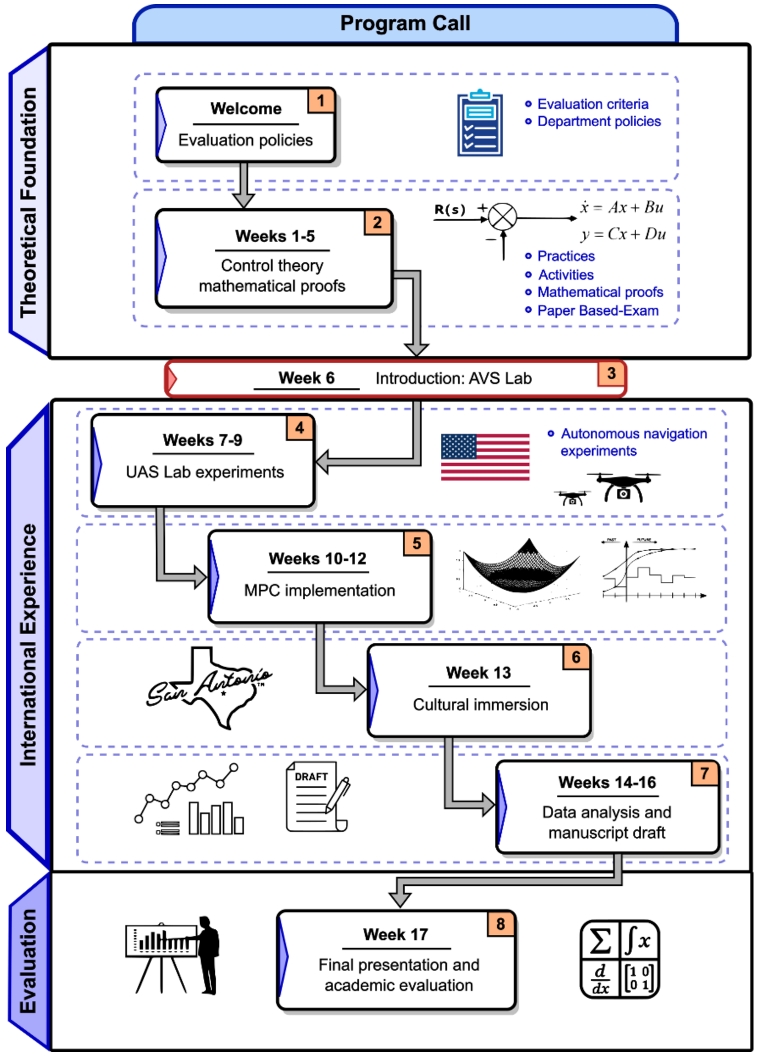


Figure 1. Structure of the research stay program.

When students select the research stay "Implementation of Advanced Control Strategy for UAVs", they perform the following stages:

1. Department policies and evaluation criteria have been presented to students since the beginning of the semester.
2. Period 1 is carried out during weeks 1-5 of the semester. It is composed of:

   Theory. Solution of the State Equation, State Space Analysis, Controllability and Observability, Canonical Forms for Single Input – Single Output (SISO) processes, Servo Control with Feedback State Matrix and LQR, Introduction to Model Predictive Control (MPC) for Multi Input – Multi Output (MIMO) systems, MPC Design, MPC for Linear Time Invariant (LTI) Systems, Definition of Cost Function, Linear Quadratic Regulator (LQR), MPC for Output Tracking.

Recommended Activities. Each per theoretical session, 1-11. Even if they are not normally graded, they do provide valuable feedback for instructors regarding student learning [12].
Formal Mathematical Proofs. There are 3 formal mathematical proofs delivered to the students, which are revised in the next session.
Paper-based Exams. There are three exams, Diagnostic Exam, Midterm Exam and Final Exam each one takes 3-6 hours.

3. In week 6, the international experience starts. Under the guidance of the engineering faculty at University of the Incarnate Word in San Antonio, TX, U.S., students engage with the Autonomous Vehicle Systems (AVS) Laboratory and its research teams, led by a prestigious Professor.
4. In weeks 7-9, Students manage Unmanned Aircraft Systems (UAS) to detect objects and navigate in autonomous mode.
5. In weeks 10-12, students develop an embedded platform to implement advanced control algorithms, test MPC strategies in the Lab under different conditions and compare the optimized algorithms against well-known control.
6. In week 13, two days were dedicated to cultural enrichment activities, during which students visited local parks and museums, and participated in a barbecue hosted in the garden of a faculty member's residence. The remaining days are dedicated to finishing with lab experiments.
7. In weeks 14–16, data are collected from laboratory experiments and then analyzed to support the development of a draft research manuscript to be submitted in an indexed journal. Here, the experimental outcomes and analyses are reviewed and validated by faculty mentors and project leaders.
8. In week 17, a final project presentation is conducted. Faculty members travel to the host institution in San Antonio, Texas, to participate as committee members during the evaluation. Although students are physically located at the institution or at the partner university, continuous communication and coordination between faculty members is kept ensuring consistent academic guidance and evaluation.

Academic Minor

This academic minor is offered to different programs of engineering and sciences faculty, such as: Bachelor's in Mechatronics Engineering (BME), Bachelor's in Robotics and Digital Systems Engineering (BRDE), Bachelor's in Chemical Engineering (BCQ), and Bachelor's in Innovation and Development Engineering (BIDE).

Students of seventh semester learn theoretical content with immersive international academic and industry experiences. Most of the content is delivered during the first two instructional periods through intensive sessions of six hours per day, four days per week. The sessions combine theory with ungraded suggested activities [12], lab practices using

Quanser® products, "Go Beyond" assignments designed to foster students' critical thinking, case studies in which course content is applied to real-world problem-solving scenarios and paper-based exams at the end of each period. In Figure 2, structure of the academic minor program is shown as a flow diagram, while parallel activities are represented in dashed lines. Both structures are chronologically integrated.

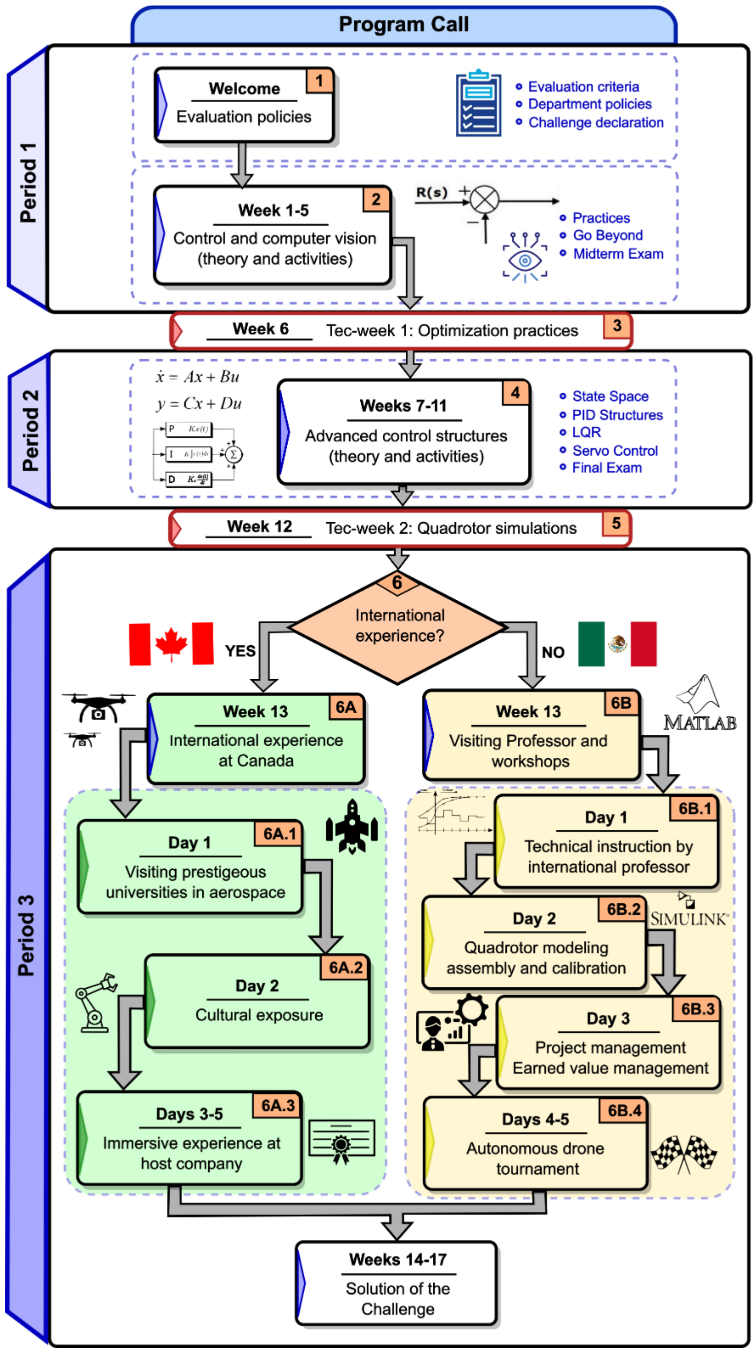


Figure 2. Structure of the academic minor program.

When students select the academic minor “Autonomy of Unmanned Aerial Vehicles”, they perform the following stages:

1. Department policies and evaluation criteria are presented to students from the beginning of the semester.
2. Period 1 is carried out during weeks 1-5 of the semester. It is composed of:

   Theory. Definition of a Transfer Function, Block Diagram Reduction, First Order Transfer Function, Process Identification by Graphical Methods, Second Order Transfer Function, Ruth Hurwitz, Stability by Root Locus Method, Design of Compensators, Design of PID controllers.
   Suggested Activities. Each per theoretical session, 1-9.
   Lab Practices. There are 6 lab practices, which can be solved by applying the theory seen in the sessions.
   Go Beyond Assignment. There are 2 assignments, one of them is focused on analysis of first order transfer function parameters and the other is related to the codification of Ruth Hurwitz in Matlab®.
   Case Study. It involves modeling the angular velocity of an inertial disk that emulates the acceleration of a virtual vehicle. In addition, students design a controller to regulate the vehicle’s speed based on specified performance indexes.
   Midterm Exam. The exam takes 3-6 hours and includes topics from week 1-5.

3. In the week 6, named Tec-week 1, optimization theory and practices are taught by the professor, focused on the topic, independent from the principal scheme.
4. Period 2 is performed in the weeks 7-11 of the semester. It is composed of:

   Theory. Cascade Control Strategy, State Space Representation, State Space to Transfer Function, Solution of the State Equation, State Space Analysis, Correlation between Transfer Function and State Space Representation, Controllability and Observability, Canonical Forms for SISO processes, Servo Control with Feedback State Matrix and LQR.
   Suggested Activities. Each per theoretical session, 10-18.
   Go Beyond Assignment. There is one assignment focused on analyzing the influence of the controller parameters on tracking performance.
   Case Study. It is based on the performance obtained using modified PID structures. Accordingly, students design a control law based on a state space representation to improve the pitch and yaw control of the Aero2 Quanser® product that emulates the helicopter dynamics.
   Final Exam. The exam takes 3-6 hours and includes topics from week 7-11.

5. In the week 12, Tec-week 2 is taken, the topics involve: Quadrotor simulations, Matlab® toolboxes and Add-ons. Developing several simulations with Simulink showing streaming, LiDAR sensors and obstacle avoidance algorithms.
6. Here the titular professors confirm the list of students that will take the international experience during the week 13.

A. Professors contact host company and universities that will be visited as part of the international experience.
B. For the students that do not take the international experience, there is a series of activities and special classes taught by an international professor.

7. In weeks 14-17, as part of Period 3, additional contents are taught, which is useful to solve the challenge, such as: quadrotor dynamics, Dj mini pro4 drone flight and photometry, project management and challenge resolution, in which students alternate among subjects and deliver practices involving hands-on activities with real drones.

During the 'Challenge', students start with the design iterations, where the initial programming and prototypes are proposed to reach the main objective of the challenge. Here, the professor provides feedback, identifying different opportunity areas in the learning process. Thus, rebuttal questions about the control strategy are carried out and feedback is provided. Finally, the professor formulates an argumentative-driven assessment to evaluate the development of competencies [13].

The international experience is carried out at Toronto, Canada, and it corresponds to Stage 6A of Figure 2.

Day 1 consisted of visiting University of Toronto Institute for Aerospace Studies (UTIAS). The students toured a remarkable complex of research laboratories, where researchers and professors shared their latest developments and ongoing projects. Figure 3 shows some photos of the laboratories visited:

- Aerospace Computational Engineering
- Combustion and Propulsion Laboratory
- Computational Aerodynamics Laboratory
- Computational Fluid Dynamics and Propulsion Laboratory
- Propulsion and Energy Conversion Laboratories
- Experimental Fluid Dynamics Laboratory
- Flow Control and Experimental Turbulence Laboratory
- Aircraft Flight Systems and Control Laboratory
- Advanced Aerospace Structures Laboratory
- Fusion Energy: Plasma Materials Interaction Laboratory

Figure 3. UTIAS students visit at Canada.

Then, students visited York University (YorkU), where professors and the Department Director of Space Engineering welcomed the delegation. At the Spacecraft Dynamics Laboratory, graduate students of the Professor in charge of the laboratory presented simulations, demonstrations and details of their doctoral projects. It is worth noting that the host university shared the students' visit on its official LinkedIn and social media platforms, allowing networking among students and post-graduate members. Figure 4 shows the meeting in which a group of students of both universities exchange experiences such as: how research can be applied in real context, when the students of the hosted university identified to follow a research life or which are the most difficult challenges faced in the laboratory.

Figure 4. YorkU students visit at Canada.

Day 2 was dedicated to cultural exposure. The students visited Niagara Falls and the surrounding village. This activity provided learners with a valuable opportunity for leisure and networking outside the academic setting.

Days 3-5 were programed to have an immersive experience in the host company Quanser®. Here, students interacted with company members from different departments, including: Mechanical, Software, Electronics, Research and Development (R&D), Sales, Marketing, and Graphic Design. They were organized into two multidisciplinary teams that worked in the corresponding small-scale challenge [14]:

> **Robotics team:** The challenge is title "Design and Control of a 3-Degree-of-Freedom Robotic Arm". It consists of using a robotic manipulator built with 3D-printed parts. Students are required to control the manipulator in two modes: manual mode, using a remote control with buttons, a joystick, and a touchscreen; and automatic mode, using a camera and sensors to locate objects and move them to target positions.
>
> **Mechatronics team:** The challenge is title "Self-Balancing Robot". It involves two-wheeled self-balancing robot. Students use an Inertial Measurement Unit (IMU), which contains accelerometers and gyroscopes, to measure motion and orientation. They are then required to build and control a self-balancing autonomous robot.

It is important to mention that students, Professors and engineers define together a workplan to solve the corresponding challenges, taking into account the facilities provided by the company. Unreleased products were used, and the main objective was to develop a functional prototype within 48 hours. Using a Raspberry Pi processor and programming in a high-level programming language, the teams integrated systems capable of reading more than 12 different sensors and controlling up to 4 types of motors simultaneously, a practical demonstration of the potential of these tools for creating modular and autonomous mechatronic projects. The company provided logistical support to the delegation with transportation and meals during these days, see Figure 5.

Figure 5. Students immersive experience in Quanser® company at Canada.

The small-scale challenge finished with a final presentation to the committee of Quanser® company: the Chief Robotics Officer, the R&D Engineer, the Academic Solutions

Consultant, the Event Specialist and the R&D Mechanical Manager. Following the demonstration of the functional prototypes, certificates of participation, signed by the Chief Robotics Officer, were awarded in recognition of the talent and dedication demonstrated, see Figure 6.

Figure 6. Students awarded for their participation at Quanser® company in Canada.

On the other hand, for the students that did not take the international experience, the sessions are in charge of the visiting Professor, and the corresponding workshops are carried out at Tecnologico de Monterrey; this corresponds to Stage 6B of Figure 2.

Day 1 was dedicated to advanced technical instruction taught by an international visiting Professor. During this session, students attended lectures focused on linear and nonlinear systems, system modeling, cost functions, and feedback linearization techniques. Figure 7 shows the simulation model of the QBot platform, developed using the Matlab® environment and Simulink, with Quanser Interactive Labs®.

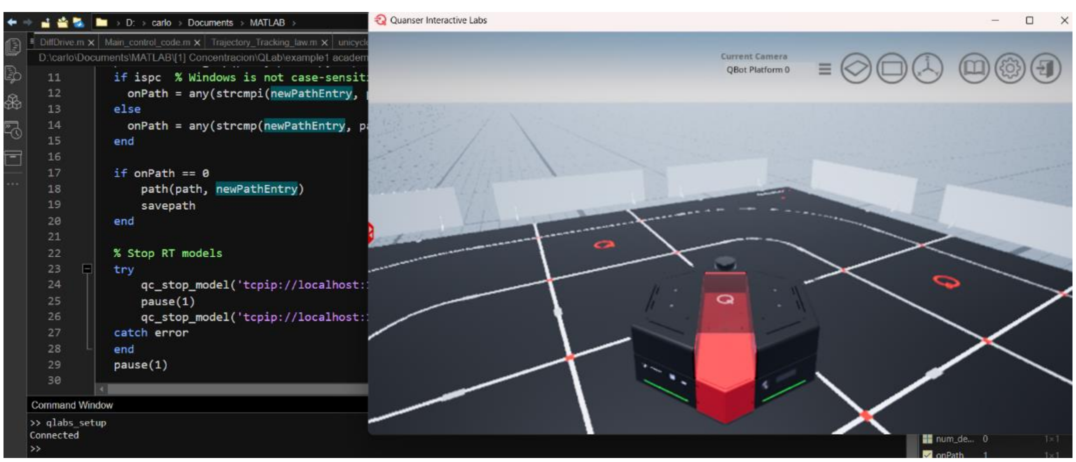


Figure 7. Matlab® and Quanser® simulation results developed as part of a course taught by the international visiting Profesor.

Day 2 was focused on quadrotor systems, including modeling, assembly, and calibration activities. Students were introduced to quadrotor dynamics in both “Cross” and “X” configurations, reviewing core flight principles before engaging in hands-on operation of small-scale aerial platforms. Meanwhile, students assembled, calibrated, and tested Pixhawk-based quadrotor systems within a controlled laboratory environment, supported through close mentorship from co-instructor faculty, see Figure 8.

Figure 8. Quadrotor assembly and calibration developed at Tecnologico de Monterrey.

Day 3 was dedicated to project management principles applied to engineering projects. Students were introduced to the importance of structured project planning, with an emphasis on defining clear objectives, scope and deliverables. Activities included critical path analysis, project cost estimation, and Earned Value Management (EVM) techniques. These concepts were reinforced through guided exercises and discussions led by a senior faculty member. Figure 9 presents a Gantt diagram developed by students to support project planning for the subsequent weeks.

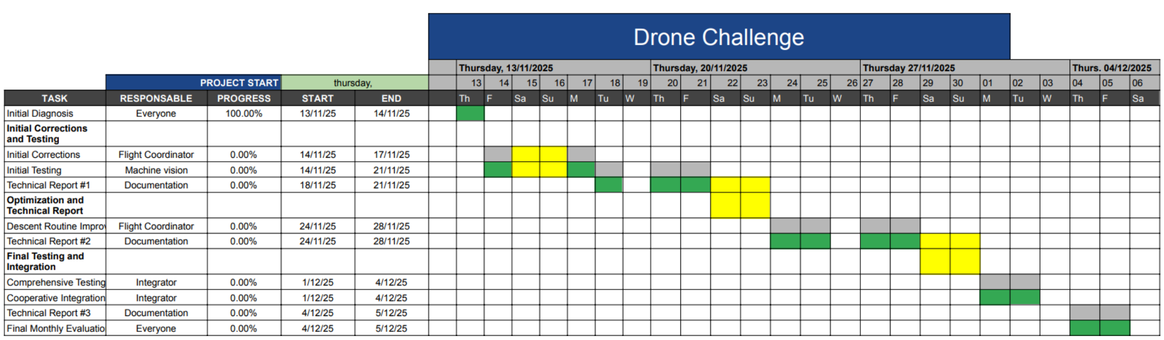


Figure 9. Gantt diagram developed by students during coursework.

Days 4-5 were centered on an autonomous drone competition designed to integrate control, perception, and programming skills. Students participated in a structured drone tournament in which autonomous aerial vehicles were required to navigate a predefined track using a combination of control algorithms and computer vision techniques. The activity required students to develop and implement perception-based navigation strategies, including the training and fine-tuning of a single neural network capable of recognizing colors and QR codes. Figure 10 shows the competition setup, including a Tello drone equipped with a downward-facing camera created by students to detect the track using Python algorithms for computer vision.

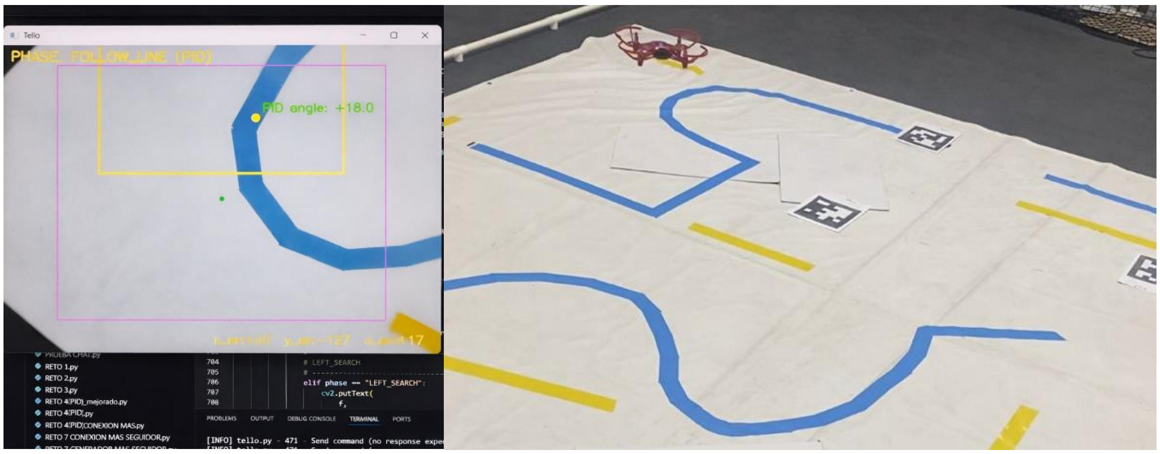


Figure 10. Autonomous drone competition at Tecnologico de Monterrey.

To support autonomous operation, students programmed their solutions using a high-level programming language and software interface, incorporating libraries for real-time data visualization, graphical interfaces, and live video streaming. Robust strategies were implemented to prevent loss of the vehicle and minimize the need for human intervention during operation. This challenge emphasized full systems integration, requiring students to coordinate sensing, perception, control, and software execution within a real-time autonomous framework.

Assessment of Service Quality

Based on [15], this section presents a statistical analysis of data collected from 26 students (mean age: 22.154 years old, SD: 1.255), enrolled either in research stay or in academic minor course at Tecnologico de Monterrey. First, service quality results are analyzed separately for each program type with international experience. Then, overall satisfaction is examined by combining both groups of senior courses with international experience.

Qualitative Results

The survey instrument SERVQUAL is implemented based on prior studies [16]. This tool has been widely used to assess the service delivered by institutions [15]. The questionnaire consists of 15 items rated on a 7-point Likert scale, with responses ranging from strongly disagree (1) to strongly agree (7). Hence, considering the level of agreement, it is possible to identify the following five thematic sections:

1. **Tangible thematic**. To evaluate how students perceive the quality of infrastructure and verbal explanations from Professors.
2. **Reliability thematic.** To determine if the course meets expectations of students regarding content organization, explained criteria and class preparation.
3. **Responsiveness thematic.** To assess the performance of the Professor in terms of the student-centered learning process, classroom environment, punctuality and adherence to timetable.
4. **Assurance thematic.** To measure the level of knowledge and attitude of the Professor to foster trust and confidence among students.
5. **Empathy thematic.** To identify the ability of the Professor to make the class interesting, and determine if the tutor presents a receptive attitude, which facilitates comprehension and encourages participation of learners during classes.

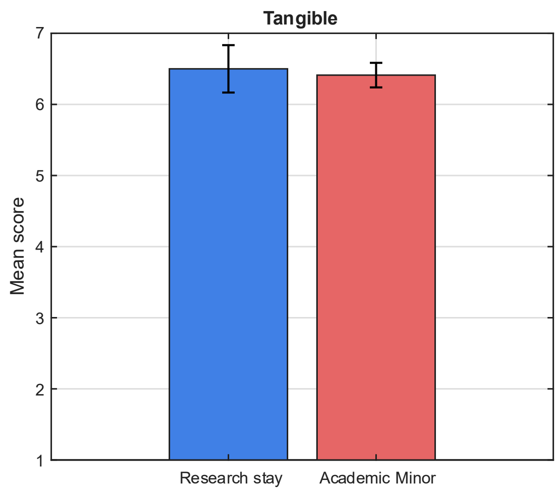
Table 1 presents the questions and their relationship to the five thematic areas.

Table 1. Questions related with the five thematic areas.

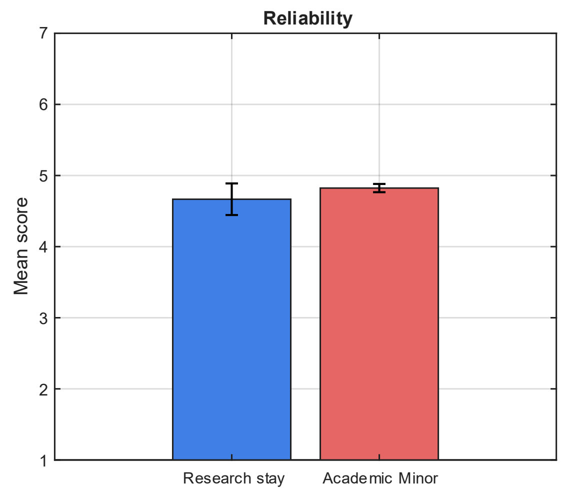
	Question	Thematic area
Q1.	The study material recommended by the teacher (texts, notes, articles) is well related to the content of the course	Tangibles
Q2.	The teacher's explanations correspond to the course objectives	
Q3.	The contents of the course were presented and organized by the teacher at the beginning of the course	
Q4.	The teacher provides clear and well-defined criteria for evaluation and assessment	Reliability
Q5.	The teacher prepares the classes well	
Q6.	The teacher takes interest in the students' progress	
Q7.	The relationship between teacher and students is good	Responsiveness
Q8.	The teacher is punctual and keeps to the timetable	
Q9.	I would like to take other courses with this teacher	
Q10.	My general rating of the teaching is good	Assurance
Q11.	My overall assessment of the course is positive	
Q12.	The teacher makes the classes interesting	
Q13.	The teacher is receptive to our suggestions and questions	
Q14.	The methods used by the teacher facilitate the understanding of the subject matter	Empathy
Q15.	The teacher encourages students to participate in class	

Then, the data are collected using an online questionnaire hosted on Google Cloud and accessed via Google Colab. Hence, the data processing stage is conducted in Phyton. Herein, libraries such as pandas, NumPy, and matplotlib are essential for data handling, statistical analysis and data visualization, respectively.

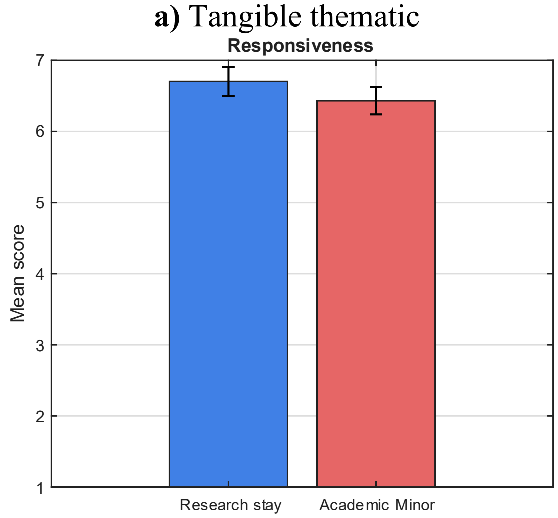
Thus, Figure 11 shows the Mean (M) results and the Standard Deviation (SD) for the five thematic sections when research stay and academic minor are considered independently. As observed, for international research stay, students ranked empathy as the most significant thematic area (M=6.889, SD=0.253) followed by assurance (M=6.852, SD=0.444), responsiveness (M=6.704, SD=0.611), tangible (M=6.5, SD=1.0) and lastly reliability (M=4.667, SD=0.667). On the other hand, students enrolled in academic minor with international experience ranked empathy as the most significant thematic area (M=6.441, SD=0.758) followed by responsiveness (M=6.431, SD=0.788), tangible (M=6.412, SD=0.712), assurance (M=6.294, SD=0.881), and lastly reliability (M=4.824, SD=0.239). Notably, senior courses with international experience offer consistent high-level results in the line of the scores provided by Professors.



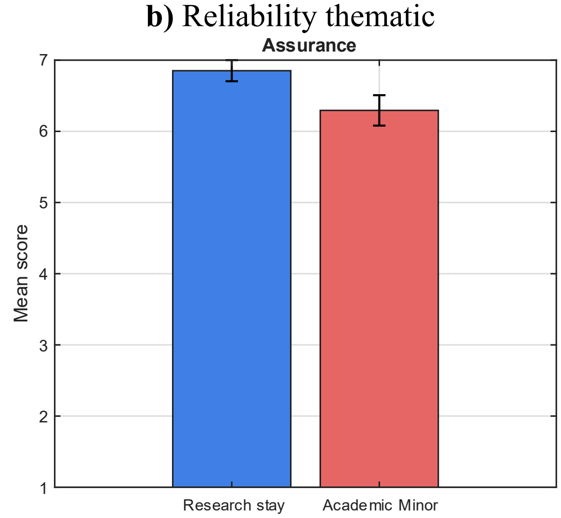
a) Tangible thematic



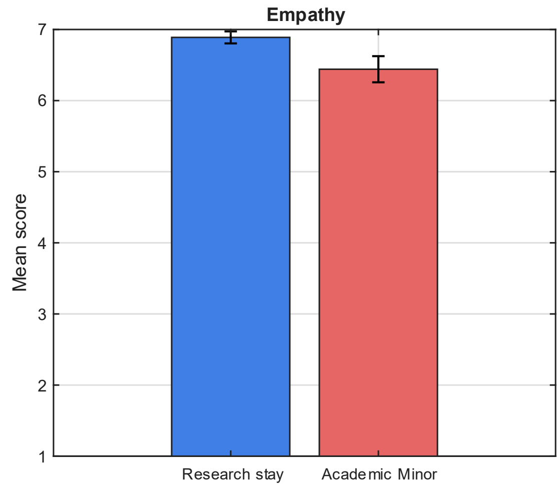
b) Reliability thematic



c) Responsiveness thematic



d) Assurance thematic



e) Empathy thematic

Figure 11. Thematic sections mean scores for national and international research stays.

Overall Satisfaction Analysis for Senior Courses

Considering both groups of senior courses with international experience, research stay and academic minor, the scale reliability of the five thematic areas is analyzed using Cronbach's alpha statistical measure [15], Eq. 1

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \mathrm{Var}(X_i)}{\mathrm{Var}\left(\sum_{i=1}^{k} X_i\right)}\right) \tag{1}$$

were α is the domain, k stands for the number of questions X_i needed to compute the corresponding domain, $\mathrm{Var}(X_i)$ stands for the variance of the i^{th}, representing the variability in responses for each specific question, and $\mathrm{Var}\left(\sum_{i=1}^{k} X_i\right)$ serves to obtain the sum of the variance for all individual items, representing the total item-level variability [15]. Hence:

- if $\alpha \geq 0.8$, the scale presents good reliability,
- if $0.8 > \alpha \geq 0.7$, the scale is considered acceptably reliable,

if $\alpha < 0.7$, the scale suggests that some items are not consistently measuring the student perception. Table 2 presents the results of the reliability analysis of the five thematic areas:

Table 2. Cronbach's alpha results for scale reliability in the thematic areas.

Thematic area	Cronbach's alpha
Tangible	0.9278
Reliability	0.8268
Responsiveness	0.8865
Assurance	0.9101
Empathy	0.9299

As it can be seen, all the thematic areas present good reliability, which suggests that the measurement scale demonstrates optimal internal consistency [17].

The correlation matrix heatmap shown in Figure 12 is computed using the questions presented in Table 2; this, to analyze the internal consistency of students' satisfaction levels in senior courses.

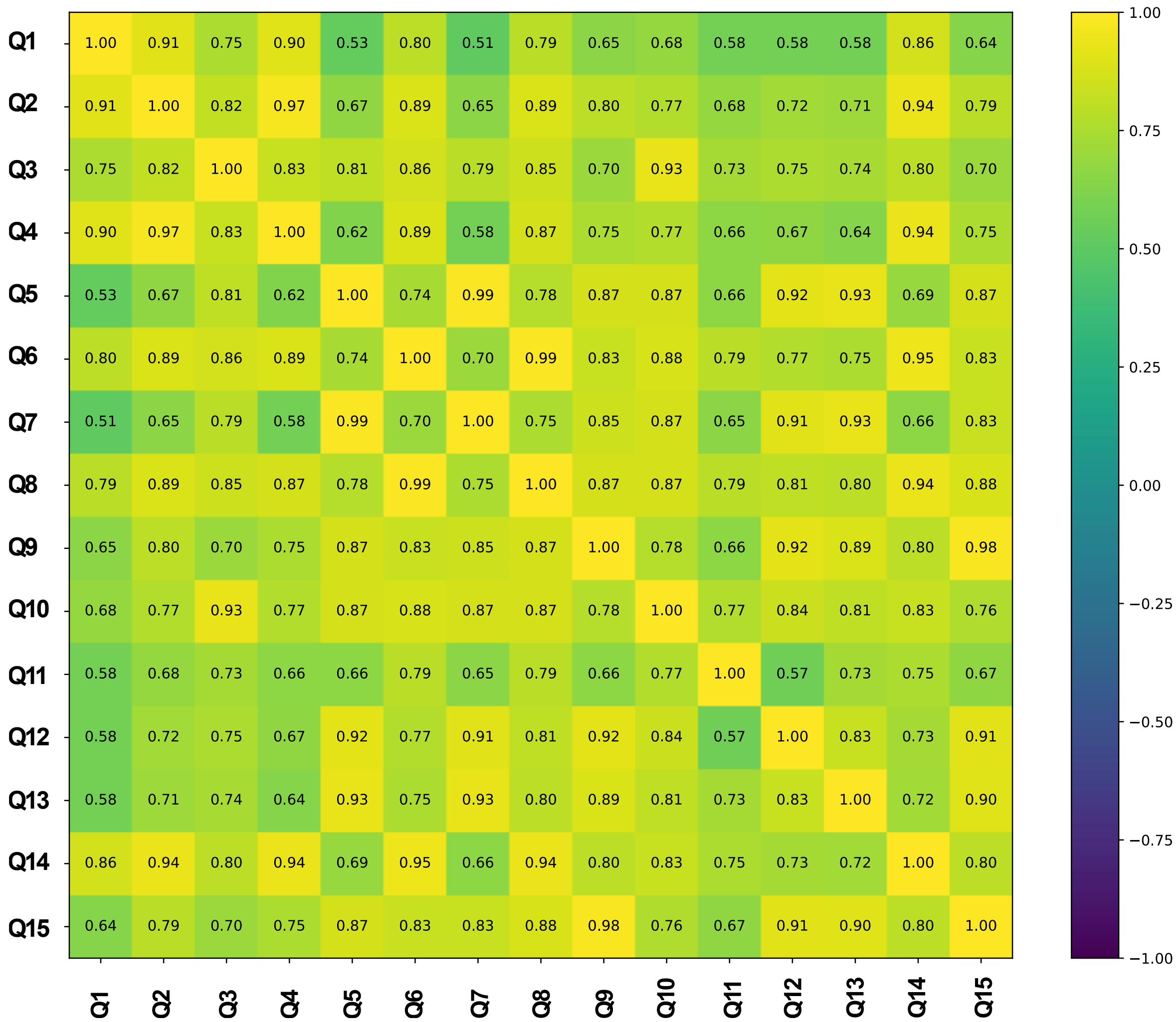


Figure 12. Correlation matrix heatmap of core satisfaction.

It is worth noting that the strongest correlation is observed between "The teacher prepares the classes well" and "The relationship between teacher and students is good" ($r = 0.99$), which suggests that the student perceive the Professor's professionalism in class preparation and how this knowledge can be properly transferred. Similarly, also "The teacher takes interest in the students' progress" and "The teacher is punctual and keeps to the timetable" demonstrate high intercorrelation ($r = 0.99$), reflecting that the tutor is interested in monitoring the progress of the learners to ensure that activities are completed on time. In addition, with a high intercorrelation ($r = 0.98$), "I would like to take other courses with this teacher" and "The teacher encourages students to participate in class", students express that they feel comfortable with sessions and are interested in taking courses with the Professor in future. This excellent learning experience is also corroborated when learners asses with an intercorrelation ($r = 0.97$) between "The teacher's explanations correspond to the course objectives" and "The teacher provides clear and well-defined criteria for evaluation and assessment", and when students evaluates with an intercorrelation ($r = 0.95$) between "The teacher takes interest in the students' progress" and "The methods used by the teacher facilitate the understanding of the subject matter".

Conclusion

This structured approach promotes deep student engagement with underlying concepts in one semester. It is an 18-credit academic specialization that is open to students from different campuses, offering a distinctly international learning experience. Here, two senior-level courses options in collaboration with University of the Incarnate Word in San Antonio, TX, U.S. and Quanser® Canadian company are presented: 1) the research stay named "Implementation of Advanced Control Strategy for UAVs", and 2) the academic minor titled "Autonomy of Unmanned Aerial Vehicles (UAVs)". In the research stay, the students are able to develop and implement their own control algorithms on a wide range of applications, such as aeronautical scenarios. The immersive experience in a globally recognized laboratory allows students to analyze ideas and phenomena from multiple perspectives, apply evidence-based rigor, and engage in problem-solving and decision-making while considering alternatives. Moreover, in the academic minor, the development of globally competitive leadership skills is performed. It involves immersive experience within the company. In this context, companies serve not only as disciplinary training partners but also provide students with hands-on opportunities that promote skill development and professional growth. Furthermore, a statistical analysis related to service quality and overall satisfaction is conducted for both courses. According to service quality results, the overall mean score for international research stay is 6.348 (SD=0.527), while academic minor with international experience shows an overall mean of 6.082 (SD=0.65). Additionally, the thematic sections with the highest and lowest ratings are consistent across both courses, research stay and academic minor, which indicates that the SERVQUAL scale is a valid tool to properly measure the service quality with regard to education services. Meanwhile, based on overall satisfaction results, for all thematic areas, an overall Cronbach's alpha of 0.9765 is obtained, which guarantees internal consistency in the measurement scale. Thus, the implementation of the structured approach, research stay or academic minor, fosters the development of professional skills and provides an international learning experience, highlighting that commonalities far outweigh any differences that may exist among students in engineering of different fields.

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References

[1] G. Tembrevilla, A. Phillion and M. Zeadin, "Experiential learning in engineering education: A systematic literature review," *J. Eng. Educ.*, vol. 113, no. 1, pp. 195-218, Jan. 2024.

[2] M. Huerta-Gomez-Merodio and M.-V. Requena-Garcia-Cruz, "Integrating theory and practice in engineering education: A cross-curricular and problem-based methodology," *Educ. Sci.*, vol. 15, no. 9, p. 1253, Sept. 2025.

[3] S. Brooks and J. Simpson, "Experiential learning in higher education: Implications for improving employability of graduates," *Ind. High. Educ.*, vol. 106, no. 2, pp. 16–21, Jun. 2014.

[4] L. Wijnia, G. Noordzij, L. R. Arends, R. M. J. P. Rikers, and S. M. M. Loyens, "The effects of problem-based, project-based, and case-based learning on students' motivation: A meta-analysis," *Educ. Psychol. Rev.*, vol. 36, no. 29, pp. 1–38 Feb. 2024.

[5] M. Galdames-Calderón, A. S. Pedersen, and D. Rodriguez-Gomez, "Systematic Review: Revisiting Challenge-Based Learning Teaching Practices in Higher Education," *Educ. Sci.*, vol. 14, no. 9, p. 1008, Sept. 2024.

[6] D. Narain and R. Dwivedi, "Importance of internship in bridging the gap between industry and academia," *Int. J. Adv. Res. Commer. Manage. Soc. Sci.*, vol. 6, no. 3, pp. 92–96, Sept. 2023.

[7] I. S. Hueck, A. Guével, R. S. MacLeod, and K. Billiar, "Integration of co-curricular experiential learning in biomedical engineering programs to increase student success," *Biomed. Eng. Educ.*, vol. 5, pp. 189–202, 2025.

[8] R. Akash and V. Suganya, “Bridging the Gap Between Industry Needs and Student Skills for Quality Education Through Sdgs: An Industry-Academia Collaboration in Curriculum Development”, *jlsdgr*, vol. 4, no. 4, p. e03616, Nov. 2024.

[9] V. Aggarwal and V. Mishra, "Aligning internship outcomes with SDG 4: A comparative study of academic institutions and industry sectors’ expectations," *Int. J. Econ. Perspect.*, vol. 18, no. 10, pp. 1702–1717, Oct. 2024.

[10] M. Seifan, Robertson, N., and A. Berenjian, "Effect of undergraduate research on students’ learning and engagement,” *Int. J. STEM Educ.*, vol. 50, no. 2, pp. 326–348, 2022.

[11] H. Gutiérrez-Pulido and C. Orozco-Rodríguez, "The contribution of professional internships to the academic development of engineering and science students: a case study," *Front. Educ.*, vol. 10, p. 1563361, 2025.

[12] P. Adams, "Assessment as learning: The role of minor assignment in teaching and learning," *Adv. Soc. Work*, vol. 5, no. 1, pp. 47–60, 2004.

[13] I. N. C. Husanu and R. Chiou, "Embedding global energy education into engineering technology curricula: The development and implementation of green energy and sustainability ET minor," in *Proc. ASEE Annu. Conf. Expo.*, Columbus, OH, Jun. 2017.

[14] R. G. Belu, L. I. Cioca, and R. Chiou, "Development and implementation of a power and energy engineering minor with limited resources: First results and lessons learned," in *Proc. ASEE Annu. Conf. Expo.*, Salt Lake City, UT, Jun. 2018.

[15] A. Perales, F. Cabanillas, J. Fernández, and L. J. Herrera, "Assessing university students' perception of academic quality using machine learning," *Appl. Comput. Inform.*, vol. 20, no. 1/2, pp. 20–34, 2024.

[16] A. P. Parasuraman, V. A. Zeithaml, and L. L. Berry, "SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality," *J. Retailing*, vol. 64, no. 1, pp. 12–40, 1988.

[17] N. K. Malhotra, *Investigación de Mercados: Un Enfoque Práctico*, 2nd ed. Pearson Educación, 1997.