Paper ID #42310

Students' perception of the effectiveness of active learning in an industrial engineering program's Management Information System course.

Roberto Patricio Carú
Dr. Juan Felipe Calderón, Universidad Andres Bello, Viña del Mar, Chile

Juan Felipe Calderón received the bachelor's in computer science and MSc and PhD degrees in engineering sciences from the Pontificia Universidad Católica de Chile. He is an assistant professor in the Faculty of Engineering at the Universidad Andres Bello. His research interests are learning design supported by technology, innovation in engineering education, sustainability in cloud computing, technological infrastructure.

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Abstract

Over the years, the diversity of pedagogical approaches used in higher education has increased, with a transition from traditional classrooms to more active and participatory methods. In teaching Information Systems in Industrial Engineering, it is necessary to apply active methodologies to actual industrial contexts, whose adoption by students is perceived as a support in their professional training.

This study aims to highlight the factors that can influence students' perception of the effectiveness of active learning in a university course in industrial engineering. To this end, a pedagogical intervention based on case studies and a flipped classroom was designed for a Management Information Systems course at a university in Chile.

The proposed methodology for this research combines quantitative methods to understand industrial engineering students' perception of traditional versus active classes during an academic period. A demographic characterization questionnaire and the application of the StRIP questionnaire were used. The sample used is composed of students of the Management Information Systems course (N=53), separated into three sections: two sections where case studies and flipped classrooms were used and the other without intervention. A correlation analysis was performed between the variables explored between the groups.

Student workers have a positive perception of the application of active methodologies. This association is most robust in students with more than four years of work experience.

Based on the results obtained with the StRIP instrument and the demographic survey, it is shown that it is convenient to use this type of pedagogical methodologies for learning during management information systems, particularly in students already linked to the workplace.

Keywords: Management information systems, Active Learning, flipped classroom, case studies, students' perception.

Introduction

This research explores the impact and effectiveness of active methodologies in teaching Information Systems. This document is the introduction to an exhaustive study that seeks to understand how contemporary pedagogical approaches can improve the training of students in a field as dynamic and critical as Industrial Engineering, specifically in the course of Information Systems.

Industrial Engineering has undergone a significant evolution in recent decades, not only in its professional practice but also in its pedagogical approach. Traditionally, teaching in this field has focused on conventional teaching methods characterized by lectures and a theoretical approach. However, the current landscape of learning in higher education is changing. There is a growing recognition of the need to adopt more dynamic and participatory pedagogical approaches, particularly in technical and applied areas such as Industrial Engineering.

Unlike traditional approaches, active methodologies emphasize student participation in the learning process [1]. These include techniques such as problem-based learning, project-based learning, case studies, and flipped classroom pedagogy. These methods focus on developing theoretical knowledge, practical skills, and competencies essential in the modern industrial environment.

Active methodologies are particularly pertinent in teaching Information Systems within Industrial Engineering [2], [3]. Information Systems is a dynamic area that requires a theoretical understanding and a practical and applied one. The speed with which information technologies evolve demands a teaching approach that allows students to stay current and use their knowledge in natural and changing situations in the industrial world.

The main objective is to identify and analyze the factors that influence students' perceptions of the effectiveness of active learning in the Information Systems in Industrial Engineering course. The aim is to understand how these active methodologies can be applied effectively and their impact on student's professional training, especially those already linked to the work environment.

To achieve these objectives, a pedagogical intervention was designed in a Management Information Systems course. This intervention includes the use of case studies and the implementation of a flipped classroom. A mixed research approach will be applied, using quantitative and qualitative methods to assess students' perceptions. A demographic characterization questionnaire, the StRIP questionnaire previously adapted to the Chilean context [4], and statistical analyses, including ANOVA, will be used to examine the differences between groups of students subjected to different teaching methodologies.

This document is organized into several sections. Following this introduction, a literature review on active methodologies in engineering education is presented, followed by a detailed description of the research methodology. Subsequently, the results obtained are explained and discussed in the context of the existing literature. Finally, conclusions and recommendations for future implementation of active methodologies in teaching Information Systems in Industrial Engineering are offered.

This study aims to contribute significantly to the body of knowledge on Industrial Engineering pedagogy and serve as a guide for educators and institutions seeking to improve the quality and relevance of their teaching in this vital field.

Literature Review

Active learning, commonly defined as any method of instruction that actively engages students in the learning process, has gained recognition for its potential to improve student engagement and achievement in various educational fields, including Industrial Engineering. This learning modality contrasts with traditional didactic methodologies, where student participation is mainly limited to passive listening. In engineering education, active learning manifests through various strategies, such as collaborative learning, problem-based learning (PBL), inquiry-based learning, and flipped classrooms.

Collaborative and Cooperative Learning: These methodologies emphasize teamwork and positive interdependence, promoting the development of interpersonal skills and deepening knowledge through peer discussion and collaboration. Previous studies have shown that these strategies foster a greater understanding of content and improve students' communication and problem-solving skills [5].

Problem-Based Learning and Inquiry: PBL and inquiry-based learning focus the educational process on actual or simulated problem-solving and guided exploration, respectively. These approaches promote critical thinking and the practical application of theoretical knowledge, preparing students for the challenges of the professional environment [3], [6].

Flipped Classroom: This pedagogical strategy reverses traditional teaching by moving direct instruction out of the classroom, freeing up class time for active learning activities. Implementing the flipped classroom effectively increases student engagement and improves learning outcomes in engineering courses [7].

Despite the favorable evidence for active learning, its adoption in engineering education faces challenges, including resistance to changing traditional methodologies and a need for teacher preparation to implement these strategies effectively. In addition, the present study seeks to address a need to understand better how students' work experience may influence their perception of the usefulness and applicability of active methodologies.

Research Methodology

This study adopted a mixed-method approach to assess industrial engineering students' perception of the effectiveness of active learning methodologies compared to traditional techniques. Through quantitative and qualitative analyses, we sought to understand student attitudes and the factors influencing their perception of active learning.

Study Design

The study design included a pedagogical intervention in a Management Information Systems course for final-year industrial engineering students. The intervention consisted of implementing case studies and flipped classroom methodology to compare student perception between sections of the course that experienced the intervention and a control section that continued with traditional teaching methods.

Population and Sample

The target population was students enrolled in the Management Information Systems course at Universidad Andrés Bello, Santiago de Chile. The final sample consisted of 53 students, divided into three sections: two experimental sections and a control section. The selection of participants was voluntary, and they were willing to participate in the intervention activities and complete the assessment instruments.

Data Collection Instruments

Two main instruments were used for data collection:

- *Demographic Characterization Questionnaire (Appendix III):* This questionnaire is designed to collect information on participants' demographic characteristics, including age, gender, and previous work experience.

- *StRIP Questionnaire* [4]: Adapted for this study, the StRIP questionnaire included questions about students' perception of the effectiveness of active learning, using a 5-point Likert scale. The questions covered topics such as the acceptance and use of active learning activities, the amount of information provided by the teacher, the frequency with which students performed the proposed activities, and their overall evaluation of the course. The details of this instrument are in Appendix I.

Procedures

The pedagogical intervention was carried out during an academic semester. Students in the experimental sections participated in learning activities based on case studies and flipped classrooms, while the control section continued with the traditional teaching format. At the end of the semester, all participants completed the StRIP and demographic questionnaires.

Data Analysis

Quantitative data collected through the questionnaires were analyzed using descriptive statistics to explore core trends and the distribution of responses. To examine differences in the perception of active learning between groups, an analysis of variance (ANOVA) was performed. Qualitative data, collected through semi-structured interviews with a subsample of participants, were analyzed using thematic analysis to delve deeper into student perceptions and challenges.

Participants

The study was conducted with students of the Management Information Systems course at the Universidad Andrés Bello in Santiago de Chile. The sample consisted of 53 final-year industrial engineering students selected to participate in this study voluntarily. Participants were informed about the research objectives and the teaching methodology that would be implemented, and they were assured that their participation was completely voluntary and that they could withdraw at any time without consequence.

The selection of participants was made as follows:

Section 1 (Daytime): This section consisted of 30 students, representing 56.6% of the total sample. Most of these students were in the 24 to 26 age range. Five students in this section chose to refrain from participating in the surveys and interviews in the study.

Section 2 (Evening): 13 students were included, constituting 24.5% of the sample. These participants were 25 to 36 years old, and three declined to participate in the surveys and interviews.

Section 3 (Evening—Control): Ten students formed this section, representing 18.9% of the total sample. All participants in this section, aged between 25 and 36, completed the surveys and participated in the interviews.

The gender distribution among the participants was 11.32% female students and 88.68% male students, reflecting the typical demographics of industrial engineering programs in the region.

This study set out to explore students' perceptions of the effectiveness of active learning compared to traditional teaching methods, taking into consideration variables such as previous work experience and course format (day versus evening) to provide a deeper understanding of how these factors can influence the perception of the value and applicability of active learning methodologies.

Data analysis

The student's perception of the effectiveness of active learning methodologies compared to traditional ones was evaluated through an analysis of variance (ANOVA) to identify statistically significant differences between the groups of students participating in the study.

Statistical Procedure

The ANOVA analysis was applied to compare student responses from the course's three sections: two experimental sections subjected to active learning methodologies (case studies and flipped classroom) and one control section that followed a traditional teaching approach. Key variables were examined, including the perception of the usefulness of active learning, the immediate application of acquired knowledge in work contexts, and the preference for the type of teaching methodology. Detailed results are in Appendix II.

Main results

The analysis revealed that 76.92% of students surveyed perceived active-format classes as more helpful than traditional classes. The remaining 23.08% found no significant differences in usefulness between the two teaching approaches (Fig. 1). This difference was particularly noticeable when comparing the responses of students in the evening sections, who work during the day, with those of day students.

Evening students, who usually have work experience, reported a higher appreciation of active methodologies, arguing that they provide them with tools and knowledge immediately applicable in their respective work environments. On the other hand, day students with less or no work experience must report a clear preference for active learning methodologies over traditional ones.

Interpretation

The findings suggest that students' previous work experience significantly influences their perception of the usefulness of active learning. Students with work experience tend to value more approaches that allow them to apply what they have learned practically and tangibly in their jobs. In contrast, those without work experience do not show a definite preference, possibly due to the lack of an applied context for the knowledge acquired in the classroom.

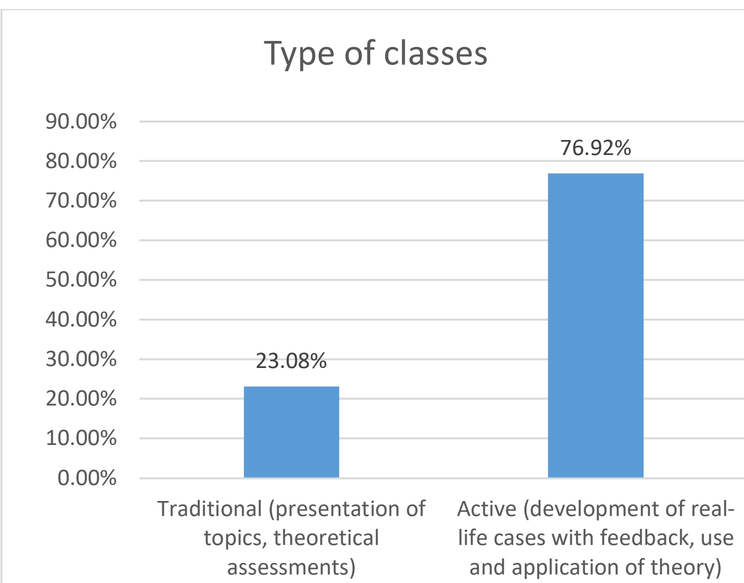

Fig.1: Perception of the usefulness of active methodologies

Analysis of Students' Work Experience

Evaluation of work experience among study participants revealed notable differences between day and evening students (Fig. 2). Within the group of day students, 38.46% indicated that they had no previous work experience. On the other hand, 15.38% of this group reported having work experience derived from their ventures, with a duration of between 1 and 4 years.

In contrast, the analysis of evening students, who commonly balance their studies with work commitments, showed that 30.77% have work experience in the 1 to 4 years range. In addition, 15.38% of evening students reported having more than five years of work experience, highlighting a greater job placement and practical experience within this group.

This disparity in work experience between day and evening student groups underscores the diversity of contexts and backgrounds that students bring to the educational environment, which may influence their perception and assessment of the active learning methodologies implemented in the course.

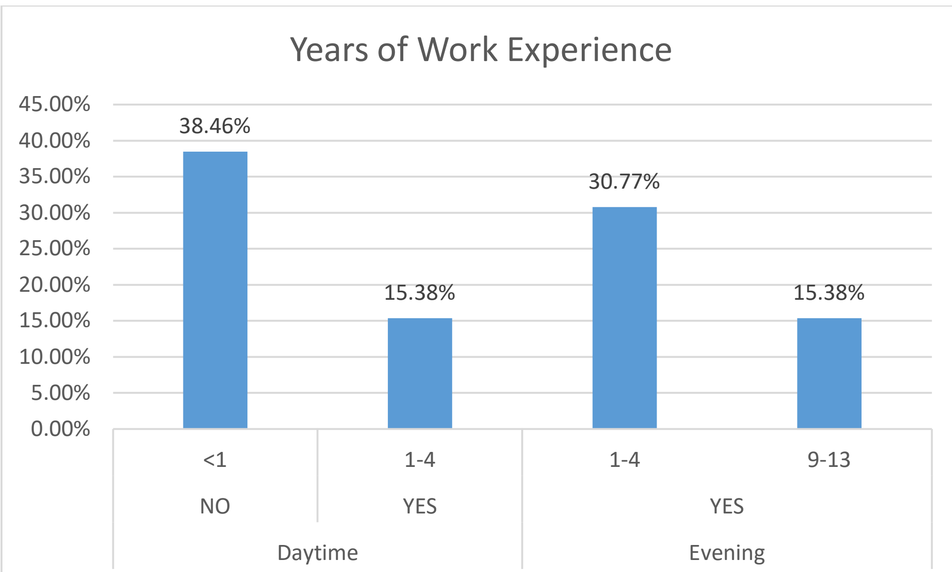

Fig. 2: Students' years of work experience

Discussion

The results of this study highlight a perceptible divergence in the assessment of active learning methodologies among students with different profiles of work experience within the context of industrial engineering education. A highlight of the findings is that 38.46% of day students presumably have less exposure to the work environment and have no previous work experience. This data contrasts with the perception of the usefulness of active methodologies among evening students, of whom 30.77% have work experience of 1 to 4 years and 15.38% have more than five years of experience.

This variation in perception can be interpreted in light of existing literature suggesting that prior work experience enriches the understanding and appreciation of pedagogical approaches that align more closely with real-world practices and challenges [3], [8]. Evening students, having a wealth of practical experiences, can see in active methodologies a greater relevance and applicability to their work contexts, reinforcing the importance of these pedagogical strategies in forming professional skills.

On the other hand, the need for a clear preference for active methodologies among day learners could reflect a disconnect between theoretical content and its practical application, a gap that active methodologies seek precisely to overcome. This finding raises questions about how engineering education can be designed to be meaningful and relevant to all students, regardless of their previous work experience.

The discussion about the limited implementation of active learning strategies in engineering classrooms, as noted in the literature (Berrett, 2012), is echoed in this study. Despite the evidence supporting their effectiveness, adopting these pedagogical strategies faces obstacles, including possible institutional resistance or a lack of teacher training in these approaches.

Practical and Theoretical Implications

The results suggest the need for a more personalized pedagogical approach, which considers students' backgrounds and experiences to maximize the relevance and effectiveness of learning. In addition, they underline the importance of integrating practical experiences or simulations of the work environment in training engineering students, especially those with no previous work experience.

Considerations for Future Research

This study provides grounds for future research on integrating active methodologies into engineering education, particularly in exploring strategies to make learning more applicable and engaging for students without work experience. Likewise, it is suggested that the study of the institutional and teaching factors that facilitate or limit the adoption of these methodologies in different educational contexts be deepened.

Regarding ANOVA results, the data suggest that students with more work experience (probably those in evening courses) tend to value active methodologies more, possibly because they can more directly relate what they have learned to their practical work environment. On the other hand, day course students, who might have less work experience, do not prefer active methodologies and traditional classes. Also, results highlight the importance of contextualizing learning in real work experiences. Working students find greater relevance and usefulness in methods that connect with their daily work lives. This could indicate greater effectiveness in environments where students can directly apply what they have learned.

Conclusions

The present study explored the perception of industrial engineering students about the effectiveness of active learning methodologies in a Management Information Systems course. The results revealed a widespread positive perception towards active learning, especially among evening students with previous work experience. This preference suggests that active methodologies, by providing a more applied and relevant context for learning, are particularly valued by those who can directly connect to their professional experiences.

Key Findings

- A significant percentage of evening students perceive active methodologies as more beneficial than traditional teaching methods, indicating the importance of these strategies for applying knowledge in real work contexts.

- Students' perceptions of the usefulness of active learning vary according to their work experience, underlining the need to adapt teaching strategies to individual student profiles.

Implications

These findings underscore the importance of incorporating active learning methodologies into engineering education to improve the relevance and applicability of learning. For educators and institutions, this implies the need to develop and implement pedagogical approaches that encourage students' active participation and consider their background and previous experiences.

Recommendations

- For Educators: Integrating actual case studies and applied projects that reflect work environment challenges is recommended, especially in courses aimed at students with no previous work experience.

For Institutions, it is suggested that teachers be trained and provided with resources to facilitate the adoption of active methodologies and foster an educational culture that values and promotes applied and collaborative learning.

- For Future Research: It would be beneficial to explore how individual student differences, such as work experience, influence the effectiveness of different active learning methodologies and how these strategies can be optimized for various engineering educational contexts.

References

[1] M. Prince, "Does active learning work? A review of the research," *Journal of engineering education*, vol. 93, no. 2, pp. 223–231, 2004.

[2] V. Vodovozov, Z. Raud, and E. Petlenkov, "Challenges of active learning given integrated engineering education." *Educ Sci (Basel)*, vol. 11, no. 2, p. 43, 2021.

[3] M. Hernández-de-Menéndez, A. Vallejo Guevara, J. C. Tudón Martínez, D. Hernández Alcántara, and R. Morales-Menendez, "Active learning in engineering education. A review of fundamentals, best practices, and experiences." *International Journal on Interactive Design and Manufacturing (IJIDeM)*, vol. 13, pp. 909–922, 2019.

[4] M. Quezada-Espinoza, Á. Domínguez, G. Zavala, and J. F. Calderón, "Student response to instructional practices (StRIP) survey in engineering classrooms: Validating a Spanish version," in *2020 ASEE Virtual Annual Conference Content Access*, 2020.

[5] M. L. Kovarik, J. K. Robinson, and T. J. Wenzel, "Why Use Active Learning? In Active Learning in the Analytical Chemistry Curriculum," American Chemical Society, 2022, pp. 1–12.

[6] L. Deslauriers, L. S. McCarty, K. Miller, K. Callaghan, and G. Kestin, "Measuring actual learning versus the feeling of learning in response to being actively engaged in the classroom," *Proceedings of the National Academy of Sciences*, p. 116(39), 2019.

[7] H. J. Cho, K. Zhao, C. R. Lee, D. Runshe, and C. Krousgrill, "Active learning through flipped classroom in mechanical engineering: improving students' perception of learning and performance," *Int J STEM Educ*, vol. 8, pp. 1–13, 2021.

[8] L. M. Guimarães and R. D. S. Lima, "Active learning application in engineering education: effect on student performance using repeated measures experimental design," *European Journal of Engineering Education*, vol. 46, no. 5, pp. 813–833, 2021.

Appendix I: StRIP Questionnaire

Survey on teaching practice opinion

Name: ______________________ID:____________Course:____________Professor

1) In this course, when the teacher asked you to do an activity in class (e.g., solving problems in groups, discussing concepts with your peers, among others), how often did you react in the following way?	**Almost never (<10% of the time)** **Rarely (~30% of the time)** **Occasionally (~50% of the time)** **Frequently (~70% of the time)** **Very frequently (>90% of the time)**				
a. I did not like the activity	1	2	3	4	5
b. I did not participate genuinely in the activity.	1	2	3	4	5
c. I put in the minimum effort in the activity.	1	2	3	4	5
d. I had a positive attitude towards the teacher.	1	2	3	4	5
e. I tried my best to do a good job.	1	2	3	4	5
f. I distracted my peers during the activity.	1	2	3	4	5
g. I pretended to participate in the activity.	1	2	3	4	5
h. I felt that the effort to carry out the activity was worth it.	1	2	3	4	5
i. I actively participated (or tried to).	1	2	3	4	5
j. I talked with my peers about topics unrelated to the activity.	1	2	3	4	5
k. I felt that the teacher was empathetic towards me.	1	2	3	4	5
l. I could appreciate that doing the activity had value for me.	1	2	3	4	5
m. I felt that the time dedicated to doing the activity was beneficial.	1	2	3	4	5
n. I enjoyed doing the activity.	1	2	3	4	5
o. I did other things instead of doing the activity (e.g., browsing websites unrelated to a specific task or using social networks for purely personal interest).	1	2	3	4	5
p. I expressed to the teacher my criticisms about the activity.	1	2	3	4	5
q. I went through the activity very quickly and superficially.	1	2	3	4	5
r. I considered evaluating the course teacher negatively.	1	2	3	4	5
s. I complained to my peers about the activity.	1	2	3	4	5

2) In this course, when the teacher asked you to do an activity in class (e.g., solving problems in groups, discussing concepts with your peers, among others.), how often did the teacher do the following?	**Almost never (<10% of the time)** **Rarely (~30% of the time)** **Occasionally (~50% of the time)** **Frequently (~70% of the time)** **Very frequently (>90% of the time)**				
a. Clearly explained what they expected me to do in the activity.	1	2	3	4	5
b. Clearly explained the purpose of the activity.	1	2	3	4	5
c. Explained how the activity was related to my learning.	1	2	3	4	5
d. Asked for my opinion and/or that of my peers about the activity.	1	2	3	4	5
e. Used activities that presented the correct level of difficulty (neither too easy nor too difficult).	1	2	3	4	5
f. Moved around the classroom to help me or my group with the activity if necessary.	1	2	3	4	5
g. Their attitude involved students in the activity.	1	2	3	4	5
h. Gave me an adequate amount of time to engage in the activity.	1	2	3	4	5

3) Indicate how often you carried out the following actions during this course. Considering that on average, there are 30 classes in the semester.	**Almost never (<10% of the time)** **Rarely (~30% of the time)** **Occasionally (~50% of the time)** **Frequently (~70% of the time)** **Very frequently (>90% of the time)**				
a. Listen to the teacher explaining the content in an expository way.	1	2	3	4	5
b. Think of different solutions to a specific problem.	1	2	3	4	5
c. Search for additional information not provided by the teacher to complete tasks.	1	2	3	4	5
d. Work in groups to complete tasks or other projects.	1	2	3	4	5
e. Give individual presentations in class.	1	2	3	4	5
f. Be graded for my class participation.	1	2	3	4	5

g. Study course content with classmates outside of class.	1	2	3	4	5
h. Take responsibility for studying and learning with other material on my own.	1	2	3	4	5
i. Discuss concepts with my classmates during class.	1	2	3	4	5
j. Make and justify assumptions when not all information is provided.	1	2	3	4	5
k. Obtain the majority of the information needed to solve tasks directly from the teacher.	1	2	3	4	5
l. Be graded based on the performance of my group.	1	2	3	4	5
m. Review concepts before class through readings, videos, etc.	1	2	3	4	5
n. Solve problems in groups during class.	1	2	3	4	5
o. Solve problems individually during class.	1	2	3	4	5
p. Answer the teacher's questions during class.	1	2	3	4	5
q. Ask questions to the teacher during class.	1	2	3	4	5
r. Take the initiative to identify what I need to learn.	1	2	3	4	5
s. Observe the teacher solving problems.	1	2	3	4	5
t. Solve problems that have more than one correct answer.	1	2	3	4	5
u. Carry out practical activities (using equipment, material, sensors, etc.) in groups during class.	1	2	3	4	5
4) Indicate how often you would like to carry out the following actions, considering that a course was designed taking into account your opinion. Take into account that on average, there are 30 classes in the semester.	**Almost never (<10% of the time) Rarely (~30% of the time) Occasionally (~50% of the time) Frequently (~70% of the time) Very frequently (>90% of the time)**				
a. Listen to the teacher explain the content in an expository manner.	1	2	3	4	5
b. Think of different solutions for a specific problem.	1	2	3	4	5
c. Search for additional information not provided by the teacher to complete tasks.	1	2	3	4	5
d. Work in groups to complete tasks or other projects.	1	2	3	4	5
e. Give individual presentations in class.	1	2	3	4	5
f. Be graded for my participation in class.	1	2	3	4	5
g. Study course content with classmates outside of class.	1	2	3	4	5
h. Take on the responsibility to study and learn with other materials on my own.	1	2	3	4	5
i. Discuss concepts with my classmates during class.	1	2	3	4	5
j. Make and justify assumptions when not all information is provided.	1	2	3	4	5
k. Obtain most of the necessary information to solve tasks directly from the teacher.	1	2	3	4	5
l. Be graded based on my group's performance.	1	2	3	4	5
m. Review concepts before class through readings, videos, etc.	1	2	3	4	5
n. Solve problems in groups during class.	1	2	3	4	5
o. Solve problems individually during class.	1	2	3	4	5
p. Answer questions from the teacher during class.	1	2	3	4	5
q. Ask the teacher questions during class.	1	2	3	4	5
r. Take the initiative to identify what I need to learn.	1	2	3	4	5
s. Observe the teacher solving problems.	1	2	3	4	5
t. Solve problems that have more than one correct answer.	1	2	3	4	5
u. Engage in practical activities (using equipment, materials, sensors, etc.) in groups during class.	1	2	3	4	5

5) **Please rate the level of agreement with the following statements (for this particular course).**	**1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree**				
a. Overall, this was an excellent course.	1	2	3	4	5
b. Overall, the teacher was excellent.	1	2	3	4	5
c.I would recommend this teacher to other students.	1	2	3	4	5

Remember: When it mentions "in-class activity", it refers to solving problems in groups, discussing concepts with your peers, among others.

6) **In how many of your university courses did the professor ask you to do this type of activity in class for 50% of the face-to-face classes or more? Select only one box.**

a. In all my university courses.
b. In almost all my university courses.
c. In approximately half of my university courses.
d. In some of my university courses.
e. In none of my university courses.

Appendix II: ANOVA analysis

	Section 1 vs Section 2			Section 2 vs Section 3 (control)			Section 1 vs Section 3 (control)		
Question	F-value	p-value	Sign.	F-value	p-value	Sign.	F-value	p-value	Sign.
1a	75.763	<0.001	*	1.954	0.177		38.776	<0.001	*
1b	77.524	<0.001	*	9.773	0.005	*	15.323	<0.001	*
1c	9.876	0.003	*	21.643	<0.001	*	13.558	0.001	*
1d	3.973	0.053		1.79	0.195		0.548	0.464	
1e	14.445	<0.001	*	66.962	<0.001	*	19.345	<0.001	*
1f	109.421	<0.001	*	296.739	<0.001	*	2.133	0.152	
1g	109.421	<0.001	*	21.101	<0.001	*	26.573	<0.001	*
1h	80.766	<0.001	*	45.041	<0.001	*	6.256	0.017	*
1i	5.225	0.028	*	0.833	0.372		1.744	0.194	
1j	75.468	<0.001	*	39.772	<0.001	*	7.236	0.011	*
1k	2.121	0.153		6.112	0.022	*	0.793	0.379	
1l	75.797	<0.001	*	34.469	<0.001	*	10.013	0.003	*
1m	75.468	<0.001	*	45.885	<0.001	*	1.182	0.284	
1n	44.505	<0.001	*	27.65	<0.001	*	0.983	0.328	
1o	47.083	<0.001	*	36.638	<0.001	*	1.31	0.259	
1p	5.847	0.02	*	51.306	<0.001	*	26.721	<0.001	*
1q	73.307	<0.001	*	40.746	<0.001	*	0.239	0.627	
1r	5.327	0.026	*	6.112	0.022	*	0.015	0.902	
1s	11.179	0.002	*	14.186	0.001	*	0	1	
2a	8.581	0.006	*	4.079	0.056		34.061	<0.001	*
2b	8.581	0.006	*	12.443	0.002	*	70.378	<0.001	*
2c	8.581	0.006	*	39.772	<0.001	*	256.5	<0.001	*
2d	12.388	0.001	*	60.776	<0.001	*	16.891	<0.001	*
2e	1.929	0.172		5.773	0.026	*	0.502	0.483	
2f	18.202	<0.001	*	12.104	0.002	*	0.376	0.543	
2g	5.327	0.026	*	6.112	0.022	*	0.015	0.902	
2h	3.489	0.069		2.412	0.135		0.016	0.899	
3a	9.445	0.004	*	3.393	0.08		16.68	<0.001	*
3b	8.382	0.006	*	14.695	0.001	*	1.08	0.305	
3c	2.86	0.098		22.344	<0.001	*	34.641	<0.001	*
3d	97.828	<0.001	*	49.717	<0.001	*	2.235	0.143	
3e	nan	nan		11.87	0.002	*	28.5	<0.001	*
3f	21.41	<0.001	*	7.913	0.01	*	1.657	0.206	
3g	17.642	<0.001	*	5.976	0.023	*	1.11	0.299	
3h	0.072	0.789		1.005	0.327		0.15	0.701	
3i	55.216	<0.001	*	7.913	0.01	*	18.269	<0.001	*
3j	40.936	<0.001	*	11.87	0.002	*	10.997	0.002	*
3k	6.31	0.016	*	0.833	0.372		1.295	0.262	
3l	14.311	<0.001	*	0.282	0.601		5.23	0.028	*
3m	58.705	<0.001	*	24.555	<0.001	*	1.188	0.283	
3n	20.898	<0.001	*	1.005	0.327		28.432	<0.001	*
3o	5.395	0.025	*	11.072	0.003	*	1.345	0.253	
3p	75.14	<0.001	*	9.311	0.006	*	148.405	<0.001	*
3q	38.474	<0.001	*	0.004	0.952		35.379	<0.001	*

3r	16.852	<0.001	*	7.913	0.01	*	2.22	0.145	
3s	7.176	0.011	*	17.804	<0.001	*	1.657	0.206	
3t	28.482	<0.001	*	6.207	0.021	*	6.37	0.016	*
3u	7.283	0.01	*	2.255	0.148		1.02	0.319	
4a	8.021	0.007	*	2.297	0.145		0.535	0.469	
4b	12.186	0.001	*	21.01	<0.001	*	2.582	0.116	
4c	32.702	<0.001	*	22.344	<0.001	*	98.965	<0.001	*
4d	40.822	<0.001	*	0.833	0.372		22.255	<0.001	*
4e	117.092	<0.001	*	5.087	0.035	*	45.315	<0.001	*
4f	22.503	<0.001	*	23.33	<0.001	*	69.607	<0.001	*
4g	6.704	0.013	*	159.788	<0.001	*	81.748	<0.001	*
4h	5.332	0.026	*	127.132	<0.001	*	106.067	<0.001	*
4i	11.658	0.001	*	58.902	<0.001	*	16.045	<0.001	*
4j	33.72	<0.001	*	127.132	<0.001	*	32.062	<0.001	*
4k	1.577	0.216		1.79	0.195		0.128	0.722	
4l	20.146	<0.001	*	17.904	<0.001	*	4.35	0.044	*
4m	51.524	<0.001	*	468.949	<0.001	*	47.5	<0.001	*
4n	0.098	0.756		0.298	0.591		0.983	0.328	
4o	10.507	0.002	*	18.918	<0.001	*	2.02	0.163	
4p	3.981	0.053		55.83	<0.001	*	67.897	<0.001	*
4q	0.579	0.451		73.61	<0.001	*	107.966	<0.001	*
4r	0.364	0.55		47.255	<0.001	*	29.565	<0.001	*
4s	8.581	0.006	*	3.437	0.078		42.75	<0.001	*
4t	29.114	<0.001	*	108.266	<0.001	*	29.462	<0.001	*
4u	33.372	<0.001	*	174.499	<0.001	*	30.699	<0.001	*
5a	1.433	0.238		41.117	<0.001	*	30.378	<0.001	*
5b	0.994	0.325		14.929	0.001	*	13.558	0.001	*
5c	0.994	0.325		3.393	0.08		1.295	0.262	

Appendix III: Characterization survey

Characterization Survey

Name: ______________________ID:_____________Course:______________Professor

a. Which semester are you currently enrolled in?"	
b. Which session do you study in (daytime, evening)?	
c. Gender: Female, Male ?	
d. How old are you ?	
e. Do you have work experience?	
f. Years of experience	
g. Do you have your own startup? (Yes/No)	
h. What type of thesis would you like to develop?	Project applied in businesses ____ Applied project that contributes to the community _____ Optimization models ____ Theoretical research _____