Building New Pedagogical Designs in the Pandemic Era

Ernesto Pacheco
Industrial Engineering, Tecnologico de Monterrey, Mexico, Mexico
Email: epacheco@tec.mx

Manuel Robles-Cardenas and Ricardo Thierry-Aguilera
Industrial Engineering, Tecnologico de Monterrey, Mexico, Mexico
Email: mrobles@tec.mx, thierry@tec.mx

***Abstract*—From the beginning of the pandemic, many universities had to modify the traditional face-to-face educational system to a remote system where the students continue having a meaningful learning process. Simulators and serious games are effective learning techniques which existed before the pandemic and there is a continuously growing interest in them given the observed benefits and the highly likely possibility that the use of these techniques will continue to be adequate beyond the pandemic. This research focuses on the use of the GOAL platform and on LOST, a serious game designed to teach supply chain concepts where the students make non-trivial decisions to maximize profit. The GOAL platform has been used at our university and several other schools for more than 3 years. This work presents the details of how the GOAL platform has been implemented at our university and the effects on the students learning.**

***Index Terms*—Higher education, educational innovation, logistic education, serious games, E-learning**

I. Introduction

COVID 19 virus has caused changes in a good number of countries in the world. As quarantine was declared by majority of governments, isolation measurements and social distancing affected in a drastic manner social, labor, and economic dynamics in all continents. For a large number of educational systems, this has represented significant changes in how knowledge is transmitted. A good percentage of universities choose to incorporate new communication technologies (ICTs) and added to their tools virtual lessons transmission using one or two communications platforms such as Zoom, Google Meet or Microsoft Teams. Despite the advantages offered by such platforms, new difficulties arise in terms of lack of interest by the students, absence of personal contact, no visual interactions, deficient distance evaluation methods, and other technological problems like a poor network system capacity band width. These platforms offered an immediate and acceptable solution to the problem created by the pandemic when the face-to-face classes were cancelled. The students could continue with their education but the lack of interaction with other students, the monotony of watching a monitor for hours, the technological problems on both sides of the class transmission and the distracting elements present at home while taking the classes generated new difficulties for the learning process.

Professors at the Tecnologico de Monterrey (Mexico City Campus), did not perceive virtual classes adoption as a new challenge. The earthquake that occurred in September 2017 in Mexico City damaged a mayor part of our campus facilities, thus forcing us to start using and experimenting different pedagogical distance education models. In particular, logistics professors in our university have worked in creating different educational platforms, new distance evaluation ways, simulators, serious games, educational videos, etc. On that occasion, the remote models were only applied for one semester, and we returned to the face-to-face model in January 2018.

New communication technologies have changed teaching paradigms. New teaching techniques downplay the importance of repeating content and memorizing concepts; and give a higher priority to the development of new skills such as seeking information, developing critical thinking, problem solving, self-regulated learning and flipped classroom strategies. Students must modify their behavior and take a more active role in their learning. To achieve this objective, the contents and activities contained in a course must be highly significant. On the other hand, the changes that are generated when moving from a face-to-face model to a remote model have very significant implications in how to design learning activities; the review of content in a course is only part of the objective, while the most important goal is to promote meaningful learning and the development of new skills that may be useful for students of the new millennium.

For a long time, traditional teaching has been the predominant way of teaching logistics. During this new millennium, new techniques have been incorporated that favor practical activities, where students acquire a more active role with the intention of favoring their own learning. Some of these activities are, for example, problem-based learning [1], [2], the case method [3], [4] and professional

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practices [5]-[8]. Furthermore, in the last decade, the inclusion of technology in educational processes has supported teaching techniques such as the augmented reality, virtual reality, simulations, and game-based learning [9]-[12].

Despite the efforts that have been made in recent years, the teaching of logistics still faces serious challenges. The knowledge that is taught in this area is functionally fragmented, that is, the vast majority of universities have chosen to divide knowledge into small topics such as forecasts, inventories, transportation, warehousing, optimization, among others; but we lack scenarios where the interrelation of these contents is studied; In this way, when students are faced with a complex system that involves all these areas, their decision making is erratic, they try to optimize the operation of only one of the parts of the system (reduce inventory costs, minimize transportation costs, get good forecasts, etc.) [13], [14]. On the other hand, the teaching of these topics is focused on solution methods, while the application in real cases is often ignored [15].

This work presents the changes made to the traditional pedagogical design and how these changes were implemented using the GOAL platform. The platform is very well suited for remote teaching and contains several tools to encourage active learning, teach relevant concepts, foster analytical thinking, make rational decisions, analyze data, create mathematical models, modify traditional assessment, and promote game-based learning using LOST. The use of this simulator has facilitated the acquisition of theoretical knowledge, has increased the motivation of the participants, has provoked significant learning, and has developed the capacity for self-regulated learning.

II. GOAL Project and Logistic Simulator

GOAL Project is an educational platform created with the intention of transmitting and teaching logistics concepts (Fig. 1). One of the main objectives is to teach students the interrelation of the different topics that are contained in this science. To achieve this goal, the logistics professors at our university designed a logistics simulator (which we call LOST), which attempts to represent the operation of a small supply chain. On each of the game's turns, students must forecast demands, create a production plan, select raw materials, choose suppliers, and determine the size of orders. This game allows participants to observe the effects that each of their decisions have on the logistics system and how they contribute to the company's profits.

Figure 1. GOAL Project Platform (https://goalproject.co).

The simulator includes multiple concepts (demand planning, production planning, inventories, optimization and transportation decisions). One of the great advantages of LOST is that it contains different scenarios, the difficulty of the simulator gradually increases in such a way that in each of the scenarios there are conditions of uncertainty which present new challenges to the students (Fig. 2).

The GOAL Project platform does not only contemplate the use of this logistics simulator. Within the platform, a series of support tools have been designed on different topics related to the decision-making process in the logistics area (videos, notes, textbooks, articles, Quizzes, etc.) Many educational videos have been placed on the YouTube platform, we currently have more than 200 videos in Spanish and English (Fig. 3).

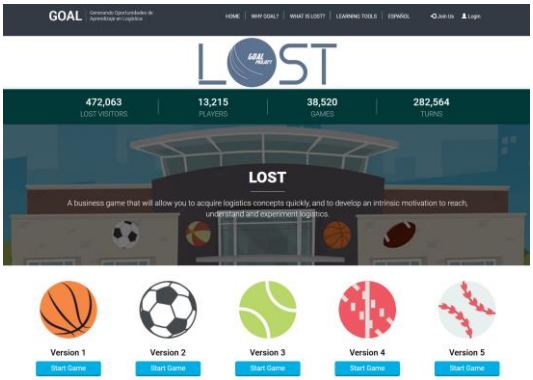

Figure 2. GOAL Project Platform (https://goalproject.co).

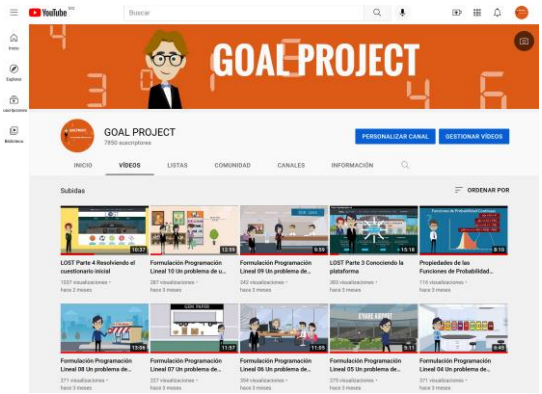

Figure 3. GOAL Project YouTube Channel.

To motivate students to consult the existing materials on the platform, GOAL has been completely gamified, so that students can receive different rewards within the game when they correctly answer the questionnaires that appear in the platform. These in-game benefits allow students to acquire certain privileges, such as increasing their warehouse space, having higher production efficiency, and increasing demand, among others.

Throughout the game, the players must make non-trivial decisions regarding vendors, production processes and transportation issues. An example of these decisions is shown in Fig. 4. The topics covered in class help the students make good decisions and playing the game several times has proven to be an effective strategy to

improve the game's score and to comprehend the important concepts.

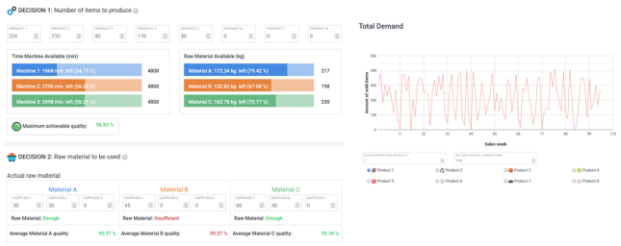

Figure 4. Decision window within the LOST Simulator.

In addition, GOAL has been completely gamified, so that students can receive different rewards within the game when they correctly answer the questionnaires that appear in the platform. These in-game benefits allow students to acquire certain privileges, such as increasing their warehouse space, having higher production efficiency, and increasing demand, among others.

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III. Instructional Design for a Face to Face Model

In the second half of 2017, we started working on a pedagogical model based on the GOAL Project platform. The main objectives of this design were the following: 1) increase student learning, 2) improve motivation, 3) develop the self-regulated learning skill.

Including videos on the platform allowed us to experiment with different methodologies, such as flipped classroom, active learning, and the use of LOST led us to conduct game-based learning (GBL). These modifications of the original course are summarized in the pedagogical design shown in Fig. 5.

This pedagogical design was used from the semester Aug-Dec 2017 to the semester Aug- Dec 2019. The main academic results obtained in this period compared to those obtained in traditional teaching for the previous semesters are presented in Table I.

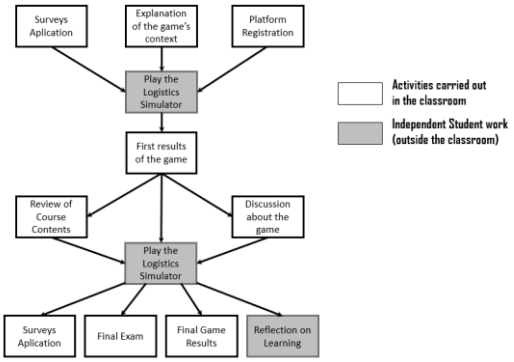

Figure 5. Pedagogical design for a face-to-face model.

TABLE I. Main Academic Indicators

	Feb-Jun 2014 Feb-Jun 2017	Aug-Dec 2017 Aug-Dec 2019
Number of students	194	103
Percentage of dropouts (%)	7.7	2.8
Average of partial exams	72.4	82.1
Final exam Average	75.3	83.4
Pass rate (%)	76.8	88.6

On the other hand, at the beginning and at the end of the course we applied three types of surveys:

1. The first survey measured the motivation of the student during the course and was based on the classical literature of the area [16]. This survey measures lack of motivation (demotivation), extrinsic motivation and intrinsic motivation.
2. The second survey was based on the student's self-perception of self-regulated learning [17].
3. The third survey was designed to measure the relevance of the selection of strategies that students follow in the game.

From the results of the motivation survey, we can conclude that while intrinsic and extrinsic motivation increase significantly, lack of motivation decreases. The results of these surveys can be found in Table II.

The survey used with the students about their perception of the importance of the self-regulated learning skill contains 52 questions, there are 418 responses from students who have used the simulator. With these data we performed a factorial analysis concluding that seven factors explain 62.15% of the total variance. These factors are as follows:

- Self-management skills
- Openness to accept new ideas.
- Critical thinking.
- Self-direction and information acquisition skills
- Enjoy learning.
- Awareness of your limitations
- High expectations

After obtaining the factors, we performed a t-test to determine if there were significant changes in the students' perception of this skill. The results show that in five of these areas the students improve their assessment of the importance of self-regulated learning. The results of this comparison can be seen in Table III.

As a final point, regarding the strategies that the students follow during the game, we found significant differences between the first and the second time they play. Looking at the game log it is possible to find significant differences in topics such as forecasting, production planning and inventory management.

IV. Instructional Design for a Remote Model

The beginning of the COVID 19 pandemic resulted in the need to discuss the strategies that can change under this new scheme of remote work. The following decisions were made:

1) Institute a greater number of personalized counselling.

2) Increase the number of activities that students will perform independently.

3) Promote team discussions about the various strategies students followed.

4) Increase the number of videos and notes that will be placed on the platform.

5) Increase flexibility in the submission of assignments and projects in the course.

The pedagogical design used during this stage is shown in Fig. 6.

In terms of the academic indicators, it is possible to assert that the results are quite like those obtained in the last two years (the dropout rate was 0%, the average of the partial exams was 80.7, the average grade in the exam final was 82.7 and the pass rate was 90.47%). We have not included a direct comparison with the results of the face-to-face courses since some activities were evaluated differently and some of the percentages of the qualification in relation to the activities changed. We consider that it is not convenient to make these comparisons.

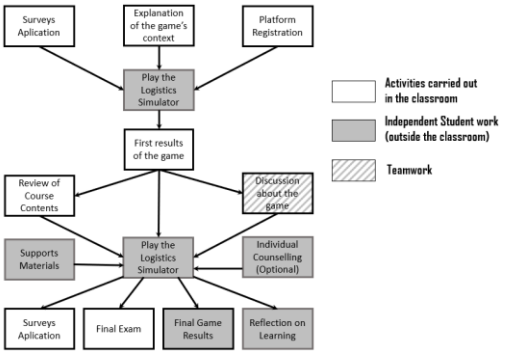

Figure 6. Pedagogical design for a remote model.

Table II shows a summary of the results of the motivation survey in the face-to-face model (2017 – 2019), and those of the remote model, (2020 – 2021). As can be seen, both in the face-to-face model and in the remote model, the lack of motivation decreases, while intrinsic and extrinsic motivation increases throughout the course. In the case of intrinsic motivation, it can be observed that in the remote model the second survey is also significantly different from that of the face-to-face model. This means, that the pedagogical design used in the remote model increases intrinsic motivation in the students.

In relation to the development of competencies of the self-regulated learning survey among students, the results are presented in Table III. In this case, the results are quite similar, however, there is a significant difference in favor of remote mode with the sub competence called "Self-Direction".

Finally, in terms of the relevance of the game's decision-making and the scores obtained by the students in the simulator, in both learning modes they were similar. The Pre-test and Post-test results were evaluated on a scale of 0 - 100 (where 0 is the lowest score, and 100 is the highest score). The game score is the result that the students obtain at the end of the game. Usually, the scores of the 5800 participants who have played this game range between 0 and 1'000,000 (consider that the median of the scores is 680,000).

The average of the scores obtained in the post-test in face-to-face mode were higher than those of the remote mode, however, the score obtained in-game is better in the remote mode than the average score in face-to-face mode. The results can be seen in Table IV.

TABLE II. MOTIVATION SURVEY RESULTS

		Remote N = 72	Face to Face N = 103
First Survey	Amotivation	2.25	2.19
	Extrinsic Motivation	4.63	4.51
	Intrinsic Motivation	4.96	5.10
Second Survey	Amotivation	1.49	1.51
	Extrinsic Motivation	5.21	5.17
	Intrinsic Motivation	6.33	5.83

TABLE III. SELF-REGULATED LEARNING SURVEY RESULTS

	Face to face Model		Remote Model	
Sub competencies	First Survey	Second Survey	First Survey	Second Survey
Self-management	27.95	29.52	27.56	29.44
Openness to accept new ideas	70.17	72.87	69.71	73.07
Critical thinking	32.15	32.17	31.87	32.46
Self-Direction on acquiring information	27.73	26.13	28.19	29.84
Enjoy Learning	31.30	33.19	30.63	34.05
Awareness of their limitations	52.18	53.22	51.16	52.93
High expectations	41.13	42.76	41.02	43.00

TABLE IV. PRE-TEST, POST-TEST AND SCORE RESULTS

		Pre-Test	Post-test	Score
Remote Model	N = 75	63.81	82.31	817 324
Face to face Model	N = 109	60.18	84.17	796 9

V. DISCUSSION

The GOAL Project is an educational innovation that we consider extremely successful in terms of the improvements seen in the most important academic indicators. In addition, this project has allowed us to experience the teaching technique of the flipped classroom, and we have contemplated the development of other skills that we consider important in this new millennium, such as self-regulated learning, critical thinking, the ability to solve problems and reflection on the learning process.

On the other hand, the use of the logistics simulator has generated greater motivation in the students. The game offers students a classification table that allows them to identify their position with respect to the other participants. This has meant that most of the participants have played

the game more times than requested, due to their desire to see their names appear at the top of the leaderboard.

In addition, in our classes we have observed how the students relate the new content to some of the characteristics or data of the game, which we interpret as the new content being significant to them. We consider that this is the greatest contribution of the game to the course, to give meaning to the contents and concepts that we review in our lectures.

One of the most important objectives of this project was to give students greater autonomy in terms of the activities to be carried out, to create an educational design that contemplated a smaller number of sessions directed by teachers and to offer students a more active participation in their learning activities. The pandemic made it possible for these changes to be implemented more quickly. In March 2020, new scenarios and new videos were generated and the number of activities outside the classroom was increased.

Comparing the traditional scheme of face-to-face classes with the distance modality, a significant increase in the intrinsic motivation of the students can be observed. We believe that this change can be explained by the availability of new scenarios in the logistics simulator. It is also important to note that six of the seven subcompetencies related to self-regulated learning were higher in the remote modality, in particular, we would like to note that the "self-directed information acquisition" subcompetence was significantly higher in students under this new format. This could be explained by the new activities planned for the course.

The results of the post-test show a difference in favor of the face-to-face methodology. We suppose that this can be explained because, in the distance modality, the students have a smaller number of theoretical elements to explain their decisions in the game, that is, the verbalization of the strategies is better expressed by the students who have had a greater number of theory classes. However, the score achieved by the students in the simulator is higher in the students in remote mode. These results indicate that an area of opportunity in the case of students in remote mode is to generate a richer theoretical content that allows them to explain more clearly the concepts applied in the simulator.

Finally, it is convenient to mention that the main academic indicators seem to be better in the distance model compared to those obtained in the face-to-face modality. However, we have decided not to make a comparison between them because certain percentages of the course evaluation were modified, the activities' submission conditions were more flexible during the time of the pandemic, and the conditions for the application of the exams were not equivalent to the face-to-face mode.

Regardless of this change in evaluation policies, we prioritize in our pedagogical design the student's commitment to their learning, the development of self-regulated learning competence and the correct application of this logistic strategy, so that the comparison of these elements is seen slightly favored by the methodology. designed for distance learning rather than face-to-face.

VI. Conclusion and Future Work

Social distancing policies implemented by governments have impacted the work of many educational systems, which have been forced to experiment with different models of distance education. This has caused the use of academic platforms and the use of simulators to multiply in the last two years.

The new pedagogical designs must have greater flexibility but must also increase the responsibility of students for their learning. An essential feature of these models is to validate that learning is meaningful and that it can promote observable and tangible changes in student behaviors.

GOAL Project is an online learning platform that caused improvements in learning when applied in the face-to-face model. The platform improves the teaching of logistics decisions by making use of gamification, the flipped classroom and self-regulated learning. Under the new conditions generated by the pandemic, the pedagogical design of the course was modified, the contents were adapted, new learning scenarios were generated, and students were given greater freedom in searching for information. This new instructional design increased the motivation and commitment of the students with their learning, significantly increased the development of the self-regulation capacity of learning and allowed the students to internalize the content of the simulator, which can be related to the increase in the score obtained in the game.

The result obtained under these new conditions lead us to conclude that the logistics simulator favors distance and self-regulated learning. This work contributes to motivate the use of simulators and educational platforms as learning spaces that can be valuable, and where students can use different technological resources and collaborate remotely.

Future work is needed to improve the use of the GOAL Project platform and logistics simulator under post-pandemic reality. In addition, we consider it a valuable tool to generate new learning scenarios and increase the variety of active learning resources.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Dr. Pacheco is the creator of the LOST game as a mean to enrich logistics education, his recent work have been centered around the improvements to be made in this gamification option according to the experience of the students. Dr. Robles analyzed data obtained directly from the students, wrote the paper in English language providing scientific style; while Dr. Thierry provided educational point of views and administered the game in educational sessions to his students obtaining opinions on

how to improve the experience. All authors had approved the final version.

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REFERENCES

[1] V. Alvarstein and L. K. Johannesen, "Problem-based learning approach in teaching lower level logistics and transportation," *International Journal of Physical Distribution and Logistics Management*, vol. 31, no. 7-8, pp. 557-573, 2001.

[2] A. Tick, "Use of problem-based learning in teaching logistics and international operations," in *Proc. International Symposium on Logistics and Industrial Informatics*, 2007, pp. 81-85.

[3] G. Neumann, "Simulation education in logistics: Case studies in a virtual learning environment," in *Proc. 22nd European Conference on Modelling and Simulation*, 2008.

[4] L. R. Kopczak and J. C. Fransoo, "Teaching supply chain management through global projects with global project teams," *Production and Operations Management*, vol. 9, no. 1, pp. 91-104, 2000.

[5] T. Gibson, D. Kerr, and R. Fisher, "Accelerating supply chain management learning: identifying enablers from a university-industry collaboration," *Supply Chain Management: An International Journal*, vol. 21, no. 4, pp. 470-484, 2016.

[6] J. Krzywda and D. Krzywda, "Theory or practice? The concept of laboratory in the teaching programme in the field of logistics," *Transport Economics and Logistics*, vol. 71, pp. 123-133, 2017.

[7] A. Romanovs and Y. Merkuryev, "Active learning approach in teaching logistics and supply chain management," in *Proc. IEEE 2nd Ukraine Conference on Electrical and Computer Engineering*, 2019, pp. 1271-1276.

[8] J. A. Cano and C. Ayala, "Logistics education for business management students: A learning-doing and service-learning approach," *International Journal of Innovation, Creativity and Change*, vol. 9, no. 3, pp. 46-55, 2019.

[9] E. Pacheco-Velazquez, "Effects of the use of simulators and an online platform in logistics education," *International Journal on Interactive Design and Manufacturing*, pp. 1-19, 2022.

[10] E. Pacheco and J. Palma-Mendoza, "Using serious games in logistics education," in *Proc. The 2nd International Conference on Industrial Engineering and Industrial Management*, 2021, pp. 51-55.

[11] J. B. Hauge, I. A. Stefan, N. Sallinen, and Baalsrud J. A. Hauge, "Accessibility considerations in the design of serious games for production and logistics," in *Proc. IFIP International Conference on Advances in Production Management Systems*, 2021, pp. 510-519.

[12] J. C. Riedel and J. B. Hauge, "State of the art of serious games for business and industry," in *Proc. 17th International Conference on Concurrent Enterprising*, 2011, pp. 1-8.

[13] E. Espinosa and E. Pacheco, "Online simulation for logistics and decision making," in *Proc. IEEE International Conference on Service Operations and Logistics, and Informatics*, 2007, pp. 1-6.

[14] E. A. Pacheco-Velázquez and M. Aguilar-Avalo, "GOAL: generating learning opportunities in logistics," in *Proc. IEEE Global Engineering Education Conference*, 2019, pp. 761-769.

[15] E. Pacheco, J. Palma, D. Salinas, and I. Arana, "Gamification and self-directed learning," in *Proc. 14th European Conference on Game Based Learning*, 2020, pp. 417-426.

[16] R. J. Vallerand, L. G. Pelletier, M. R. Blais, N. M. Briere, C. Senecal, and E. F. Vallieres, "The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education," *Educational and Psychological Measurement*, vol. 52, no. 4, pp. 1003-1017, 1992.

[17] M. Fisher, J. King, and G. Tague, "Development of a self-directed learning readiness scale for nursing education," *Nurse Education Today*, vol. 21, no. 7, pp. 516-525, 2001.

Ernesto Pacheco-Velazquez is long life Educator in Tecnologico de Monterrey. He is a mathematician by education and continuing education referent in his University. Dr. Pacheco obtained his Ph.D. in Operations Management from ITESM & University of Texas joint degree in 2004; his field of expertise is Logistics and SCM.

Manuel Robles-Cardenas is the Head of the Industrial Engineering Department in Toluca Campus of Tecnologico de Monterrey. He holds a Degree as a Ph.D. in Industrial Engineering from Georgia Institute of Technology. Dr. Robles is a subject matter expert in the field of Operations Research and a cherished professor at his community.

Ricardo Thierry-Aguilera is an extension professor at Tecnologico de Monterrey, Mexico City with 37 years of experience in academy. He is a regular consultant for industry for the past 22 years and has 10 years of professional experience in the automotive sector. Dr. Thierry-Aguilera Holds a degree in Interdisciplinary Engineering from Texas A&M University, his interests are Logistics and Ergonomics.