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## DIDACTIC RESOURCES FOR REMOTE PRACTICAL ACTIVITIES IN AUTOMOTIVE MAINTENANCE

**Lucas Silva Yoshida**
**Vinícius Rodrigues Borba**
Federal Institute of Santa Catarina
lucas.yoshida@ifsc.edu.br
vinicius.borba@ifsc.edu.br

***Abstract.*** *During the period of social distance and online learning activities due to the Covid-19 pandemic at the Federal Institute of Santa Catarina, alternative teaching modalities were implemented aiming to improve adaptation to restrictions on practical classes of internal combustion engines and electronic ignition systems. The work was implemented in the classes of the Automotive Maintenance Technician Program. During the period of execution of the project, there were students who participated both in person and remotely. In this regard, the professors developed some strategies aiming at introducing practical activities, developing the idea of making videos and teaching materials available, their own videos on topics that were in line with learning and developing analysis techniques with devices to complement the teaching of the automotive maintenance area. The didactic resources used were: videos recorded in the classroom of practical activities carried out by a small group of students who attended in-person classes; and an OBDII scanner with Bluetooth connection was lent to the students. At the end of the academic semester, a survey was presented to the students to evaluate the impact of the project on the learning experience. The students evaluated project strategies positively for the teaching-learning process, in opposition to the current virtual teaching format quite abstract.*

***Keywords:*** *Engineering education, Educational Kit, OBD-II, Automotive, Student Dropout.*

## 1. INTRODUCTION

Students of the Technical Course in Automotive Maintenance employ a variety of equipment and tools during their in-person learning sessions. These resources are housed within the course laboratories located at the Florianópolis campus of the Federal Institute of Education, Science and Technology of Santa Catarina (IFSC). However, with the onset of the COVID pandemic, traditional classes were replaced by online classes, known as non-face-to-face activities (ANP, acronym in Portuguese), as mandated by Ministry of Education (MEC) Ordinance No. 617/2020. Consequently, IFSC promptly adapted its teaching methods to facilitate remote instruction and sustain academic operations.

During online classes, the utilization of conventional teaching materials for the teaching-learning process in automotive technology was impeded by physical constraints. Specifically, tools, equipment, engines, and even vehicles could not be employed. In response, certain teachers of the automotive maintenance course devised strategies to incorporate practical activities by utilizing portable didactic kits and instructional videos. It is important to highlight that the integration of videos into engineering education has been implemented across numerous universities to enhance student engagement and motivation (Gomez-Del Rio & Rodríguez, 2022). The utilization of videos serves as an effective means to encourage student interaction with the subject matter, as they serve as tools that assist student engagement with practical activities (Nunes et al. 2007).

Borba and Razzini (2021) have inserted some practice examples in the classes of the electricity curricular unit of the technical course in automotive maintenance during the initial phase of social distancing measures related to the COVID-19. Considering this work and the importance of practical activities in Internal Combustion Engines (ICE) and Ignition and Injection Systems (IIS) classes, strategies were devised for the use of resources to assist in the teaching-learning process of distance classes and to uphold students' motivation levels. It is acknowledged that this can be employed as a tool to deter school dropout. The inclusion of research activities to support students' learning corroborate Freire (1996) statement: “there is no teaching without research and research without teaching”, as these complement each other.

Such a methodology supports student learning, as well as adapting teaching to temporal needs and encouraging students with practical activity. It should be noted that the didactic resources and methodology do not guarantee learning, but are an attempt to contribute to the students' learning process and your motivation.

Furthermore, it was an alternative to reduce the difficulties presented by the students and to encourage their autonomy. It was a necessary quick intervention in these subjects to guarantee continuity, the offer of a more dynamic teaching, the quality of the learning process and the motivation of students in remote teaching. The motivation has a strong importance in the endogenous factors of students, because the more motivated the student is, the better their academic results will be (Paez-Quinde & Arroba-Freire, 2023).

The utilization of teaching resources in research serves the direct purpose of enhancing learning and teaching through motivation. However, it leads to an indirect consequence, namely the mitigation of school dropout rates. It is worth highlighting that school dropout is a problematic and complex event, influenced by institutional, individual, financial and external factors, leading students to leave school prematurely. Numerous studies endeavor to elucidate the underlying causes of school dropout, with one of the models employed in this research being rooted in the works of scholars Vincent Tinto (1975) and Russell Rumberger (1987), extensively discussed in the study conducted by Feitosa and Oliveira (2022).

Consequently, the present study demonstrates techniques employed to incorporate practical activities into the aforementioned subjects, aiming to foster learning through methods related to those used in traditional face-to-face classrooms. Moreover, these techniques are designed to address the issue of school dropout. The research methodology integrates both quantitative and qualitative approaches, enabling an exploration of the challenges faced by stakeholders. Proposed solutions are grounded in the observed phenomena, drawing on qualitative data related to motivation and dropout rates, as well as quantitative data on learning outcomes.

Additionally, it is essential to note that the methodology implemented at the technical level is viable for higher engineering education, particularly in the fields of mechanical and automotive engineering. Consequently, this study outlines the strategies employed to introduce practical activities in the aforementioned subjects, aiming to enhance teaching methodologies using tools reminiscent of those employed in traditional in-person classes.

## 2. METHODOLOGY

Throughout the project's duration, there were students who participated both in person and remotely, simultaneously. As the IFSC Health Safety Policy (HSP) progressed through different phases, several subjects within the Automotive Maintenance Course were offered in a hybrid format, combining traditional and online classes. The development of these didactic resources was prompted by the challenges encountered during the initial semesters of non-contact activities, which resulted in absenteeism and students frustration. The subjects covered in the second semester traditionally involve the utilization of laboratory equipment and tools, making them highly motivating due to the hands-on nature of the practical activities. The inability to carry out these activities as a result of physical distancing regulations generated significant disappointment among the students.

The methodology employed the student access to audiovisual material on automotive maintenance procedures and the utilization of diagnostic tools in non-invasive tests on privately owned vehicles accessible to the student, according to Figure 1. In the initial approach, only internet access is required. However, for the completion of asynchronous practical activities, a smartphone and access to a vehicle are necessary.

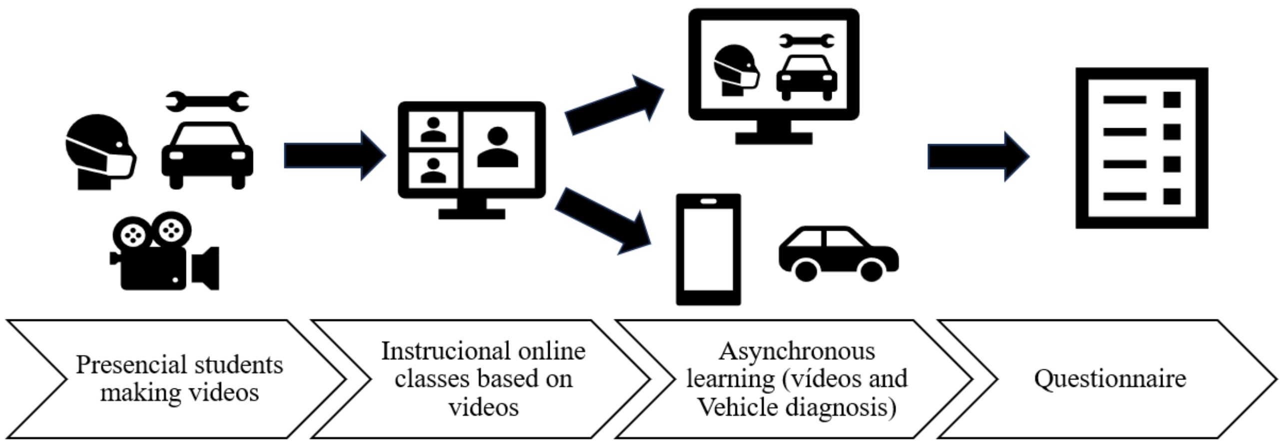


Figure 1. Methodology for asynchronous learning based on audiovisual material and device for ECU diagnosis.

### 2.1 Audiovisual material of practice activities for online students

The video content aligns with teaching techniques and the use of devices to facilitate the investigation of automobile problems and maintenance. The dissemination of these didactic resources has fostered students' autonomy in accessing supplementary study materials. Initially, the different modalities of classes, whether face-to-face or online, posed challenges. However, they ultimately presented an opportunity for the production of audiovisual materials. The practical activities conducted by students in traditional face-to-face classes were recorded and made available for distance learning purposes. This recording process proved beneficial as it facilitated content review for the face-to-face students who prepared for the video, while also allowing other students to review the material multiple times at their own pace of learning. It is worth noting that all students provided consent for their participation and identification in the recordings. The videos were produced using recording equipment (tripod, webcam, ring light, and computer), as well as vehicles, components, and equipment from the Internal Combustion Engine Laboratory and the Automotive Systems Laboratory. Subsequently, the teachers edited and published the videos on a private YouTube channel.

Table 01 – Theme of the videos and the links.

| Video title | Links |
|---|---|
| ANP video - Spark plug replacement | https://youtu.be/DWrL2d_qBFo |
| ANP video - Fuel injector cleaner machine | https://youtu.be/Q5Qz5L1eeO0 |
| ANP video - Combustion chamber volume measurement | https://youtu.be/lioObGk5i9w |
| ANP video - Sandero Oil change | https://www.youtube.com/watch?v=LFK1yavRZWQ |

Four videos were produced, covering the following topics: spark plug replacement, fuel injector cleaner machine, oil change, and combustion chamber volume measurement. The links to these videos are listed in Table 1.

The videos also addressed the procedures and methodologies employed, as exemplified in Figure 2, which illustrates the utilization of torque measurement equipment for spark plug replacement. The correct application of torque is crucial to prevent damage, ensure proper sealing, enhance heat transfer, and achieve uniform tightening torque across all spark plugs in the engine. It is important to note that spark plug torques vary among different vehicle models and manufacturers, necessitating the use of torque values specified in the  manuals or provided by the manufacturers.


Figure 2. Video Frame of spark plug replacement showing the correct application of torque.

Figure 3 showcases the video recording process of a student preparing measurements of the compression chamber volume. The video demonstrates and explains the procedure, highlighting the direct influence of this measurement on performance and efficiency analysis of the combustion engine. The volume measurement, performed by introducing a liquid into the chamber, is used in the calculation of the compression ratio of the fuel-air mixture within the engine.

The instructional videos were uploaded on YouTube, and the corresponding links were shared throughout the semester within the Virtual Learning Environment (VLE) of the institution known as SIGAA (acronym for Sistema Integrado de Gestão das Atividades Acadêmicas in Portuguese), which serves as a comprehensive platform for managing academic activities. At the end of classes, an online questionnaire was submitted to all students using Google Forms.

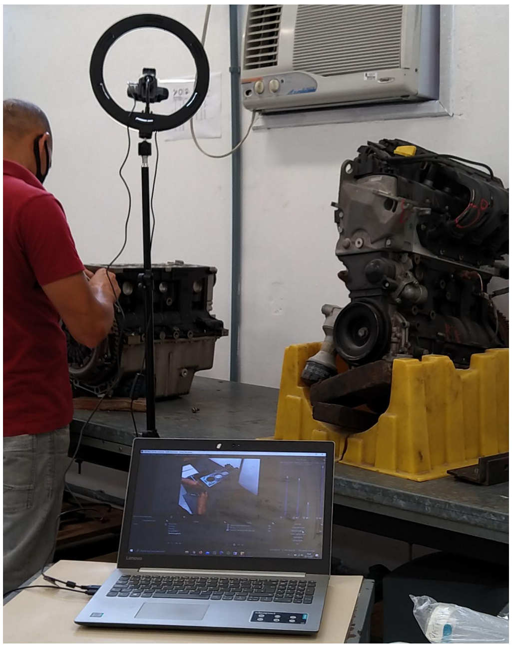

Figure 3. Combustion chamber volume measurement performed by a student.

### 2.2 Bluetooth communicator for Electronic Control Unit diagnosis

There was an additional didactic resource implemented to enhance the teaching methodology for non-face-to-face activities: a didactic kit designed for learning electronic ignition systems and engine diagnosis. This kit consisted of an Electronic Control Unit (ECU) Bluetooth communicator intended for smartphone use. The communicator, as illustrated in Figure 4, is connected to the On-Board Diagnostic II (OBDII) port of the vehicle's electronic control unit. It is worth noting that only vehicles equipped with an OBDII port are compatible with the Bluetooth communicator. It is important to mention that the majority of vehicles up to fifteen years old in Brazil are equipped with an OBDII port, thus allowing connectivity with the Bluetooth communicator.

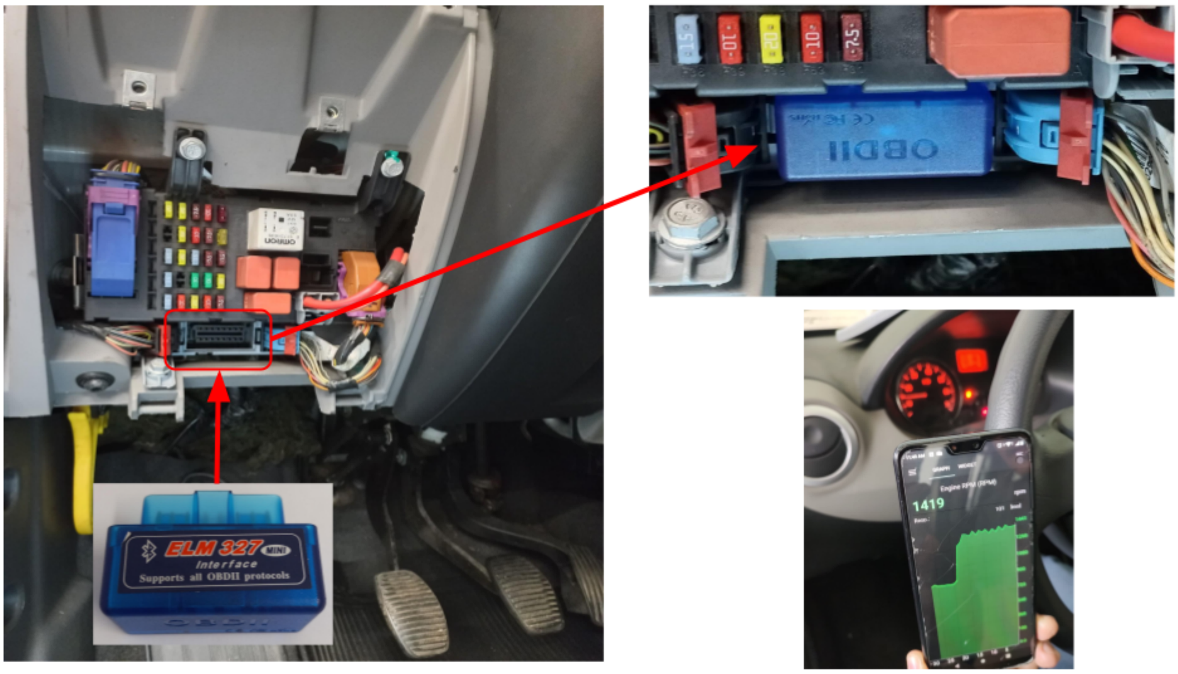


Figure 4 - Scheme of using the OBDII communicator in the ECU.

The communicator can be connected via Bluetooth to any smartphone using a dedicated application, which may be available either for free or at a cost. This application enables the reading and management of engine electronic parameters, providing a comprehensive means of accessing and controlling relevant data related to the engine's performance.

## 3. RESULTS AND DISCUSSION

The didactic resource to support practical classes was made available to the academic community with the purpose of demonstrating the activities developed by the students in this project. The videos of hybrid classes have been shared with students and the community, including their family and friends, as an audience with whom the students can share the video links, thereby contributing to extension activities. The classes on internal combustion engines and Ignition and Fuel Injection systems include resources that can be integrated with smartphones, providing information about more affordable preliminary diagnostic tools such as an endoscopic camera (to be inserted into the engine and hard-to-reach areas) and an OBDII scanner (connected to the engine's electronic control module to capture signals received and sent by this unit). In this context, these disciplines offer practical distance learning activities that enable students to perform preventive maintenance on external vehicles based on the content covered in the classroom.

At the end of the academic semester, the students answered a survey to evaluate the impact of the project on the learning experience. Eight students answered the questionnaire out of a total of fourteen engaged with Internal combustion engines and Ignition and Fuel Injection systems classes.

The questions were divided into three parts: the first to identify the student; the second to confirm the visualization; and the third for evaluation.

The first part of the questionnaire pertains to student identification and the type of teaching modality they experienced in the curricular units (Online, or Hybrid). The second part consists of a question for each of the four available videos, aimed at verifying whether the videos were actually watched. All the students who participated in the questionnaire answered the first part correctly, demonstrating that they have attained a sufficient level of content absorption.

Finally, students who answered the questions in the second section correctly were directed to evaluate the videos in a third part of the questionnaire. The response required assigning a rating on a scale of 1 to 5 to the following question: "To what extent did the videos contribute to your knowledge in automotive maintenance?" Additionally, students were asked an optional open-ended question: “Did you learn any new details or interesting facts from the videos?”.

All participants correctly answered the second part of the questionnaire, corroborating the verification of their learning. Regarding the third section, five students gave the maximum score, while three of them answered score four (scale of one to five).

Some students contributed with messages:

a) *"Yes, there are several and corrects ways to do maintenance";*
b) *“Yes, very well explained videos, congratulations !!;*
c) *“(I have learned) how the oil filter is removed and how it works inside it.”;*
d) *“Yes, (I did not know) the part of the video about pressure relief with the oil dipstick.”*

The authors translated the responses from Portuguese.

The videos resulted in more views than the number of students participating in the classes. In YouTube's creator environment, videos were tagged as "unlisted", so only a person with the video link could watch. Table 02 indicates the number of views.

Table 02 – Number of views of educational videos at the end of semester.

| Video title | Number of views |
|---|---|
| *Vídeo ANP IFSC - Medição do Volume da Câmara de Compressão* (ANP video - Combustion chamber volume measurement) | 43 |
| *Vídeo ANP - Máquina de limpeza de bicos* (ANP video - Fuel injector cleaner machine) | 20 |
| *Vídeo ANP - Troca de vela* (ANP video - Spark plug replacement) | 34 |
| *Vídeo ANP - Troca de óleo Sandero* (ANP video - Sandero Oil change) | 16 |

The videos resulted in a number of views above the amount of students participating in the classes. In YouTube's creator environment, videos were tagged as "unlisted", so only a person with the video link could watch. Table 02 indicates the number of views obtained.

It is not possible to track all audiences in detail, but it is possible to correlate with two situations: repeated viewing through different devices and sharing the video link with student family members or friends.

In relation to the utilization of OBDII communicators, the demand for their use was lower than anticipated due to the significant resource requirements associated with their implementation. Despite the widespread availability of smartphones among the general population, the activities needing the use of a vehicle equipped with an OBDII port.

The application of these devices yielded positive outcomes and received unanimous approval from students. Furthermore, their incorporation significantly contributed to the teaching-learning process, as relying solely on virtual instruction can often result in a heightened level of abstraction.

When analyzing the results from the final class council for the 2021.2 semester (Figure 5), a 29% rate of students who did not succeed can be observed, meaning they dropped out of both analyzed subjects. There were no failures recorded during the analyzed semester. It is important to note that all students who responded to the questionnaire were approved. Some students might have participated partially in the methodology and did not respond to the survey; however, they will not be considered as there is no metric to assess their performance. The purpose of the questionnaire at the end of the methodology was to assess the learning outcomes of the method and obtain feedback from students regarding the methodology.

'Dropout' refers to a student who left classes and evaluative activities at some point during the course, failing to achieve the minimum grades and attendance requirement of 75%. Students who did not meet the approval requirements but still attended the activities are considered failed.

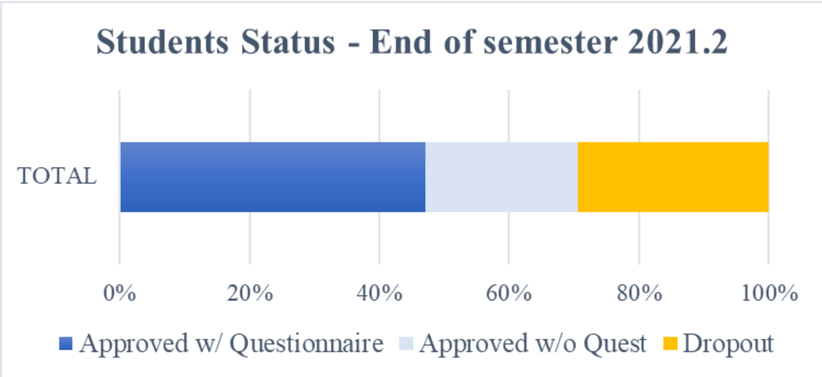


Figure 5 - Class Council 2021.2 semester results. Only IIS and ICE classes were considered.

In Figure 6, the same student data were separated by modality, hybrid, or distance learning. It is noticeable here that students in the hybrid model had fewer dropouts compared to those in the ANP model. Furthermore, the engagement with the applied methodology was proportionally higher among students in the ANP modality.

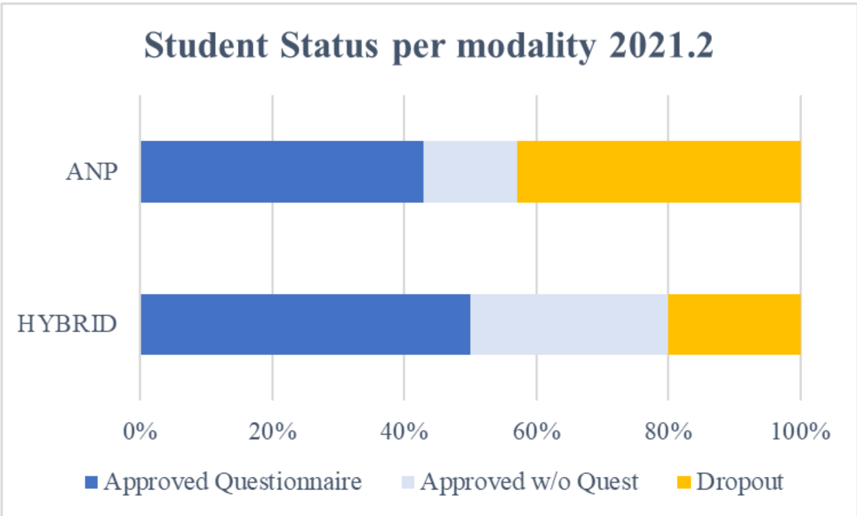


Figure 6 - Class Council 2021.2 semester results separated by classes

Just to illustrate the context of dropout rates found in these two subjects, it's important to note that these are part of the second semester of the program. Figure 7 provides a historical overview of the semesters as discussed in each final class council. The 2021.1 semester was conducted entirely online, while the 2021.2 semester followed hybrid and online formats. In-person teaching resumed in 2022.1. Therefore, it can be inferred that these students completed the first semester of the program online and the second semester entirely in person. The semesters 2022.2 and 2023.1 consist of students who have pursued the entire course in person from the beginning.

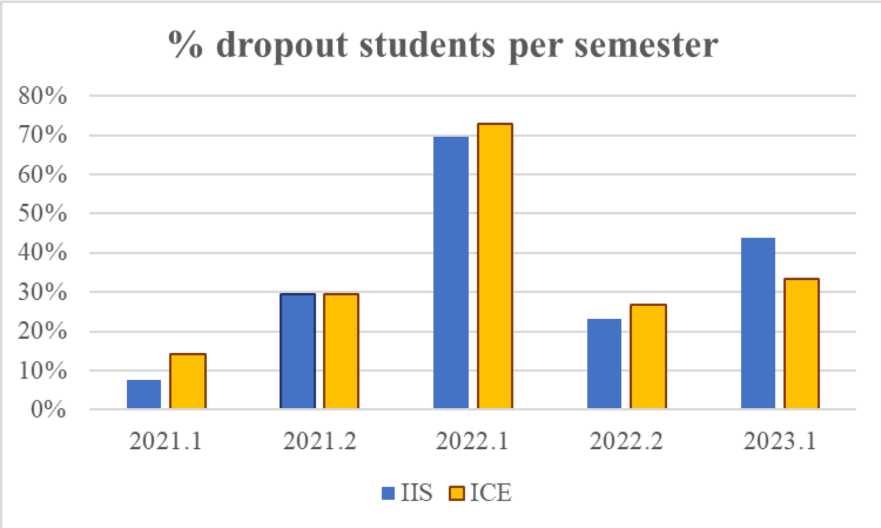


Figure 7 - Class Council results from pandemic semesters until nowadays. Only IIS and ICE classes were considered.

Thus, it is evident that the semester in which the methodology was applied showed dropout rates similar to the current in-person semesters, indicating that the transition period back to in-person activities was significantly impacted in this regard. This emphasizes the discussion that dropout rates are influenced by various factors, and the activities were conducted under special circumstances to mitigate some of these factors. Learning is not straightforward to measure; assessment grades alone are insufficient. We were able to evaluate if the students grasped the minimum requirements. The activities were focused only on two subjects: ICE and IIS, and students had other subjects and educational experiences at different times throughout the week. Therefore, in the realm of education, we must exercise caution when analyzing purely numerical outcomes.

The methodology's effectiveness is considered positive for several reasons. Firstly, students engaged in activities in both modalities achieved similar approval rates and underwent identical assessments during the course. Secondly, the semester in which the methodology was applied demonstrated dropout rates comparable to regular, in-person semesters, even though it operated in a hybrid condition with changes in the daily teaching routine.

## 4. CONCLUSION

The COVID-19 pandemic and the consequent implementation of social distancing measures had a notable influence on the occurrence of school dropouts, particularly in practical-based courses. Consequently, it became important for educational institutions and agents to explore alternative teaching methodologies that could effectively sustain engagement and connection with students.

The project aimed to propose a didactic pedagogical methodology that integrates teaching and research to facilitate the implementation of practical activities within certain curricular units of the automotive maintenance course. This initiative was developed during a period of social distancing enforced by the ongoing pandemic. These alternatives were implemented with the secondary objective of maintaining students' motivation during such an adverse period, considering that lack of motivation is one of the factors contributing to school dropout.

The work findings demonstrated favorable outcomes regarding the utilization of didactic resources. The students positively responded to the employed methodology, as they were able to participate in practical activities proposed. Furthermore, the evaluation process verified the effectively comprehend the proposed content, thereby corroborating the project's objectives. It is important to note that evaluating a teaching-learning process using numerical metrics and grades to judge acquired knowledge can be challenging. Due to this sensitivity, this study relied on qualitative assessments.

The extension of teaching instructions provided an opportunity for the students' families to engage with automotive-related topics, thereby promoting the project's objectives and generating curiosity among this audience.

It is worth mentioning that with the return of hybrid classes, the approach can be useful in conditions where there is no infrastructure or classroom time available to carry out practical activities. For example, in disciplines related to internal combustion engines or Otto cycle thermodynamics in undergraduate courses, it is possible for the student to independently verify the ignition timing advancing pattern with increasing engine speed, air-fuel strategy, and closed-loop control system operation of the engine control unit. In this case, the student can access the data through the scanner provided, a smartphone, and use a laboratory vehicle during off-hours or even a personal automobile, as it is a low-risk and non-invasive activity. This work suggests the methodology application for undergraduate subjects as System Dynamics Practice, Control Systems, General Physics Practice, Heat and Mass Transfer and Automotive Embedded Systems.

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## 7. RESPONSIBILITY NOTICE

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