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# Design and evaluation of a balanced scorecard to measure the impact of COVID-19 on a Mexican higher education institution

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## Abstract
The COVID-19 pandemic has highlighted the importance of effectively monitoring and understanding its impact on the general population, especially regarding mental health and well-being. The isolation measures implemented during the lockdown significantly affected people's lives by changing habits and circumstances. To address this challenge, this project aims to develop a comprehensive Balanced Scorecard for data gathered through surveys from higher education students at a Mexican university.

This study aims to validate the usability of the Balanced Scorecard for users and ensure that it effectively meets their needs. The project encounters significant challenges, such as ensuring the quality and accuracy of collected data and addressing potential data cleansing issues. However, the insights generated could be crucial for decision-making in future pandemics and epidemics.

## Keywords:
Balanced Scorecard; COVID-19 impact; Mental Health and Well-Being; Survey Data Analysis; Higher Education; Usability Validation.

## 1 Introduction
The COVID-19 pandemic highlighted the importance of monitoring and understanding the impact of epidemics and pandemics on the population. During the lockdown period, individuals experienced significant changes in their habits and personal circumstances, leading to considerable risks in areas such as mental health [6, 13] and economic stability [14]. The effects of confinement, mobility restrictions, and social distancing underscored the need for tools to comprehensively evaluate these repercussions across various sectors of society, including higher education students [20].

In response to this need, the present project proposes the development of a Balanced Scorecard (BSC) [18, 19] based on data obtained from a survey conducted with students at a public state university in Mexico. This tool aims to provide a detailed and dynamic view of the pandemic's social impact on the student population. It allows for interactive visualization of the collected data, identification of specific trends, and meaningful analyses. It ultimately contributes to understanding the effects of the pandemic on mental health, risk perception, and the adoption of preventive measures within the student community.

Implementing tools like the Balanced Scorecard (BSC) in the educational context facilitates a multidimensional assessment of the pandemic's effects, considering key factors such as mental health, disease impact, and student risk perception. Previous studies have shown that university students experienced a significant increase in anxiety and depression levels during the pandemic, attributed to factors such as academic uncertainty, reduced social interaction, and fear of infection [4, 22]. Additionally, the overload of educational tasks and lack of adequate technological resources exacerbated stress levels, highlighting the need for tools that help monitor and address these challenges promptly [5].

The contributions of this project lie in its ability to provide essential information for formulating policies and strategies for prevention and treatment during future pandemics and epidemics. It also supports adopting dynamic and adaptable analytical tools to monitor students' mental health and well-being during health crises, which can guide more effective and tailored interventions for this population [11]. In this regard, developing a BSC tailored to the specific context of public higher education institutions in Mexico could provide an invaluable framework for continuous monitoring and policy formulation that promotes student resilience and well-being.

In this context, the development of a specific BSC to assess these impacts is innovative and becomes an essential tool to strengthen responses to future health emergencies. The data

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generated will enable health professionals, public health authorities, researchers, and the general population to gain a deeper understanding of the effects of COVID-19 and, based on this, develop more effective strategies to mitigate the impacts of future pandemics and epidemics.

## 2 Related works

During the COVID-19 pandemic, higher education students worldwide have been significantly affected, with impacts on their academic performance and mental and social well-being. Several studies have highlighted these repercussions and emphasized the importance of using tools like Balanced Scorecards to monitor and evaluate these effects on students comprehensively.

Aristovnik et al. [2] conducted one of the most extensive studies to date, covering a sample of 30,383 students from 62 countries, to assess how students perceived the pandemic's impact on their lives. The results showed that, despite the challenges such as poor computer skills and an increased workload, students managed to adapt and continue their academic journey. They valued the support from their universities and faculty, but also reported high levels of anxiety and frustration, particularly concerning their professional futures.

In the United States, Son et al. [26] investigated the pandemic's effects on university students' mental health through interviews. The findings indicated that 71% of students reported increased stress and anxiety due to COVID-19. The most common stressors included concerns about their health and that of their loved ones, difficulty concentrating, and disrupted sleep patterns.

Another significant study conducted in Istanbul by Bulut et al. [8] analyzed the pandemic's impact on the academic and mental well-being of higher education students, finding high levels of depression, academic stress, and a significant decrease in physical activity and social contact. The study underscored the urgent need for targeted social and mental health interventions for students during health crises, highlighting the severity of the situation.

In an analysis of the pandemic's effects on students' academic performance, González et al. [12] found that COVID-19 confinement had a positive impact on students' performance in terms of more consistent and efficient study habits, resulting in higher grades in assessments. These findings highlight how the shift to a more autonomous learning environment during the pandemic altered students' study strategies.

These studies highlight the various effects of the pandemic on the student community and emphasize the critical role of comprehensive tools like the Balanced Scorecard. Its capacity to incorporate multiple dimensions of analysis makes it a compelling and valuable tool for decision-making in the educational sector during crises [23].

## 3 Materials and methods

This research project utilizes User-Centered Design (UCD) as its primary methodology. UCD emphasizes understanding the users' needs and characteristics as the starting point to ensure that its potential users find the final product suitable and well-accepted [1]. The UCD process was complemented by a systematic data collection and data processing phase to inform and feed the Balanced Scorecard. Additionally, a usability evaluation was conducted to assess the effectiveness and user experience of the system.

### 3.1 Design

To understand how users will use the system, we used a participatory design approach [9] in collaboration with staff members from the University of Colima in Mexico. Four design specialists participated in the process. We gathered user insights in three stages: initial interviews to get user insights, a co-design process to identify the system's needs, and finally, a usability evaluation phase to assess the proposed solution.

### 3.2 Data Collection

The second stage of this project consist in collect the data with the objective of to know the impact that COVID-19 has had on the student population at the Universidad de Colima and understand their behaviors and attitudes regarding health containment measures in the country (vaccines, use of a mask, etc.). The data was collected in a web-based survey among University of Colima, Mexico students. The survey consisted of 52 closed-ended questions. Topics included demographic information, changes in diet, effects of isolation, potential risk factors, effects of contagion and disease, vaccination status, health measures, and perceptions of public policies implemented in the country. Data collection took place from 31 May to 11 June 2022, and the survey was conducted in Spanish to improve comprehension and accessibility for respondents. The survey was adapted from the work of Joaquin Damas and colleagues, some of whom are coauthors of this work [17].

#### 3.2.1 Sample

When the survey was conducted, the University of Colima had a total student population of 26,076 [7], of which 20,158 (77.3%) participated in the survey. Participation varied across educational levels: at the high school level, there were 13,308 students, with 77.04% (10,252 students) participating in the survey. At the undergraduate level, there were 11,922 students, with a participation rate of 79.92% (9,528 students). The graduate student population was 846, and 44.68% (378 students) responded to the survey. These participation rates reflect a high level of engagement among students across the university, as seen in Figure 1.

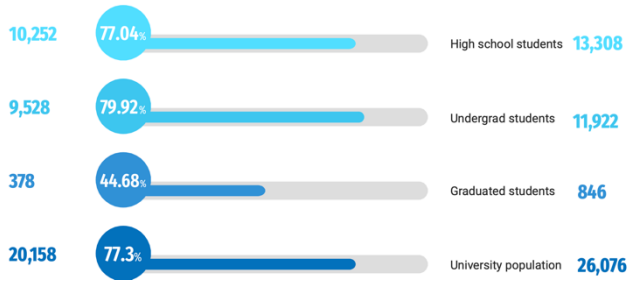


**Figure 1. Response rates by educational level.**

### 3.3 Usability test

The usability test was conducted to systematically evaluate the effectiveness, efficiency, and user satisfaction of the developed system, providing feedback on its overall usability. The evaluation was designed to identify usability issues that could negatively affect the user experience and inform further iterations of the design process.

The usability testing involved 36 fifth-semester Software Engineering students actively engaged in a Human-Computer Interaction (HCI) course. The test employed the System Usability Scale (SUS) as the primary tool for quantitative usability assessment. The SUS, a widely recognized and reliable instrument, consists of a 10-item questionnaire that provides a standardized measure of usability by capturing user responses on a five-point Likert scale [3, 15].

Participants were given a set of tasks to perform within the system, simulating real-world usage scenarios. These tasks assessed the system's navigation, functionality, and interface design. Upon finishing the tasks, participants filled out the SUS questionnaire. The data collected were then analyzed to produce usability scores and identify areas for improvement.

# 4 RESULTS

The current results of this research focus on the designed system and its usability assessment.

## 4.1 Balanced Scorecard

A fully functional Balanced Scorecard (BSC) prototype was created as a responsive web application, complete with analytical and visualization engines. The BSC's system architecture is service-oriented [24], aiming to centralize prediction algorithms and data analysis while making deployment seamless across any device with an integrated web browser.

The application can be accessed via any web browser on desktop or mobile devices. Figure 2 shows the BSC's home screen. The interfaces display generic data for privacy reasons.

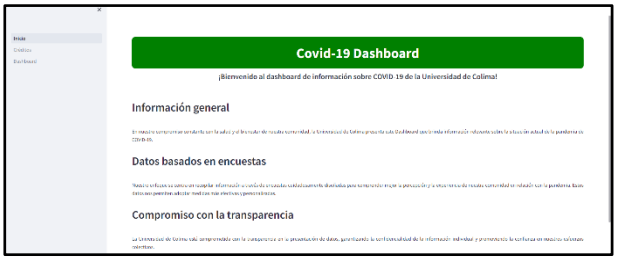


**Figure 2. Landing page.**

Information is organized into tabs based on major themes from the survey. The first level of visualization shows the number of students who responded to the survey, categorized by their level of study (see Figure 3).


**Figure 3. Responses by educational level.**

Another important visualization provides information about changes in students' dietary habits during the pandemic lockdown (see Figure 4). The responses are categorized as follows: "No, it remains the same," "Yes, my consumption of fruits and vegetables has increased," and "Yes, my consumption of fruits and vegetables has decreased."


**Figure 4. Dietary habits.**

The system also contains information about the preventive measures students implement daily to reduce the risk of contagion. These measures include handwashing, wearing masks, maintaining a distance of at least one meter from others, and the option of not taking any preventive actions (see Figure 5).

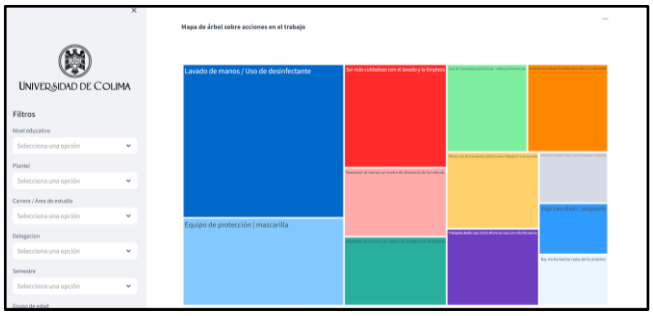


**Figure 5. Measures to reduce risk of contagion.**

Furthermore, the application provides information directly related to the disease, such as whether students were vaccinated and if they had access to timely information on recommended health measures. These insights help to understand students' behaviors and actions during the lockdown, offering valuable data for potential policy-making and institutional responses.

## 4.2 Usability evaluation

Assessing usability is crucial when developing technological systems and tools, especially those used by many people to make important health-related decisions. In these cases, the aim is to enhance user experience and ensure that products meet accessibility and ease of use standards. As mentioned, the SUS was used to evaluate a technological tool with fifth-semester Software Engineering students actively involved in the HCI teaching and learning process. Using the SUS scale in this context ensures a standardized and comparative usability evaluation, providing a quantitative framework that facilitates the identification of areas for improvement.

The decision to involve Software Engineering students in the evaluation process, rather than potential or final users, was made to help them acquire the necessary HCI skills. The student's technical and theoretical knowledge about usability principles, user-centered design, and interface evaluation, gained from their participation in their HCI course, makes them well-suited evaluators. Their valuable and technically sound feedback provides insights into the tool's functionalities and weaknesses.

Involving students directly in designing and evaluating technological tools as part of their education in real-world scenarios

is important for supporting learning [25]. It is also vital to adapt the tool to the actual needs of the academic environment where the BSC will be used.

### 4.2.1 Findings

The results of the SUS score analysis are as follows.

The average SUS score is 70.83, indicating that the system's overall usability is above the established benchmark of 68 [15]. It suggests that the tool has acceptable usability and is generally well-received by users. The standard deviation is 19.07, reflecting moderate variability in student responses, indicating that users' usability experiences vary significantly. The scores range from a minimum of 37.5 to a maximum of 100, showing that while some users experienced significant usability issues, others found the tool highly usable (see Figure 6).

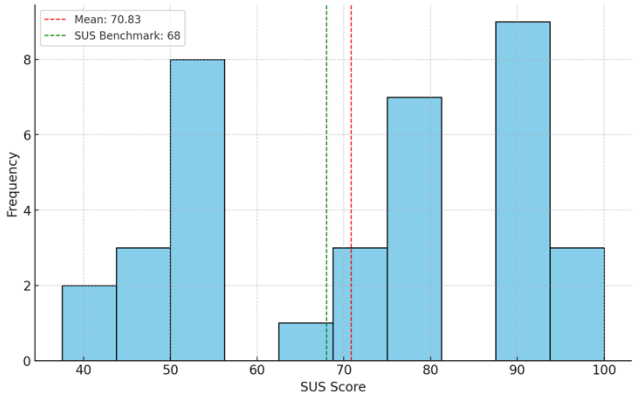


**Figure 6. Distribution of SUS scores.**

The Figure 7 shows the boxplot of the general SUS scores that provides an overview of the distribution, highlighting key statistics that reflect the overall usability perceptions. The median score is 75, indicating that half of the users rated the system above this value, reflecting a generally positive usability experience. The interquartile range (IQR) spans from 50 to 88.13, revealing that 25% of the scores are below 50, suggesting usability problems for a significant minority of users, while 50% of the scores are at 75, and 75% exceed 88.13, indicating that most users perceive the tool as very usable.

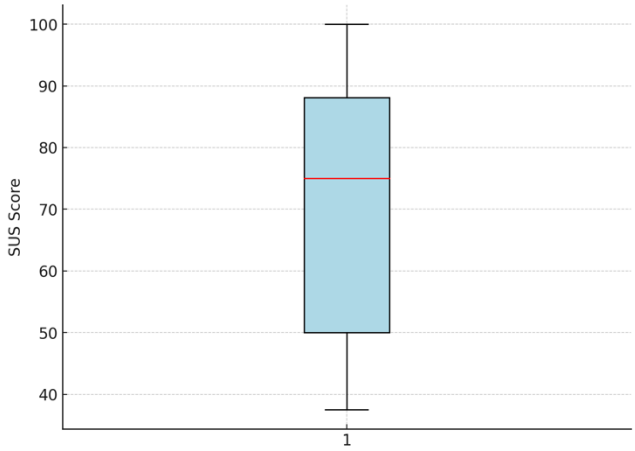


**Figure 7. General boxplot of SUS scores.**

The strip plot, in Figure 8, illustrates the individual SUS scores for each user, providing a clear visual representation of the distribution of usability ratings across participants. Each dot represents a user's score, with the vertical positioning showing how each participant evaluated the system's usability. The green dashed line indicates the benchmark score of 68, which serves as a standard threshold for acceptable usability, while the red dashed line represents the average score of 70.83. This comparison highlights that many users rated the system above the benchmark, suggesting that the system generally meets usability expectations. However, several scores fall below this threshold, indicating variability in user experiences and identifying potential areas for improvement. The spread of scores emphasizes the need for targeted adjustments to enhance consistency in user satisfaction, particularly for those participants whose scores are significantly lower.

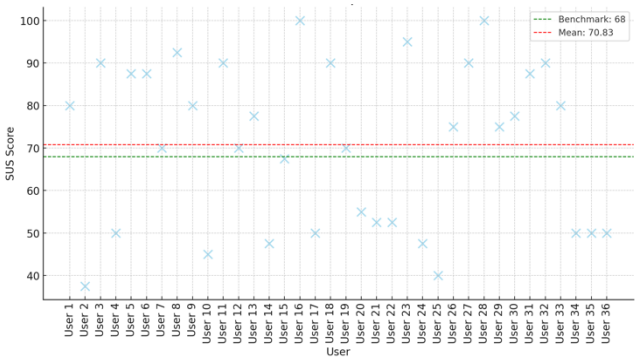


**Figure 8. SUS scores per user.**

## 5 Discussion

The SUS evaluation revealed several usability issues and strengths that critically influence the user experience. These findings align with existing literature on usability challenges and strengths across various systems, providing a broader context for the observed results.

### 5.1 Usability issues

Common usability issues identified in the system, such as poor error handling and inadequate feedback mechanisms, are well-documented in the literature as factors that significantly impact user experience. For example, Marcilly et al. [21] found that usability flaws, particularly poor error handling and unclear feedback in

medication alerting systems, have severe cognitive, emotional, and attitudinal consequences on users. These issues degrade workflow efficiency, reduce technology effectiveness, and compromise safety in critical systems like healthcare.

The steep learning curve, exacerbated by the absence of onboarding tools like tutorials or help features, is a pressing issue. Research has consistently shown that the lack of clear guidance and support systems can overwhelm new users, particularly in complex interfaces. For instance, Wijayarathna and Arachchilage [27] underscored that overly complicated application programming interfaces (APIs) often deter effective use, leading to frequent errors and a negative user experience, especially among less experienced users.

## 5.2 Usability strengths

Despite the challenges, the system boasts several strengths, such as intuitive navigation and a well-organized interface. These elements significantly enhance the user experience by reducing cognitive load and improving task efficiency. The significance of clear and straightforward navigation is underscored by Ferreira et al. [10], who demonstrated that efficient navigation and layout significantly contribute to user satisfaction and task performance.

The system's consistent visual design and responsive performance also foster trust and reliability, enhancing overall user satisfaction. This finding aligns with Jiang et al. [16], who showed that consistent performance and ease of maintenance in user interfaces are crucial in creating a positive user experience, particularly in high-stakes environments like medical ventilators.

# 6 Conclusion

This work presents the design and usability evaluation of a Balanced Scorecard software tool conducted with Software Engineering students as part of their Human-Computer Interaction training. The design and evaluation were grounded in a user-centered design approach, emphasizing the alignment of the tool's functionalities with the needs and expectations of an intended academic audience. The initial evaluation results demonstrate that the tool achieves an acceptable level of usability, as indicated by SUS scores above average. However, some usability challenges were identified, indicating further design refinement is needed to enhance user experience.

Addressing the identified usability issues, such as improving error handling and enhancing onboarding tools, can significantly improve the overall user experience and system satisfaction. Maintaining and refining the system's strengths, like intuitive navigation and responsive design, will ensure continued user trust and efficiency in future iterations. These findings are consistent with broader research on usability, highlighting the need for balanced, user-centered design to optimize system performance and user satisfaction.

The primary limitation of this study is that it used a specific student sample in a controlled academic environment. This suggests the need for additional testing with potential users in more realistic settings to ensure broader applicability. Our future work will focus on implementing the improvements to address the identified usability issues. Further evaluations with final users will be conducted to validate the generalizability across the targeted scenario.

As a final instance, after deploying the BSC, it will serve as a decision-support tool by providing actionable insights into various dimensions of student well-being. For instance, administrators such as managers, principals, tutors, and advisors can use the data to identify the mental health support services that are most required, adjust academic policies to accommodate students' changing needs, and develop targeted communication strategies to promote health measures effectively. Moreover, the BSC can help make decisions about resource allocation, such as investing in technology for improved remote learning or expanding counseling services. Through these data-driven findings, institutions can create a more responsive and supportive environment that directly addresses the challenges of the pandemic and be prepared with well-informed decisions for future health emergencies.

# 7 Acknowledgments

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