Human-Centered Design and User Experience, Vol. 114, 2023, 683–691
https://doi.org/10.54941/ahfe1004289

A Digital Platform for Respiratory Rehabilitation in Patients With Post-COVID19: Design and Usability Evaluation

Marco Santórum[1], Mayra Carrión-Toro[1], Patricia Acosta-Vargas[2,3], David Morales-Martínez[1], Julián Galindo-Losada[1], Camila Madera[4], Gloria Acosta-Vargas[5], Verónica Maldonado-Garcés[6], Manuel Ayala-Chauvin[7], Mario González-Rodríguez[2,3], and Esteban Ortiz-Prado[8]

[1]Departamento de Informática y Ciencias de la Computación, Escuela Politécnica Nacional, Quito 170525, Ecuador
[2]Intelligent and Interactive Systems Laboratory, Universidad de Las Américas, Quito, Ecuador
[3]Facultad de Ingeniería y Ciencias Aplicadas, Universidad de Las Américas, Quito, Ecuador
[4]Facultad de Enfermería, Pontificia Universidad Católica del Ecuador, Quito, Ecuador
[5]Facultad de Medicina, Pontificia Universidad Católica del Ecuador, Quito, Ecuador
[6]Facultad de Psicología, Pontificia Universidad Católica del Ecuador, Quito, Ecuador
[7]Centro de Investigación en Ciencias Humanas y de la Educación - CICHE Universidad Tecnológica Indoamérica, Quito, Ecuador
[8]One Health Research Group, Universidad de las Américas, Quito, Ecuador

ABSTRACT

In response to the imperative to address the lingering respiratory effects of COVID-19, we present the outcomes of our endeavor to develop a digital platform tailored for effective therapeutic education in respiratory rehabilitation. This platform meets the escalating demand for remote rehabilitation services, particularly for patients contending with post-COVID-19 respiratory conditions. It not only furnishes therapeutic education and facilitates self-guided rehabilitation sessions but also caters to the training needs of healthcare professionals and students specializing in respiratory rehabilitation. Employing a meticulous user-centered approach, we engaged rehabilitation therapy experts and collaborated with educational institutions to shape the platform's design. Its usability evaluation was guided by Abhay Rautela's protocol, supplemented by the Computer System Usability Questionnaire (CSUQ). The evaluation encompassed 58 participants undertaking tasks reflective of their roles as patients. Insights collected via the CSUQ provided a comprehensive assessment of user satisfaction and overall platform usability. The ensuing analysis of usability evaluation results offers valuable insights into the platform's strengths and areas for enhancement. The cumulative usability acceptance percentage of 72.56% positions our platform within the "Acceptable" range on the System Usability Scale (SUS). This research advances respiratory rehabilitation by offering a solution that is accessible, efficient, and adept at supporting post-COVID-19 recovery journeys.

Keywords: Telerehabilitation, Usability evaluation, SARS-COV-2, Telemedicine, E-rehabilitation, COVID-19, CSUQ

INTRODUCTION

The COVID-19 pandemic caused by SARS-CoV-2 has posed unprecedented challenges to global healthcare systems, necessitating efforts to contain its spread and minimize its impact on mortality. Addressing the long-term health effects experienced by COVID-19 survivors, especially respiratory conditions, has emerged as a significant concern, profoundly affecting the quality of life and functional abilities of recovering patients.

In response, the healthcare field has rapidly evolved with the emergence of Information and Communication Technologies (ICT), playing a pivotal role during the pandemic by facilitating work and social interactions. Telemedicine and tele-rehabilitation have arisen as essential tools in providing comprehensive post-COVID-19 care, bridging the gap between patients and healthcare providers while ensuring the safety and accessibility of healthcare services.

The field of telerehabilitation has gained prominence as a valuable approach to delivering remote healthcare services, particularly in the context of the COVID-19 pandemic. Several telerehabilitation platforms have emerged to address the challenges of delivering rehabilitation interventions to individuals with COVID-19-related sequelae. Notable platforms include ReCOVery (Samper-Pardo *et al.*, 2023), Rehab Guru (RehabGuru, 2022), Rehab My Patient (RehabMyPatient, 2023), and FreePT (FreePT, 2023). Additionally, platforms like Microsoft Teams, Zoom, Google Hangouts, Skype, Facebook Messenger, and Apple Facetime have played pivotal roles in facilitating telemedicine, offering video consultations with synchronous and asynchronous support for ambulatory patients.

For successful TR technology, usability is crucial, embracing principles and patterns that promote effectiveness, quality, and service usefulness. The evaluation of usability in TR platforms holds significance in assessing user satisfaction and optimizing system design. Abhay Rautela's protocol (Rautela, 2018) and the Computer System Usability Questionnaire (CSUQ) offer structured methods for evaluating usability (Lewis, 2018). These frameworks guide the identification of user needs and preferences, shaping platforms that cater to user expectations.

Our research aims to advance post-COVID-19 care by developing a usable digital platform for therapeutic education in respiratory rehabilitation. We assess the platform's usability using a proposed protocol and the Computer System Usability Questionnaire (CSUQ).

This article presents the findings of our research, focusing on the results of the usability evaluation and their implications for respiratory rehabilitation. By providing evidence-based insights, we make a significant contribution to the advancement of tele-rehabilitation and telemedicine as integral components of post-COVID-19 care. The article is organized as follows: Section 2 elaborates on the specifics of the conducted case study. Following that, Section 3 outlines the developed protocol for usability evaluation and the corresponding experimental process. Lastly, Section 4 presents the findings and ultimate conclusions.

MATERIAL AND METHODS

As contemporary healthcare landscapes become increasingly reliant on technological solutions, the intricate interplay between user-centered design and efficacious rehabilitation interventions emerges as a focal point of investigation. The developed platform presents tele-rehabilitation with an asynchronous approach. The usability evaluation was conducted considering the platform's main functionalities, focusing on those of greater value from the patient's perspective.

Case Study

The platform provides free and open access to asynchronous tele-rehabilitation sessions for all users with COVID-19 sequelae. Figure 1 shows the main interface of the tele-rehabilitation platform, where four main sections can be clearly identified. Section a) features a Log In for registered users, section b) presents a button to access the platform as a guest, section c) provides a link for user registration on the platform, and section d) offers a link to learn more about the platform.

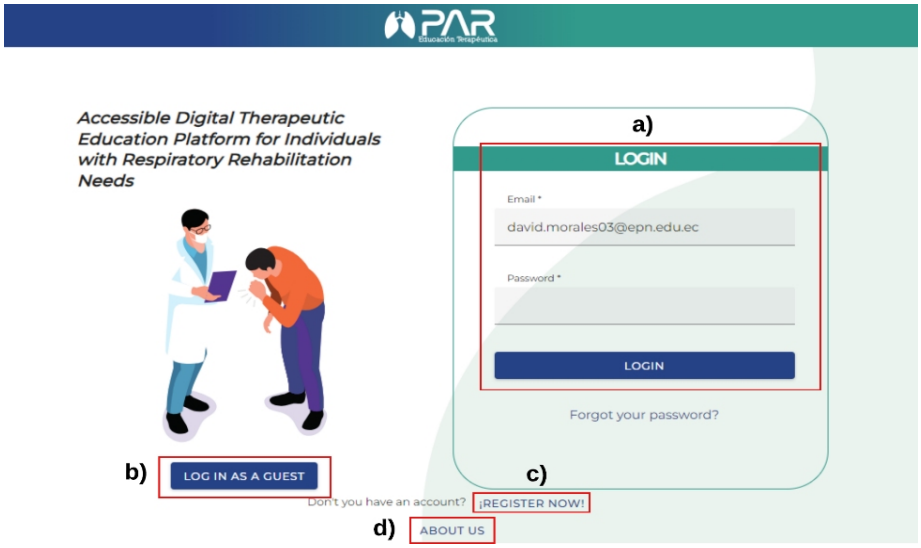

Figure 1: Principal interface of telerehabilitation platform.

In section a), the user can access all the exercises on the platform, including comprehensive rehabilitation plans, as shown in Figure 2, section a). Once the exercise is selected, the patient can perform it by following the video demonstration, which clearly shows how to perform the exercise. Additionally, a description of the exercise can be read as detailed in section b).

Users who do not wish to register on the platform can access tele-rehabilitation materials as guests. In this section, the user can view exercises with low difficulty and suitable for all audiences. However, they won't be able to track their progress with exercise assessments, which are conducted after completing each exercise, as depicted in Figure 3.

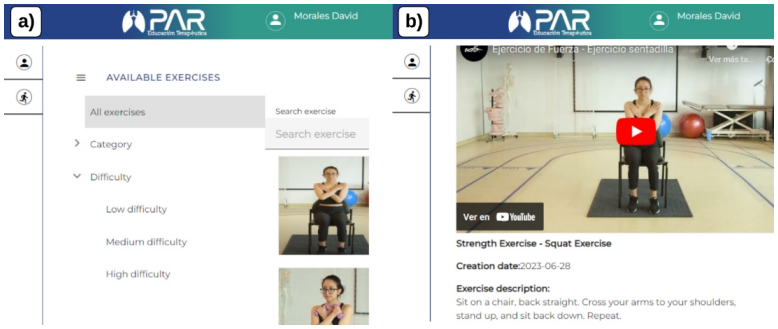

Figure 2: Telerehabilitation exercises.

The feedback obtained from the exercise evaluation helps the platform keep a record of the patient's progress and learn about their well-being during the tele-rehabilitation session.

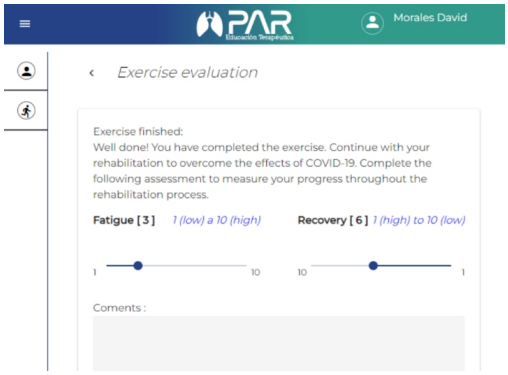

Figure 3: Exercise evaluation.

The platform allows users to register easily and intuitively by filling out forms, as shown in Figure 4. This involves entering their personal information in section a), providing consent for the handling of their personal information in section b), and specifying the specific aftermath they are experiencing in section c).

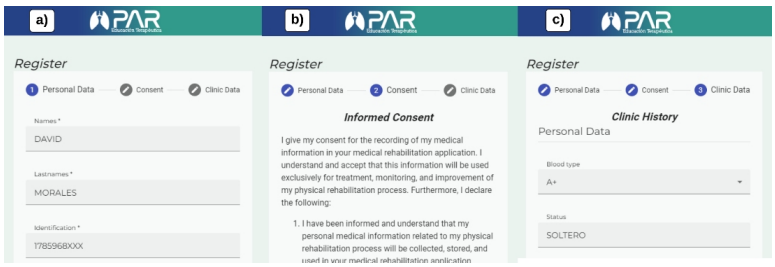

Figure 4: User registration.

Section d) provides information about the platform, its creators, the purpose of the platform, and acknowledges all those who have contributed to its realization.

EVALUATION RESULTS AND DISCUSSION

In this section, the usability evaluation process of the web platform PAR "Therapeutic Education" is described. The usability evaluation was carried out following the usability evaluation protocol proposed by (Rautela, 2018) see Figure 5. This protocol was accompanied by the inquiry method proposed by (Lewis, 1993, 2018) as seen in the Computer System Usability Questionnaire (CSQU).

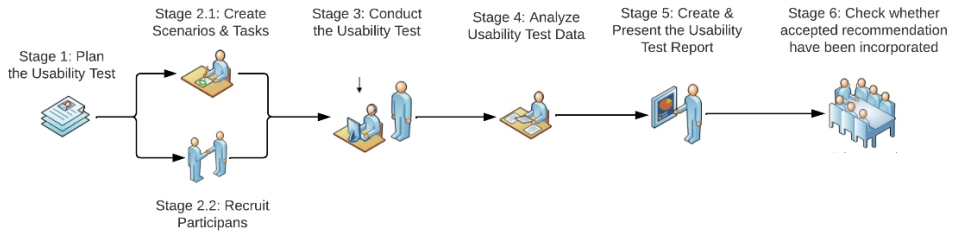

Figure 5: Usability evaluation protocol.

Below, each of the stages of the protocol is described:

Defining Evaluation Objectives

The following objectives are defined.

1. To use the inquiry method, CSQU questionnaire, to evaluate the PAR Web platform.
2. To understand the responses of patient users and their level of satisfaction regarding the platform.

Preparing the Evaluation

In this stage, the necessary materials or documentation are prepared to be provided to each user. This documentation may include the following documents: consent letter, manuals, or tool instructions. In our case, an instructional guide was provided, which specifies a description of the platform and the details of the tasks to be performed by the users.

Participant Selection

This evaluation process was carried out with 58 users considered patients who have experienced COVID, their ages ranging from 23 to 28 years old.

Usability Evaluation Execution

During this stage, the usability evaluation session of the PAR web platform takes place, where the following points are explained:

- General instructions on how the usability evaluation will be conducted.
- Delivery of the necessary documentation or links to each user.

Tasks

Among the specified tasks to be performed by each user are the following:

Table 1. Activities performed in the role of patient.

Tasks and subtasks	
T1. Register as a patient on the Platform	1. Enter first name. 2. Enter last name. 3. Enter identification. 4. Enter date of birth. 5. Enter email address. 6. Enter a password 7. Select user type. 8. Confirm consent. 9. Enter medical history.
T2. Log in to the platform	1.Enter email address. 2.Enter password.
T3. Explore rehabilitation exercises by workout plans	1. Access the Rehabilitation menu. 2. Click on workout plans. 3. Select a workout plan. 4. Click on difficulty and review plans categorized as advanced, low, and basic. 5. Click on category and review the muscular and respiratory options.
T4. Follow a low-difficulty training exercise	1.Click on a video from the workout plans or free training based on your need. 2. Repeat what you see in the exercise video.
T5. Evaluate an exercise when it has been completed	1. Click on completed exercise. 2. Click and move the fatigue line according to your progress level considering 1 (lower) to 10 (higher). 3. Click and move the recovery line according to your progress level considering 1 (higher) to 10 (lower). 4. Click on Finish. 5. Check if the message "Exercise completed for the day" appeared.
T6. Disconnect from the platform	1. Click on the user with your name. 2. Click on Log Out.

Analyze and Present the Results of the Usability Evaluation

In this stage, the obtained values are analyzed and presented through the inquiry method of the CSQU usability surveys (Lewis, 2018). The values ranged from 1 (Strongly Agree) to 7 (Strongly Disagree), including the "Not Applicable" (N/A) option; lower values were interpreted as indicators of

higher satisfaction. To calculate the usability acceptance percentage, a correspondence between CSUQ and SUS values was established to transform the CSUQ scale values from 1 to 7 into a 0 to 100-point scale that matched the SUS scale for interpretation. Equation 1 presents the formula for this transformation.

$$CSUQ = 100 - \left(\left(\left(\frac{\sum_{n=1}^{16} CSUQn}{16}\right) - 1\right) * \left(\frac{100}{6}\right)\right) \quad (1)$$

The process to obtain an equivalent score to that of the SUS from a CSUQ score involves subtracting 1 from the mean of the 16 individual CSUQ questions and multiplying that value by 100/6 to extend it to a 0 to 100-point scale. Then, this value is subtracted from 100 to reverse the scale (Lewis, 2018). The transformation was carried out to utilize the SUS scale (Bangor, Kortum and Miller, 2009), presented in Figure 6, which allows us to compare adjective ratings and acceptability scores in relation to the obtained SUS score. As we can observe in the SUS scale (Brooke, 2013), it assigns the label "Acceptable" when the evaluation score is above 70, "Not Acceptable" when the value is below 50, and "Marginal" when it falls between 50 and 70.

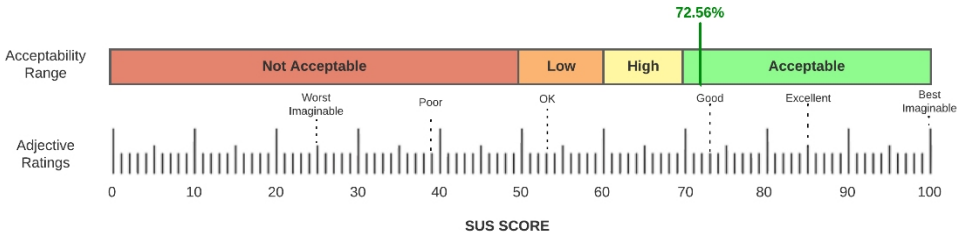

Figure 6: SUS scale.

Figure 7 presents the results of the average analysis for each question and its correspondence between CSUQ and SUS, obtained from the usability evaluation of the PAR platform. Its average is 72.56%, which falls within the "Acceptable" range according to the SUS scale, see Figure 6.

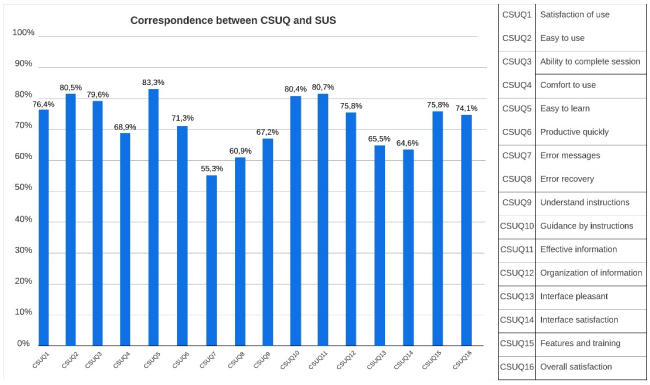

Figure 7: Usability evaluation results per question.

CONCLUSION

This paper has presented the development and evaluation of a digital platform for respiratory rehabilitation in post-COVID-19 patients. The platform addresses the growing demand for remote rehabilitation services, especially in the context of respiratory conditions resulting from COVID-19. By providing therapeutic education and supporting self-rehabilitation sessions, the platform caters to the specific needs of patients while also facilitating the training and education of healthcare professionals and students in the field of respiratory rehabilitation.

The platform's design process, guided by a user-centered approach, incorporated insights from rehabilitation therapy experts and collaboration with educational institutions. The usability evaluation, conducted using the protocol proposed by Abhay Rautela and the Computer System Usability Questionnaire (CSUQ), involved a cohort of 58 participants in roles simulating patients. Through the CSUQ, feedback was gathered to assess user satisfaction and overall platform usability.

The results of the usability evaluation indicated that the platform's usability falls within the "Acceptable" range based on the SUS scale. This research offers valuable insights into the strengths and potential areas for improvement of the platform. It serves as a significant step forward in advancing respiratory rehabilitation, offering accessible and effective solutions for patients on their journey to post-COVID-19 recovery.

The study's findings contribute to the ongoing evolution of telerehabilitation and telemedicine as integral components of post-pandemic healthcare. By prioritizing usability and user-centered design, this research assists healthcare providers in delivering high-quality, patient-centric care remotely. As we continue to navigate the challenges posed by the COVID-19 pandemic and its aftermath, the usability-driven solutions presented in this study hold promise for improving the lives of patients and the efficacy of healthcare services.

ACKNOWLEDGMENT

The authors would like to thank the "Corporación Ecuatoriana para el Desarrollo de la Investigación y Academia – CEDIA" for the support of this research work, through the I+D+I-XVII-2022-27 program, especially for the funding of the project: "Plataforma digital para educación terapéutica accesible hacia las necesidades de rehabilitación respiratoria". The authors want to remark on the contribution of the "Laboratorio de Investigación de Sistemas de Información e Inclusión Digital" (LudoLab - https://ludolab.epn.edu.ec/) for the support for the research and publication of this article.

REFERENCES

Bangor, A., Kortum, P. and Miller, J. (2009) 'Determining what individual SUS scores mean; adding an adjective rating', *Journal of usability studies*, 4(3), pp. 114–23.

Brooke, J. (2013) 'SUS: A Retrospective', *The Physiologist*, 49(2), pp. 29–40.

FreePT (2023) *FreePT - Secure Log in*. Available at: https://securelogin.freept.com/FreePt/login.do (Accessed: 28 March 2023).

Lewis, J. R. (1993) *IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use*, *International Journal of Human-Computer Interaction*. doi: 10.1080/10447319509526110.

Lewis, J. R. (2018) 'Measuring Perceived Usability: The CSUQ, SUS, and UMUX', *International Journal of Human-Computer Interaction*, 34(12), pp. 1148–1156. doi: 10.1080/10447318.2017.1418805.

Rautela, A. (2018) *The Usability Testing Process*, *ConeTrees*. Available at: https://medium.com/conetrees/the-usability-testing-process-diagram-cone-trees-c77941edfeeb.

RehabGuru (2022) *Rehab Guru - Exercise Prescription*. Available at: https://app.rehabguru.com/dashboard (Accessed: 11 August 2023).

RehabMyPatient (2023) *Exercise prescription software for therapist | Rehab My Patient*. Available at: https://www.rehabmypatient.com/ (Accessed: 11 August 2023).

Samper-Pardo, M. *et al.* (2023) 'Effectiveness of a telerehabilitation intervention using ReCOVery APP of long COVID patients: a randomized, 3-month follow-up clinical trial', *Scientific Reports*, 13(1). doi: 10.1038/s41598-023-35058-y