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PAPER

Perfusionists' Perception of a Blended Training Process in the Management of Extracorporeal Membranes

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ABSTRACT

During the SARS-CoV-2 pandemic, many challenges were faced in the global healthcare system, one of which was the lack of competent professionals to implement therapies such as extracorporeal membrane oxygenation (ECMO), which proved to be lifesaving during the H1N1 virus infection. In response to this need, this project aimed to determine the characteristics of a blended training process to contribute to the development of competencies in the management of ECMO therapy and to understand the perception of participants regarding this training process as a suitable strategy for competency development. A mixed design with a descriptive scope based on design-based research was used. The main results indicated that the designed learning environment was suitable for competency development in ECMO therapy management, as well as the importance of including high-quality simulation scenarios in the development of skills for managing this type of therapy. However, the most significant impact was observed in the development of competencies and skills of the participating healthcare professionals through the process of feedback.

KEYWORDS

blended learning environment, medical simulation, clinical skills, perfusionist, ECMO, SARS-CoV-2

1 INTRODUCTION

The SARS-CoV-2 pandemic has posed a significant challenge to the global healthcare system. Approximately 5% of diagnosed patients have developed respiratory distress syndrome (ARDS), necessitating ventilator support in the intensive care unit (ICU) [1]. However, patients with comorbidities such as arterial hypertension, diabetes mellitus, and hypothyroidism, among others, have exhibited a mortality rate of around 40% [2]. Considering the age of this diverse patient population, the World Health Organization (WHO) [3] has proposed the use of extracorporeal membrane oxygenation (ECMO) as a last resort in medical treatment because it allows for pulmonary recovery and reduces mortality rates.

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ECMO is not a new therapy for managing severe ARDS, as it has been used during previous public health crises with increased mortality rates due to pulmonary complications. For instance, during the H1N1 pandemic, it was used in 2.6 cases per million people [4]. In the Middle East with the MERS pandemic in 2012, ECMO was used in 5.6% of patients on mechanical ventilation [5], and during the onset of the SARS-CoV-2 pandemic in China, it was employed in approximately 2.8% of patients who required mechanical ventilation [6].

Furthermore, ECMO is not limited to patients with ARDS but is also indicated for those with clinical conditions that necessitate cardiac and hemodynamic support, such as cardiogenic shock, post cardiotomy shock, myocarditis, and post-resuscitation status. Thus, its use is directly correlated with the incidence of structural heart disease and coronary heart disease, which affect approximately 800,000 patients per year in Europe and the United States of America according to WHO data [7], around 150,000 patients per year in Latin America as reported by the Pan American Health Organization (PAHO), and is the leading cause of death in Colombia with approximately 18,000 surgical corrections per year according to the National Administrative Department of Statistics of Colombia in 2021.

The increased mortality in individuals over the age of 65 due to SARS-CoV-2 has resulted in a sudden surge in the use of extracorporeal membrane oxygenation not only in Colombia but also worldwide. Consequently, there is an urgent need for interdisciplinary teams composed of various clinical specialists, including those in critical care, cardiovascular surgery, cardiovascular anesthesia, perfusion, and extracorporeal circulation, and nursing. The clinical perfusionist plays a vital role in reestablishing tissue perfusion by replacing the patient's heart and/or lung using various extracorporeal devices to assume the vital functions of these organs [8], making their role crucial in the implementation of ECMO.

Currently, perfusionists develop clinical competencies in ECMO management through assisted-directed practice, problem-based learning, literature review, collaborative learning, case analysis, and low-, medium-, and high-fidelity clinical simulation, which serve as fundamental pillars in their development and strengthening [9]. With the aid of digital tools, high-fidelity clinical simulation has enabled analogous, secure, and controlled practice that enables students to engage in interactions that mimic professional reality [10] and receive feedback through various debriefing techniques.

Simulation is a strategy that enables the replication of real patient experiences through guided and controlled scenarios [11]. It can ensure the development and strengthening of core competencies in clinical specialists, including perfusionists [12], improve the performance of trainees in complex tasks [13], and develop the technical skills needed in extracorporeal membrane oxygenation (ECMO) [14]. Therefore, the American Association of Perfusionists (Amsect), the European Association of Cardiothoracic Surgery (EACTS), the Extracorporeal Life Support Association (ELSO), and several perfusion training schools around the world have included simulation scenarios in virtual or face-to-face learning environments as a fundamental pillar in the development of competencies.

However, the situation in Latin America, particularly in Colombia, differs in several aspects. Firstly, the specialty trains a diverse range of professionals, including physicians, nurses, and surgical instrumentalists, each with varying levels of skills and competencies. Secondly, the development of competencies is primarily based on assisted-directed practice, where future perfusionists actively participate in the implementation of extracorporeal life support under the guidance of clinical specialists. This approach does not rely on the use of high-fidelity simulators. However, a more concerning issue arose during the SARS-CoV-2 pandemic, as perfusionists in training experienced a reduction of over 50% in their participation in clinical scenarios. This significant decline impeded the development of their skills.

In response to this situation, the current study aims to determine the characteristics of a blended training process that can strengthen clinical competencies in the management of patients supported with ECMO, as well as explore the perceptions and opinions of students about this process. This text only reflects the perceptions of the participants in the study and aims to provide guidance to the academic community on aspects to consider when integrating blended learning environments in the training process of clinical specialists.

The text will present previous studies on the training of perfusionists, followed by the methodological design, perceptions of the participants regarding the learning environment, and conclusions.

1.1 Perfusionist training process

When reviewing the literature, a diversity of proposals for the training of perfusionists can be found, including short courses, diploma courses, fellowships, and specializations offered by various institutions of higher education and medical-surgical specialist organizations. However, most proposals emphasize the use of clinical simulation, whether analog or digital, as a fundamental strategy for strengthening or developing competencies, regardless of the type of training process or the mentor.

There are several main reasons why the use of clinical simulation is crucial for this clinical specialty. First, research indicates that simulation allows for specialist training without putting the patient at risk [12, 13, 14, 15]. It also enables the development of skills to manage rare or infrequent events [12, 15], allowing the clinical specialist to practice resolving crises without compromising patient safety. For instance, Gierig et al. [16] investigated the use of clinical simulation in training specific competencies such as air embolism and arterial decannulation and found that specialists' learning becomes evident in the resolution of real situations, as measured by eye-tracking glasses that measure time and performance. Their conclusions highlight the importance of simulation in recreating, practicing, and resolving crises as many times as needed.

Similarly, Alsalemi et al. [17] used digital simulation to develop extracorporeal membrane oxygenation (ECMO) skills for perfusionists and found that this type of simulation can recreate several scenarios with varying levels of difficulty, ensuring the development of clinical competencies. Likewise, Sawyer et al. [18] examined the impact of large-scale simulation in a training program for extracorporeal circulation resuscitation. Each simulation scenario was standardized to ensure a consistent approach, and deliberate practice was established as the preferred method for developing basic clinical competencies in resuscitation. The study found that the simulated environment provides an additional benefit to the traditional form of instruction, resulting in improved performance and reduced errors.

In a similar vein, Bonet et al. [19] developed a training program for perfusion students using augmented reality, immersing students in a fully controlled environment to enhance their experience and positively impact the development of clinical competencies. On the other hand, Fouilloux et al. [20] developed a serious video game with gamified elements to train perfusionists in management during extracorporeal circulation, focusing on improving communication skills, following and imparting verbal orders, and acting as active members of the surgical team. However, the results also identified four types of errors committed by perfusionists in this type of procedure (errors in decision making, communication, crisis resolution, and practical errors), which were approached from a perspective beyond the game itself.

In conclusion, clinical simulation enables the development of the clinical skills and competencies necessary for perfusionists. It provides trainees and retrained perfusionists with the opportunity to make mistakes, practice, and repeat procedures as many times as necessary to clarify, understand, and reinforce their knowledge and technical skills. It also promotes learning from errors and feedback without putting patients' lives at risk in the process. Furthermore, clinical simulation is a fundamental tool for developing non-technical skills such as teamwork and verbal and non-verbal communication, which are required by perfusionists to provide care with appropriate quality standards [20, 21, 22, 23, 24].

2 METHOD

This research is based on the interpretive paradigm and has a descriptive scope. It uses a mixed approach as it provides a holistic view of the object of study. The research methodology employed is design-based research (DBR), which is chosen because it facilitates the creation of new teaching-learning environments, the development of context-based theories of instruction and learning, and the advancement of knowledge about didactic design [25].

DBR is characterized by its ability to link external agents to the research process, its interventionist nature, its iterative approach, its process-oriented focus, its utility-driven orientation, and its theory-driven nature. It involves testing new techniques, devices, strategies, processes, or learning environments in a controlled, iterative manner [26]. This allows for the consolidation of the object of study through multiple iterations and the generation of theories.

Given that the present study aims to transform the reality of perfusion education in Colombia through an innovative learning environment that enhances clinical competencies in perfusion and extracorporeal circulation in the management of ECMO patients, the use of DBR is highly relevant.

The population of this study is made up of 104 Colombian perfusionists who have received their training in different schools, of which 50% were trained in national universities and the remaining 50% in foreign universities. The sample size for this study was 25 professionals from different cities in the country, each of whom voluntarily decided to participate in the course. The study was conducted in several phases, as shown in Table 1.

Table 1. Phases developed in the study

Phases	Description
Context analysis and problem identification	In which a detailed analysis is made of the situation of the Colombian health system secondary to the SARS-CoV-2 pandemic and the impact this has had on the use of ECMO therapy. The knowledge that various professionals have for managing these critically ill patients.
Approach solutions and theoretical foundation	The theoretical basis of the approach to this problem around the world is developed and some possible solutions are established, choosing the most relevant and innovative.
Prototyped and implemented	A blended learning environment was designed and implemented to solve the established problem.
Validation and evaluation	The learning environment and its effect on the solution to the problem situation posed and determined are evaluated. To develop the evaluation, both the researcher and participants must be active participants in the process.

Data collection was conducted over a period of 16 weeks through semi-structured interviews, videos, evaluation of each module of the theoretical and practical component (LORI Methodology), registration of researchers, and activities of the blended learning process. The data collected were coded to ensure the anonymity of the study participants. Subsequently, to respond to the research objective, the information was processed using Qualitive Data Analysis (QDA) Miner software.

3 RESULTS AND DISCUSSION

Twenty-five students participated in the virtual classroom, and the Learning Object Rating Instrument (LORI) methodology was used to evaluate the virtual classroom [27] by means of the categories shown in Table 2.

Table 2. Categories LORI methodology

Category	Description
The quality of content	Accuracy, balanced presentation of ideas and appropriate detail, truthfulness.
Learning objectives	Consistency between objectives, activities, evaluations, and participant profile
Feedback	Tailored to each participant
Motivation	Ability to generate interest in the group of participants
Design and presentation	Optimal processing of information through multiple visual aids
Usability	Navigability with intuitive interface for the participant
Accessibility	Adaptability to various mobile devices
Reusability	It can be used in a variety of learning scenarios
Compliance with standards	According to international standards and specifications

3.1 Quality of the contents

After analyzing the results, it is evident that the virtual classroom in this learning environment provides high-quality content that facilitates the development of participants' competencies in knowledge. The content is clear, concise, precise, and presented engagingly, as indicated by the following feedback from participants:

Participant 7: *"Each piece of content in the virtual classroom was absolutely clear, concise, and precise. It provides relevant materials, such as articles and well-made videos, that complement the delivered content. I found the classroom engaging and not boring to stay in."*

Participant 13: *"I rate the virtual classroom 5 as each piece of content was presented in a timely manner before the synchronous session. This allowed me to review the materials before the teacher's presentation and address any doubts during class. Moreover, there was no confusion in the topics and contents presented, neither in the classroom materials nor from the teachers."*

Participant 3: "*The virtual classroom offers rich and high-quality content that guides students step by step to acquire the necessary theoretical knowledge to confidently tackle simulation scenarios. It equips students with the tools needed for success without any fear.*"

3.2 Learning objectives

Ninety-two percent of the participants concurred that the proposed activities were pertinent and aligned with the learning objectives. However, it is noteworthy to mention the feedback from participant 18. He expressed, "*Although the activities are interesting, there are instances when the volume of activities is overwhelming, leaving little time for conscientious completion. Many of us ended up rushing through them. I recommend allocating additional time for completing the activities thoroughly*."

3.3 Feedback

All participants unanimously agreed that personalized feedback was one of the most crucial elements of the course. Participant 11 specifically highlighted this aspect, stating: "*Having taken several courses with virtual modules before, I have experienced situations where either no feedback was provided or the feedback received was not helpful. However, in this course, the feedback was personalized, with no two comments being the same. This individualized approach allowed me to learn from my mistakes and understand the errors made*."

3.4 Motivation

Although all participants reported being highly motivated in the learning process, participant 3 expressed, "*While navigating the virtual classroom is generally enjoyable, at times the content can be heavy, long, and dense, particularly when presented solely in English, which sometimes made me hesitant to review them thoroughly*." This feedback prompted a reevaluation of the texts and an exploration of alternative multimedia options to replace certain readings.

3.5 Design

In terms of design, there were divergent opinions among the participants. Some expressed positive perceptions, while others had reservations, which is typical in a blended learning environment where meeting the diverse expectations of participants can be challenging. For instance, participant 19 remarked, *"The virtual classroom is visually appealing, but I find the color scheme and organization of materials boring."* In contrast, participant 25 stated, *"The design and colors of the virtual classroom are fitting for the student profile, and the organization of content is excellent. It creates a serious learning environment."*

3.6 Usability

The navigation in the virtual component of the course was found to be straightforward, user-friendly, and tailored to the needs of the participants, as evident from their feedback. Participant 2 remarked, *"The navigation is fast and simple and does not require much time to read instructions because the system is intuitive and easy to use."* Similarly, participant 23 stated, *"It is very easy to use, intuitive, and doesn't require extensive knowledge of systems. Additionally, there is no need to spend much time exploring the virtual classroom, as everything is easily accessible and easy to find."*

3.7 Accessibility

This variable generated significant controversy among the participants, as 30% of them (12 participants) rated it below 3, while the remaining 70% (15 participants) rated it 4 or 5. For instance, participant 13 mentioned, "*It is terrible trying to view and access the virtual classroom from my cell phone, as the content is impossible to review and see. I am not sure if the issue is with my phone*." Participant 6 also expressed dissatisfaction, stating, "*The platform is not user-friendly when accessed from a phone. The content appears tiny and unreadable, and videos often take you out of the virtual classroom, requiring you to re-enter to access other information. It is inaccessible from platforms other than computers*." However, participant 11 had a different experience, stating, *"It was easy to access and view the virtual classroom from my iPad. I believe it can be easily accessed from other electronic devices apart from computers."*

Given the diversity of responses to this variable, it may be worthwhile to consider developing an app for the next iteration that allows for a virtual classroom experience on mobile phones, ensuring quick and convenient access to all the proposed content.

3.8 Reusability

All participants rated this category with a score of 5, and they all attributed it to the excellent option of being able to download all course materials, including readings, videos, synchronous class recordings, and activities, from the virtual classroom. This feature allows everyone to access the material even without an internet connection. As participant 18 stated, *"The reusability of the material provided by the virtual classroom of the diploma course is perfect because it can be downloaded to the computer and kept forever, even after the course is over."*

3.9 Compliance with standards

Regarding compliance with standards, 90% of the participants gave the highest rating for respecting copyrights, but no explanation was provided in 89% of these responses. However, the remaining 10% did not provide a rating and verbally expressed confusion about how to verify compliance with quality standards such as operating systems and copyrights. Considering this feedback, it is important to emphasize referencing and copyrights in the design of the next virtual classroom.

Design of the clinical simulation scenarios. The clinical simulation scenarios included in this learning environment consist of six workshops and 10 high-fidelity scenarios based on Bloom's methodology. All 25 participants in the AA evaluated the practical component by asking questions about elements like the venue, the number of participants per scenario, the level of fidelity, the use of simulators, and the exposure time.

Environment. The simulated hospital of CES University in Medellin, which has 17 scenarios, was used as the space for developing the simulation scenarios. Participants were asked about this aspect with the following question: "Does the space used for conducting the simulation scenarios have enough space, light, and adequate general conditions?" Participant 2 responded, *"The environment where the 5 days of simulation occurred is adequate, well lit, and designed for this purpose."*

Participant 20 stated, *"It is a perfect space for the practical part of the course, as it is spacious, well lit, well-constructed, and the environmental conditions are ideal. I liked it very much."*

Participant also expressed satisfaction, stating, "*I generally liked the place where the practical part of the course took place, including the rooms where we received feedback, because constant reminders through signs about the principles of simulation created a conducive learning environment.*"

Based on the participants' feedback, it can be concluded that the space used for the second component of the learning environment meets the requirements for space, lighting, and general conditions necessary for conducting clinical simulation.

Number of participants per scenario. When asked if the number of participants (5 participants) per scenario was optimal, all participants responded affirmatively, and their reasons were as follows: Participant 21 stated, *"Regarding the number of peers in my simulation group, I think it was perfect because each of us could assume a role, just like in a real clinical setting. Moreover, being part of a group enabled us to work together to solve each simulation situation to the best of our abilities, which indirectly helped us develop other essential skills such as teamwork and assertive communication."*

Participant 17 stated, *"Having more colleagues in the same environment and facing the same situation was beneficial as it taught me to communicate more effectively and assertively. With five participants, we could discuss diagnoses and problem-solving approaches, which closely mirror our professional practice, where decisions are rarely made in isolation, especially with complex patients. I found this experience very enriching."*

Based on these responses, it can be concluded that, overall, the number of participants per scenario was a positive experience for the participants as it allowed them to enhance non-technical competencies such as teamwork, assertive communication, and decision making, which are crucial skills in managing patients with extracorporeal membrane oxygenation.

Level of fidelity in each simulation scenario. In the data collected to evaluate the level of fidelity, there was diversity in the responses from each participant, leading to improvement actions within the academic activity (AA). For instance, participant 12 expressed, *"The realism of the simulators and scenarios is 100%. I felt like I was in a real clinical environment, where my visual acuity and knowledge were constantly challenged, as if I were dealing with a real patient on ECMO."*

On the other hand, participant 8 stated, *"The development of the simulation scenarios is excellent, and it successfully immerses participants in a realistic environment with ECMO patients. However, all participants should have the opportunity to visit an ECMO center at least once during the course, as it would allow us to see and understand how it works in real life because simulation is one thing and real life is another."*

Participant 4, who has training in clinical simulation and is an instructor, shared, *"From my knowledge, I can say that the fidelity provided by the space and simulators is comprehensive, along with the structured scenarios. I would even venture to say that the instructors fulfilled all the proposed objectives in the scenarios. However, what was missing was an animal lab where we could observe ECMO in action in real life."*

The data analysis allowed us to determine that both the level of fidelity of the scenarios and the number of simulations performed were adequate; however, as indicated by the participants, it is important to establish a teaching-service agreement with a university to allow them to visit reference centers with patients treated with ECMO in order to contrast the simulations with reality.

Exposure time. In the responses of the participants to the question of whether the practical exposure time mediated by simulation was optimal for developing competencies, various opinions were obtained. For instance, participant 14 stated, *"Initially, I thought 5 days was too much time, but now I feel like I need more. I would have liked even more time."*

Participant 4 expressed, *"Although it is the complete ECMO course I have attended, I still feel like the time is not enough. The exposure time to simulation situations is excellent, but I believe the objectives were achieved in the given time frame."*

Participant 1 shared, *"I always feel like it's never enough, and I wish there was one more day, one more stage. However, I also understand that the current duration is appropriate considering the target audience."*

These opinions show that the exposure time in the academic activity (AA) is perceived as necessary to achieve the objectives set. However, the process could be improved by giving the participants the opportunity to have contact with ECMO therapy beforehand, for example, through a laboratory with animals, where its functioning is better understood.

4 CONCLUSIONS

The objective of this study was to investigate the characteristics of a blended learning process designed to enhance clinical competencies in the management of patients undergoing extracorporeal membrane oxygenation (ECMO), and to assess students' perceptions and opinions regarding this process. It is important to clarify that ECMO is a therapy that facilitates blood oxygenation through an artificial lung. Consequently, specialists need to develop competencies such as assembling the equipment that connects the patient to the artificial lung and fostering effective teamwork, enabling synchronization with other specialties involved in patient care.

The implementation of the blended learning process, which combines online and offline components, facilitated competency development through high-fidelity clinical simulation. As expressed by Marcelo, this approach fostered active learning, allowing participants to construct their own knowledge autonomously and collaboratively. Moreover, the process promoted skills such as effective communication, respect, and professionalism, building upon the participants' existing knowledge acquired throughout their lives.

The achievement of the proposed objectives was directly linked to the effective utilization of information and communication technologies (ICTs) as a fundamental part of the training process. ICTs enabled efficient communication between participants and instructors through diverse channels, facilitating doubt resolution and creating collaborative learning spaces via forums, chats, and other activities that provided both individual and group feedback. Additionally, ICTs eliminated time and space constraints, enabling participants to access the virtual classroom from any location and at any time. This flexibility facilitated the training process while considering the social and professional characteristics of the study sample.

Furthermore, this training process highlighted the pivotal role of individualized and personalized feedback, not only from instructors but also from the interdisciplinary team, in developing the technical and non-technical skills essential for managing patients undergoing ECMO therapy. Based on the aforementioned points, it can be concluded that this training process should incorporate a robust theoretical component, utilizing various strategies such as problem-based learning, collaborative learning, and project-based learning, with ICT playing a fundamental role. These theoretical approaches would empower participants to effectively diagnose, manage, and resolve situations that may arise during extracorporeal assistance. Furthermore, the training process should incorporate diverse clinical scenarios to promote the development of both technical and non-technical skills crucial for the successful management of ECMO patients, with clinical simulation serving as an excellent ally.

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