Efficacy of Blended Learning in the Teaching of Basic Surgical Skills in Medical Students at a Public University in Peru Between 2018 and 2022

Maritza D. Placencia-Medina[1], María A. Valcárcel-Saldaña[1], Christian Nole-Álvarez[1], Isabel Mendoza-Correa[1], María E. Muñoz Zambrano[1], Javier Silva-Valencia[2], Julián Villarreal-Valerio[1], Carlos H. Contreras-Pizarro[1,3(✉)], and Anel J. Roca-Béjar[1]

[1] Grupo de Investigación "Educación Médica", Universidad Nacional Mayor de San Marcos, Lima, Perú
carlos.contreras2@unmsm.edu.pe
[2] Unidad de Telesalud, Universidad Nacional Mayor de San Marcos, Lima, Peru
[3] Sociedad Científica de San Fernando, Universidad Nacional Mayor de San Marcos, Lima, Peru

Abstract. The objective of the research was to evaluate the efficacy of a Blended learning (B-learning) intervention to improve basic surgical skills in human medicine students at a public university in Lima, Peru. A quasi-experimental pretest/posttest study was carried out among enrolled in the Surgery course at Universidad Nacional Mayor de San Marcos (Peru). The achievement of basic surgical skills related to biosafety, tying, and suturing using simulators of low to intermediate complexity were evaluated. The McNemar´s and Kruskal-Wallis test were used for result analysis. The results showed that the intervention improved biosafety surgical skills (including handwashing, clothing, glove usage), as well as knot-making and suturings ($p < 0.05$). Observation revealed challenges with fine psychomotor skills and ergonomic risk factors. Interviews yielded positive reactions, significant learning, and motivation for continuous learning. Left-handed students reported serious procedural difficulties, indicating a need for more targeted training. Teachers provided audiovisual materials contributing to the achievement of basic surgical skills. The incorporation of b-learning into the learning process in basic surgical techniques significantly increase students' skills. Further refinement of the model for left-handed students and ongoing training for teachers in virtual material design is necessary.

Keywords: Clinical Competence · B-Learning · Efficacy · General Surgery · Educational Technology

T. Guarda et al. (Eds.): ARTIIS 2023, CCIS 1935, pp. 169–181, 2024.
https://doi.org/10.1007/978-3-031-48858-0_14

1 Introduction

The teaching of surgery in medical school represents a critical period during which essential surgical skills are imparted to any physician in training [1], and it can influence their aspirations for a surgical [2]. Traditionally, a model has been followed in which experienced professionals teach students individually or in small groups [3], often within the context of an operating room. A disadvantage of this approach is that student learning can be limited by different factors, including instructor availability and complexity of surgical procedures [3].

Therefore, it falls upon medical schools to use a learning methodology that facilitates the training of various technical, cognitive and/or behavioral skills. This approach should establish a secure learning environment that does not compromise patient safety or lead to ethical and legal dilemmas. Additionally, the chosen methodology should be adapted to the diverse learning needs of each student [4].

One of the methodologies employed for teaching surgery is Blended Learning (B-learning), which combines both online (asynchronous) and face-to-face (synchronous) learning. This approach has demonstrated significant benefits in terms of knowledge acquisition, particularly when compared to traditional learning methods within the health area [5]. Notably, this methodology has generated a significant increase in accurate diagnoses, skills, and student´s affinity for this approach [6]. Another innovation like live streaming of surgical procedures conducted in the operating room, has shown promise as an alternative or complement to traditional face-to-face teaching [7].

In Peru, the National University of San Marcos pioneered the initial application of B-learning to strengthen basic surgical skills, addressing the challenge posed by a high student enrollment in 2018 [8].This learning approach incorporated a hybrid assessment system, providing training to both teachers and students in utilizing virtual resources for educational materials. The model contemplated successful events as well as potential critical scenarios, leveraging online resources for positive student feedback [8].

In 2019, improvements were introduced to the educational model including pre-class evaluations; furthermore, then in 2022, revisions were made to the assessment tools for gauging basic surgical skills. The present study seeks to evaluate the effectiveness of the B-learning-based educational model in enhancing surgical skills among students pursuing human medicine at a public university in Lima, Peru.

2 Materials and Methods

Study Design and Population

Quasi-experimental study. The population was made up of medical students from the Universidad Nacional Mayor de San Marcos (UNMSM) in Lima, Peru, during the years 2018, 2019 and 2022.

The General Surgery course at UNMSM is a compulsory theoretical-practical subject comprising ten learning units. The curriculum features an Operative Technique unit spanning 16 weeks, with classes conducted at the Institute of Experimental Surgery within the Faculty of Medicine of the UNMSM. For this study, the population included three cohorts of medical students, comprising 212 participants in 2018, 100 in 2019, and

72 in 2022. Importantly, classes in the years 2020 and 2021 were conducted online due to the COVID-19 pandemic.

Participation in the study was extended to all enrolled students of both. Data was collected from those students who gave their consent to participate in the study. The accessibility of the population was facilitated by the unified learning environment they had and the specific class schedules. Exclusions comprised students who withdrew from the course or did not attend more than 30% of scheduled practical activities.

The control group consisted of students from the 2017 cohort who undertook the Operative Technique course using the traditional face-to-face teaching approach. This cohort did not undergo competency-based evaluations or utilize checklists for assessing individual basic surgical skill.

Variables and Measurement

The assessment of basic surgical skill encompassed biosafety measures, including hand washing, donning gloves and proper attire, as well as proficiency in suturing and knot-making. Each skill was evaluated using a checklist that was validated by the instructors of the Operative Technique learning unit. Scores ranged from 0 to 20. Students with a score greater than 14 were considered competent.

Academic performance was assessed as a numerical variable, measured through the vigesimal grading system of the theoretical and practical component of the Operative Technique unit (with theory accounting for 40% and practice for 60%). Students achieving a final grade greater than 14 were considered approved.

Description of the Intervention

The intervention, designed for educational purposes with Blended learning covered the following areas:

1. Integration of virtual and face-to-face activities. This aspect of the intervention began in 2018 by establishing a virtual classroom on the Moodle 3.0 platform dedicated to the Operative Technique subject (https://unmsm.online/medicina/loginepmedicinahumana/). Within this virtual space, recorded theoretical lectures, teacher-created procedure demonstration videos, discussion forums and consultation channels, as well as a repository of relevant literature for both teacher and student were made available (see Fig. 1). Additionally, a designated area allowed students to upload they own recorded the videos of procedures from multiple angles (see Fig. 2). Teachers underwent training to effectively utilize the virtual classroom and develop virtual materials, including practice guides and assessment tools such as rubrics and checklists.

2. Preparation of checklists for student evaluation. Comprehensive checklists were prepared for assess student´s proficiency in biosafety protocols, knot making and suturing techniques. These checklists aimed to establish a standardized evaluation process that encompasses cognitive, procedural, and attitudinal aspects in the evidence of achievement. Checklists are available in: https://drive.google.com/file/d/13ajY2jsD-pR75WEb4Sa3bofsqPuaXbnL/view?usp=sharing.

In 2019, the educational model was further refined, but with less changes, including the incorporation of pre-class assessment preceding each theory session. In 2022, new teachers were hired and trained to adopt the same approach, considering that some

Fig. 1. A: Main interface of the virtual classroom B: Demonstrative video of hand washing C: Demonstrative video of knot with two hands D: Demonstrative video of suture

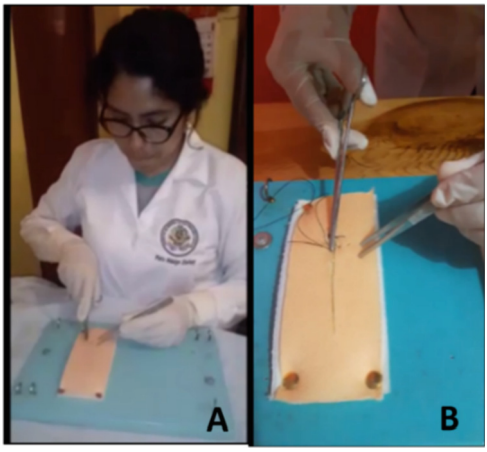

Fig. 2. Recordings made by students showing their skills in performing sutures.

teachers who had participated in 2018 and 2019 had left. Additionally, a validation of the checklists used to assess basic surgical skills was conducted with the new teaching staff.

Procedures in Qualitative Research

Simultaneously with the implementation, an observation and interview technique was carried out, guided by a team member with expertise in qualitative research. The approach used was phenomenological, which seeks to explore the life experiences of people

regarding a certain event. According to Husserl [9], this paradigm aims to explain the nature and veracity of the phenomena from the perspective of each subject.

The focus of the observation centered on the behavioral manifestations among the research participants, which, in the context of education, is important to analyze and interpret [10]. Both motor and verbal skills were considered as the unit of analysis. Together with another member of the team, they observed students during face-to-face practice sessions for basic suturing procedures, as well as the recordings made by the instructor.

In 2019, 10 students and 5 teachers participated. The sample size was done iteratively based on how the information emerged during field work, eventually reaching the saturation point. This observation extended over a period of 16 weeks, totaling 96 h (equivalent to 4 h per week). This timeframe allowed for the establishment of the finding´s plausibility criteria concerning the experiences of the individuals under study [11].

Finally, semi-structured interviews were also carried in 2019 to complement the objective of the investigation. Based on Kirkpatrick's model [12], which established the usefulness of link learning evaluation to student satisfaction and the acquired skills, the following questions were asked: How did you feel in relation to the implementation of B-Learning as a part of the course? To what extent did the educational model lead to improvements in your ir knowledge, skills and attitudes?

Statistical Analysis

Statistical analysis was carried out using the IBM SPSS Statistics V. 24.0 software. For descriptive analysis we determined the absolute and relative frequencies of categorical variables. To assess the change in the achievement of basic surgical skills, we employed the McNemar´s test.

Data normality analysis was performed using the quantile-quantile plot, and the Kruskal-Wallis test was used to assess whether there were significant differences between the scores of the theoretical and practical components with the teaching method. The analysis of the obtained performance was carried out comparing it with the qualifications from the year 2017 for the respective comparisons. The significance level was established at 0.05.

Ethical Aspects

This study was approved by the Institutional Ethics Committee of the Faculty of Human Medicine at Universidad Nacional Mayor de San Marcos (Approval Number: 1825). Student participation was both anonymous and voluntary. An informed consent form was prepared, which explained that the decision not to participate would not influence their grades.

3 Results

A total of 384 students participated in the study, with 212 in 2018, 100 in 2019 and 72 in 2022. Among them 65.4% were male and 34.6% female. No student withdrew from the course. During the year 2018, the increases in the percentage of proficient students after the intervention were significant in all areas (see Table 1).

Table 1. Number and percentage of students competent in basic surgical skills, in the years 2018, 2019 and 2022.

Assessments**	2018(n = 212)		2019(n = 100)		2022(n = 72)	
	Pre n (%)	Post n (%)	Pre n (%)	Post n (%)	Pre n (%)	Post n (%)
Hand washing[1]	148 (69.8%)	206 (97.2%)*	67 (67.0%)	100 (100%)	63 (87.5%)	63 (87.5%)
Gown placement[1]	164 (77.4%)	204 (96.2%)*	97 (97.0%)	100 (100%)	70 (97.2%)	70 (97.2%)
Donning gloves[1]	155 (73.1%)	203 (95.8%)*	98 (98.0%)	100 (100%)	66 (91.7%)	66 (91.7%)
Knot making[2]	155 (73.1%)	203 (95.8%)*	88 (88.0%)	94 (94.0%)	63 (87.5%)	63 (87.5%)
Making sutures[2]	186 (87.7%)	207 (97.6%)*	99 (99.0%)	100 (100%)	66 (91.7%)	66 (91.7%)

[1]Biosecurity
[2]Knots and sutures
* McNemar´s test. Statistically significant difference at 5% significance level
** In the year prior to the start of the intervention (2017), no competency was carried out

Regarding the performance of the students in the subject, it was compared based on the group of students who received traditional teaching (2017). The results show that the intervention, in its application in 2018, was significant for the theoretical (see Table 2) and practical (see Table 3) components, and the resulting final grade (see Table 4).

Table 2. Qualification of the theoretical component according to the B-learning didactic strategy in the students of Operative Technique, UNMSM.

Year	n	Theoretical grades		
		mean ± SD	Median ± IQR	p-value†
2017	148		5.6 ± 1.20	0.01*
2018	212		6.19 ± 1.31	
2019	100		6.69 ± 0.90	
2022	72	6.32 ± 0.61		

†Kruskal-Wallis test
*Statistically significant difference at 5% significance level

Simultaneously it was carried out the technique of observation and interviews (Fig. 3). Being a thoughtful, planned and intentional observation, the fortuitous factors found in the course practices were considered, such as recurring patterns of support

Table 3. Qualification of the practical component according to the B-learning didactic strategy in the students of Operative Technique, UNMSM.

Year	n	Practical grades	
		Median ± IQR	p-value†
2017	148	9.96 ± 0.60	
2018	212	10.36 ± 0.73	0.01*
2019	100	10.85 ± 0.89	
2022	72	10.20 ± 0.86	
Total	532		

†Kruskal-Wallis test
*Statistically significant difference at 5% significance level

Table 4. Final qualification according to the B-learning didactic strategy in the students of Operative Technique, UNMSM.

Year	n	Final note		p-value†
		mean ± SD	Median ± IQR	
2017	148	15.45 ± 1.12		0.01*
2018	212		16.58 ± 1.81	
2019	100		17.54 ± 1.49	
2022	72	16.49 ± 1.13		
Total	532			

†Kruskal-Wallis test
*Statistically significant difference at 5% significance level

among the members of the groups assigned by each work table, verifying a lot of pressure imposed by themselves to carry out practice in the best way, for the development of skills and abilities in the various techniques, to maintain and/or improve your weighted average. Likewise, it was possible to observe that the size of the students was varied and extreme, which caused certain difficulties when preparing the work table for a certain technique to be executed (Fig. 3), it was uncomfortable for some and adequate for others, it should be noted that they had ergonomic tables and could vary the height according to their needs, doing so caused a delay in completing its rotation. It was evidenced that in certain students there was lack of coordination in activities that required a fine clamp, they had to practice repeatedly due to the lack of skill at that level. There was in the groups of left-handed young students what demanded greater concentration, since the demonstrations were with examples for right-handed people and the teacher in charge had the ability to demonstrate it as if he were left-handed. Within the group there were students with laterality problems, which causes a disorganization in their fine motor

planning required in the course. They were very willing to carry out their practices following the model of the video-recording of the instructor teacher. Most of the teachers were attentive in the development of the technique by their assigned students. It was possible to observe six designated teachers and three practice teachers who transmitted confidence to the students to resolve doubts, speaking confidently and fluently about the topic to be developed. The verbal level of the students was good in the majority.

After the semi-structured interviews, the following categories were obtained:

Liking Reactions

Female students were the ones who participated the most in answering the questions provided. They expressed that they were pleased to find support information in the virtual classroom to reinforce their knowledge and clear up any doubts about the instrumental procedures taught in face-to-face classes. He was also pleased by the easy access and the fact that his learning could take place in a flexible way.

- *When something is not clear to us, we go to the virtual classroom and review the videos that are there from the classes. (Sam).*
- *I think it is a great support to reinforce the course. (Leti).*
- *In the virtual classroom we find the course ordered according to the topics of the syllabus. (Juan).*
- *I think it's cool. (Susan).*

Meaningful-Combined Learning (Face-to-Face-Virtual)

The participants stated that B-Learning improved their knowledge and interest in the different topics developed in the subject, information acquired through the video tutorials, clinical cases of virtual patients, scientific articles, complementing the face-to-face classes, allowing them to select the content on the Moodle platform about some theoretical knowledge of a disease, surgical procedures or other higher cognitive functions.

- *It is the only course that we have everything in order and that does comply with the syllabus". (Lalo).*
- *I am happy with the course, I am learning. (Rita).*

Perceptions of Teachers About the Educational Intervention

In the same way, we proceeded to understand the perceptions of teachers about the educational intervention. The testimonials regarding B-learning were:

- *Each time the virtual classroom was friendlier for me. (Teacher A).*
- *At first I didn't even know how to enter the virtual classroom, I was afraid. (Teacher B).*
- *Points to improve? I would say, more commitment on our part. (Teacher C).*
- *Motivated attitude to continue with the virtual classroom, I say. (Teacher D).*
- *Now I can make forums in the virtual classroom. (Teacher E).*
- *Review easily assigned tasks. (Teacher F).*
- *I think that measuring the achievement of course competencies achieved by the students would serve to validate the intervention model. (Teacher H).*

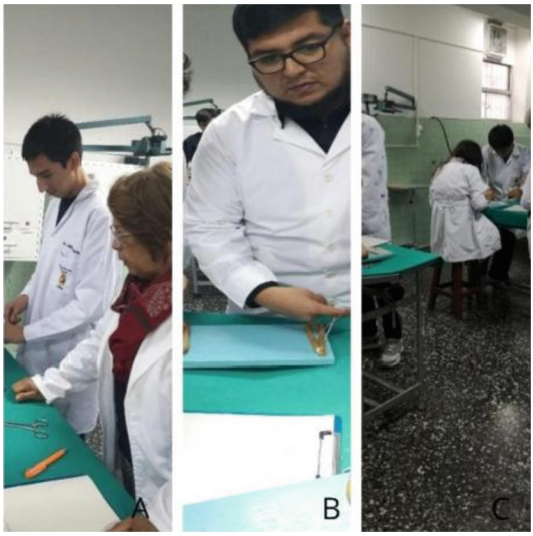

Fig. 3. Students during the practical classes of Operative Technique, year 2019. **A and B**. Teachers attentive to the development of the skills of tying knots with low complexity simulators by the students. **C.** Inadequate posture of the students maintained during practice

4 Discussion

The present study aimed to evaluate the effectiveness of the B-learning educational model in imparting basic surgical skills. The findings clearly indicate that its application during the years 2018, 2019 and 2022 led to an increase in the number of students demonstrating competency in basic surgical skills. While significant differences were only found in 2018, it is important to consider the potential explanatory factor of heterogeneous numbers of students across the 3 application years.

The effectiveness of B-learning has been demonstrated in previous studies. A meta-analysis conducted in 2019 concluded that B-learning effectively improved the knowledge of nursing students [13]. In the study carried out by Moon et al. [14], the application of B-learning in a cardiopulmonary resuscitation (CPR) program was found to effectively enhance the knowledge and attitudes of nursing students. Furthermore, the study by Chen et al. [15] revealed a significant improvement in average test scores of the laboratory for laboratory courses through the utilization of B-learning, in comparison to the traditional learning method.

To the best of our knowledge, we could not find prior studies that used the B-learning methodology in basic surgical skills with simulators of different complexity (low, medium and higher complexity), which highlights the originality of the study carried out and the flexibility in the use of any of these simulators where the student must be prepared to obtain the same results or close data [8].

The utilization of checklists for assessing each of the surgical skills is a noteworthy factor. Its implementation has demonstrated potential benefits, particularly in intensive

and highly complex procedures in humans that involve multiple steps. The use of checklists contributed to fostering coherence and precision in executing specific tasks [16]. Recently, a study focused on enhancing teaching outcomes in surgical skills employed a competency and performance checklist, resulting in increased competency, performance, and student satisfaction within the course [16].

In addition, the creation of demonstrative videos that were accessible prior to the face-to-face sessions emerge as a pivotal element contributing to the achievement of the learning objectives. This methodology has been used to teach a variety of surgical skills [17, 18]. A program that comprised a total of 12 video tutorials addressing instruments usage, suturing and knot making, demonstrated that students significantly improved their surgical familiarity, knowledge and competence [3].

From the analysis of the interviews, it is evident that both students and teachers perceive the implementation of B-learning positively, which is also consistent with other investigations in the surgical area; such as training in maxillofacial surgery [19] and spinal surgery [20]. Zambrano G. et al. [21], reported that a significant majority of Medicine students found practice with standardized or simulated patient to be conductive to knowledge integration. In their study, 95.8% (45 of 47) of responded perceived this strategy as useful for developing communication skills [21]. Likewise, in the study by Oliveros [22], it is evident that after the implementation of a specialty program in Anesthesiology under the B-learning model allowed to make the reading content and the learning load more flexible so as not to exceed the dedication time of 10 h per week, showing great benefit for the feedback of information and self-learning. In a systematic review and meta-analysis [23], authors point out that the success of the platform would be related to the commitment of students in their free time.

Considering medical education as a process of constant change and innovation using information and communication technologies, the strengthening of skills in operative techniques has been determined in compliance with biosafety standards in surgery and the results obtained are similar to other research carried out in a laparoscopic anastomosis course where a statistically significant improvement of 80.5% was observed in all the parameters of the procedure (94.8% residents vs. 67.3% specialists) [24]. Likewise, it has also been shown that the use of simulations and virtual training through educational videos on compliance with biosafety standards and surgical skills have been feasible and equally effective as face-to-face [24].

B-learning allows teaching to be individualized, adapting it to the learning needs of each student and allows training technical, cognitive or behavioral skills [25], as well as determining the correct position to perform them, the ability of the hands (left and right) to harmonize their best skills, teamwork and the development of a professional who complies with basic biosafety standards in a surgical environment, making the right knot and suture for each patient, learning and recognizing the satisfaction and needs of the actors main: the student and the teacher facilitator [3, 19].

The present study should be interpreted considering some limitations. First, it is noteworthy that all the equipment purchased (materials, real estate) was aimed at the right-handed population. Consequently, left-handed students encountered difficulties during the intervention, particularly related to ergonomics (an important factor for the development of these skills in clinical practice) [26, 27]. This fact highlights an area for

innovation in subsequent studies. Second, a limiting factor was the level of interaction between teachers and student, especially in cases where both have little or no experience in applying this model. Addressing this, induction and preparatory training for the facilitating teacher becomes important, alongside the engagement of an instructive team with experience and knowledge of this model. This approach encourages active participation in forums, and even from an early educational stage, it becomes essential to enhance personal and investigative skills [28, 29].

In conclusion, the B-learning model implemented in UNMSM during the years 2018, 2019 and 2022 for teaching basic surgical techniques have demonstrated a significant increase in the students' skills. To further enhance, it is necessary to complement the model for left-handed students, include the ergonomic considerations, and provide continue training for teachers in the design and management of virtual materials.

Acknowledgments. To the students, teachers, administrative staff and authorities of the Vicerrectorado de Investigación y Posgrado, UNMSM (VRIP-UNMSM). The research was part of the project A19010022, year 2019, approved and financed by the VRIP-UNMSM.

References

1. Down, B., Morris, S., Kulkarni, S., Mohiuddin, K.: Effectiveness of a multisession combined near-peer and faculty-led surgical skills course on self-perceived ability to perform basic surgical skills. Ann. Med. Surg. **57**, 153–156 (2020). https://doi.org/10.1016/j.amsu.2020.07.045
2. Peel, J.K., Schlachta, C.M., Alkhamesi, N.A.: A systematic review of the factors affecting choice of surgery as a career. Can. J. Surg. **61**(1), 58–67 (2018). https://doi.org/10.1503/cjs.008217
3. Kumins, N.H., Qin, V.L., Driscoll, E.C., Morrow, K.L., Kashyap, V.S., Ning, A.Y., et al.: Computer-based video training is effective in teaching basic surgical skills to novices without faculty involvement using a self-directed, sequential and incremental program. Am. J. Surg. **221**(4), 780–787 (2021). https://doi.org/10.1016/j.amjsurg.2020.08.011
4. Ruiz-Gómez, J.L., Martín-Parra, J.I., González-Noriega, M., Redondo-Figuero, C.G., Manuel-Palazuelos, J.C.: Simulation as a surgical teaching model. Cir. Esp. (English Ed) **96**(1), 12–17 (2018). https://doi.org/10.1016/j.ciresp.2017.09.005
5. Vallée, A., Blacher, J., Cariou, A., Sorbets, E.: Blended learning compared to traditional learning in medical education: systematic review and meta-analysis. J. Med. Internet Res. **22**(8), e16504 (2020). https://doi.org/10.2196/16504
6. Funke, K., Bonrath, E., Mardin, W.A., Becker, J.C., Haier, J., Senninger, N., et al.: Blended learning in surgery using the Immedea Simulator. Langenbecks Arch. Surg. **398**(2), 335–340 (2013). https://doi.org/10.1007/s00423-012-0987-8
7. van Bonn, S.M., Grajek, J.S., Schneider, A., Oberhoffner, T., Mlynski, R., Weiss, N.M.: Interactive live-stream surgery contributes to surgical education in the context of contact restrictions. Eur. Arch. Otorhinolaryngol. **279**(6), 2865–2871 (2022). https://doi.org/10.1007/s00405-021-06994-0

8. Placencia Medina, M.D., Valencia, J.S., Valcárcel Saldaña, M.A., Somocurcio Vilchez, J.G., Carreño Escobedo, J.R., Villarreal Valerio, J.A, et al.: Primera experiencia de Blended-learning para fortalecer habilidades quirúrgicas básicas en estudiantes de Medicina Humana de una Universidad Nacional en Perú. En Callaos, J., Horne, E.J., Martinez Lopez, B., Sanchez, A. (eds.), CISCI 2019 - Decima Octava Conferencia Iberoamericana en Sistemas, Cibernetica e Informatica 2019, vol.2, pp. 71–76. International Institute of Informatics and Systemics, IIIS
9. Waldenfels, B.: Phenomenology of experience in Edmund Husserl. Arete **29**(2), 409–426 (2017). https://doi.org/10.18800/earring.201702.008
10. Piza Burgos, N.D., Amaiquema Márquez, F.A., Beltrán Baquerizo, G.E.: Methods and techniques in qualitative research. Some necessary precisions. Conrad **15**(70), 455–459 (2019)
11. Reeves, S., Peller, J., Goldman, J., Kitto, S. Ethnography in qualitative educational research: AMEE Guide No. 80. Med. Teacher **35**(8), e1365–e1379 (2013). https://doi.org/10.3109/0142159X.2013.804977
12. Gaxiola-García, M.A., Kushida-Contreras, B.H., Sánchez-Mendiola, M.: Teaching surgical skills: relevant educational theories (second part). Res. Med. Educ. **11**(42), 95–105 (2022). https://doi.org/10.22201/fm.20075057e.2022.42.22433
13. Gagnon, M.P., Gagnon. J., Desmartis, M., Njoya, M.: The impact of blended teaching on knowledge, satisfaction, and self-directed learning in nursing undergraduates: a randomized, controlled trial. Nurs. Educ. Perspect **34**(6), 377–382 (2013). https://doi.org/10.5480/10-459
14. Moon, H., Hyun, H.S.: Nursing students' knowledge, attitude, self-efficacy in blended learning of cardiopulmonary resuscitation: a randomized controlled trial. BMC Med. Educ. **19**, 414 (2019). https://doi.org/10.1186/s12909-019-1848-8
15. Chen, J., Zhou, J., Wang, Y., Qi, G., Xia, C., Mo, G., et al.: Blended learning in basic medical laboratory courses improves medical students' abilities in self-learning, understanding, and problem solving. Adv. Physiol. Educ. **44**(1), 9–14 (2020). https://doi.org/10.1152/advan.00076.201
16. Luo, P., et al.: A WeChat-based competence and performance checklist in basic surgical skills course for military medical acade-my undergraduates. BMC Med. Educ. **22**(1), 858 (2022). https://doi.org/10.1186/s12909-022-03939-x
17. Vaughn, C.J., Kim, E., O'Sullivan, P., et al.: Peer video review and feedback improve performance in basic surgical skills. Am. J. Surg. **211**, 355–360 (2016). https://doi.org/10.1016/j.amjsurg.2015.08.034
18. Wright, A.S., McKenzie, J., Tsigonis, A., Jensen, A.R., Figueredo, E.J., Kim, S., et al.: A structured self-directed basic skills curriculum results in improved technical performance in the absence of expert faculty teaching. Surgery **151**, 808–814 (2012). https://doi.org/10.1016/j.surg.2012.03.018
19. Bock, A., Modabber, A., Kniha, K., Lemos, M., Rafai, N., Hölzle, F.: Blended learning modules for lectures on oral and maxillofacial surgery. Br. J. Oral Maxillofac. Surg. **56**(10), 956–961 (2018). https://doi.org/10.1016/j.bjoms.2018.10.281
20. Acaroglu, E., Assous, M., Bransford, R., Dal Oglio Da Rocha, LG., Falavigna, A., France, J.: Evaluation of blended online learning in three spinal surgery educational courses. J. Eur. CME **11**(1), 2014042 (2022). https://doi.org/10.1080/21614083.2021.2014042
21. Zambrano Sánchez, G., Montedesoca Coloma, L., Morales López, T., Tarupi Montenegro, W.: Medical students' perception of the use of simulated patients as a strategy for training in comprehensive patient management. Educ. Medica **21**(2), 123–126 (2020). https://doi.org/10.1016/j.edumed.2018.08.004
22. Oliveros, A., Mertz, V., Corvetto, M., Delfino, A., De La Fuente, R.: Transformación de los contenidos teóricos del programa de especialidad de anestesiología en un diplomado de formato b-learning. Investigación en Educación Médica **4**(14), e14 (2015). https://doi.org/10.1016/S2007-5057(15)30053-3

23. Liu, Q., Peng, W., Zhang, F., Hu, R., Li, Y., Yan, W.: The effectiveness of blended learning in health professions: systematic review and meta-analysis. J. Med. Internet Res. **18**(1), e2 (2016). https://doi.org/10.2196/jmir.4807
24. Martinez, E.T., Martin, J.I., Magadan. C., Lopez, A., Fernandez, R., Regaño, S., et al.: Influence of previous experience on the benefits of laparoscopic surgical training based on simulation. Cir. Esp. **97** (6), 314–319 (2019). https://doi.org/10.1016/j.cireng.2019.06.001
25. León Ferrufino, F., Varas Cohen, J., Buckel Schaffner, E., Crovari Eulufi, F., Pimentel Müller, F., Martínez Castillo, J., et al.: Simulation in laparoscopic surgery. Cir. Esp. **93**(1), 4–11 (2015). https://doi.org/10.1016/j.ciresp.2014.02.011
26. Betsch, D., Gjerde, H., Lewis, D., Tresidder, R., Gupta, R.R.: Ergonomics in the operating room: it doesn't hurt to think about it, but it may hurt not to! Can. J. Ophthalmol. **55**(3 Suppl 1), 17–21 (2020). https://doi.org/10.1016/j.jcjo.2020.04.004
27. Catanzarite, T., Tan-Kim, J., Whitcomb, E.L., Menefee, S.: Ergonomics in surgery: a review. Female Pelvic Med. Reconstr. Surg. **24**(1), 1–12 (2018). https://doi.org/10.1097/SPV.0000000000000456. PMID: 28914699
28. Vázquez-Reyes, J.M., Rodríguez-Guillén, J.H., Cortés-Algara, A., González-Ramírez, P.A., Millán-Hernández, M.: Ten tips for future medical specialty professors. FEM **22**(5), 245–326 (2019). https://doi.org/10.33588/fem.225.1019
29. González-Rubio, R., Latasa Zamalloa, P., Aginagalde Llorente, A.H., Peremiquel-Trillas, P., Ruiz-Montero, R., Gullón, P., et al.: Competencias para Medicina Preventiva y Salud Pública: propuestas tras un proceso comparativo y participativo. Educ Medica **22**(2), S62–S69 (2021). https://doi.org/10.1016/j.edumed.2019.09.004