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Simulation-Based Learning Impact on Medical Students. Interdisciplinary Formative Approach

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Abstract

Introduction: Simulation-based learning (SBL) is a valuable complement to the training of more qualified, competent and efficient professionals. Objective: To evaluate the scope and limitations of the implementation of a simulation-based learning environment with an interdisciplinary approach called "Simulation Clinic" from a teaching, curricular and evaluative perspective. Methods: Descriptive-exploratory study aimed at students of a higher education institution in 2022. A total of 272 students participated in the interdisciplinary SBL. Results: This strategy was approved by both students (4.28 average rating and 21% of students rated the activities with 5/5) and professors (4.56 average rating and one of them gave the maximum rating). There was evidence of an increase of 34.4% in the development of generic and specific competencies. The feasibility and effectiveness of the interdisciplinary SBL requires complex organizational, structural, technological and human factor adjustments for its adequate implementation in higher education institutions. Discussion: The results are in line with the objectives of several research studies that promote simulation-based teaching and learning leading to better performance in the clinical practices of medical and nursing students, while preparing students from other programs for professional practice.

Keywords: *Simulation-Based Learning, Interdisciplinarity, Technological Competencies, Educational Technologies, Third Generation Universities.*

Introduction

Multisectoral transformations drive the educational community to embrace new paradigms that promote the integral development of human talent (1,2). Third generation universities are those in which teaching, and research converge to solve community problems and integrate various disciplines that lead to the formation of professionals of the 21st century. This involves the holistic development of the fundamental pillars of education: Being, Knowing How to Do and Knowing How to Be (3). All the above is further enhanced by the recent events of global impact that meant greater difficulties for modern education.

Simulation-based learning (SBL) has been consolidated as an innovative didactic strategy for the training of health professionals (4,5). Through the representation of real situations in

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controlled, safe and planned simulation scenarios, general competencies such as communication, teamwork, leadership, problem-solving, role-playing, professional identity (6) and patient/client-centered care can be strengthened, as well as the disciplinary and specific competencies of the students (5). It is therefore important to facilitate the curricular integration of SBL supported using technological elements and high-fidelity simulators (7–10). In this regard, it is necessary to establish and complement the most suitable methodologies to obtain the fundamental learning outcomes during the higher education process.

Research has reported the benefits of incorporating interdisciplinary and interprofessional learning in areas such as Medicine, Nursing, Respiratory Therapy and Physical Therapy.(11–13) However, the SBL is an indisputable complement during professional training (6,14).

There is little published research on interdisciplinary practices with areas of knowledge other than health (15,16). The research consisted of implementing Simulation Based Learning as an innovative, immersive, inclusive and interdisciplinary (SBL-in) didactic strategy with the objective of determining the scope and limitations of the development of simulated practices in an environment called "Simulation Clinic" in a higher education institution in Colombia.

Method & Materials

The present study is of a mixed descriptive-exploratory type cuali-cuantitative. The implementation of the SBL-in strategy was carried out through transformations in the teaching, curriculum, and assessment of strategic subjects in each undergraduate program of the higher education institution in Colombia. The SBL-in was established as an active and safe interaction strategy developed in simulated environments designed to foster cooperative work and assertive communication. The components of the proposed strategy are: Innovation: Development of simulation activities focused on providing solutions to challenges in the real environment; Immersion: Curricular modification for the inclusion of high-fidelity simulation activities with an hourly intensity equivalent to 30% of the hourly intensity of the training practices; Interdisciplinarity: Dynamics that unify knowledge and favor the strengthening of competencies; and Inclusion: Participation of all students without distinction.

Theoretical-practical subjects were selected to develop participation in the study. These strategic subjects underwent curricular updating to include SBL-in activities. At the same time, guidelines were established to include Challenge-Based Learning (CBL) strategies and the competencies and learning outcomes that will be assessed after students participate in the management of potentially reproducible solutions in the real scenarios from which the challenges are extracted. This curricular adaptation allowed the immersion of students in the simulation environments and the application of assessment methodologies related to the process. Figure 1 describes the foundations that made possible the creation of the innovative

pedagogical strategy, the intervention topics and the evaluation models per group.

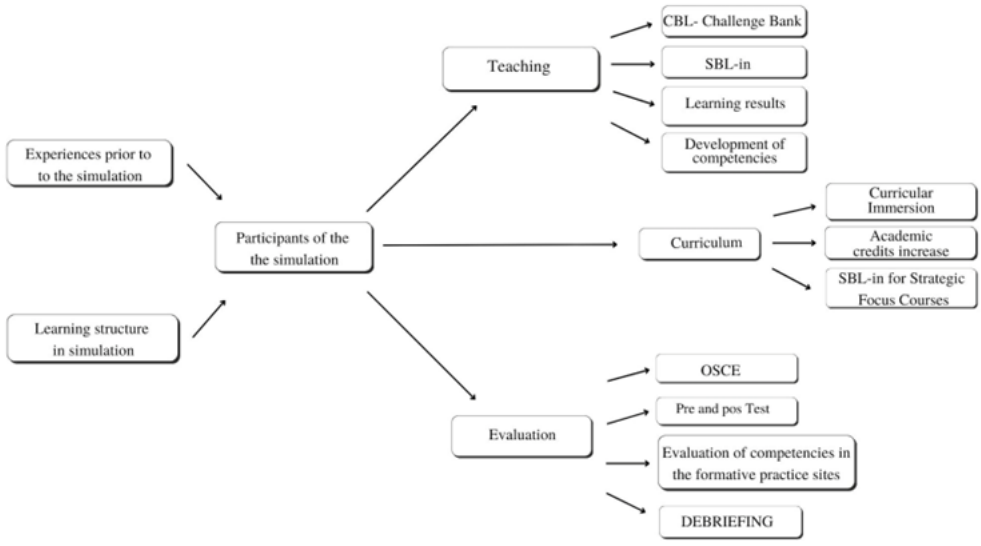

Figure 1. Transformation Strategy Design.

The central axes of the intervention were constituted and aligned with the institutional teaching model, the redesign of the curriculum and the structuring of the evaluation. They also follow a structure that contemplates a sequence consisting of didactic strategies developed in the classroom (review of programmatic content topics), simulation activities and training practice in the real environment. The institutional learning model called Theory-Simulation-Practice (TSP), contemplates the integration of the fundamental pillars of knowledge with interdisciplinary simulated practices as follows: Theory: constructivism learning model (To know); Simulation (in): development of competencies and skills (To make); Practice: strengthening of competencies in the real environment-training practice (To be - professional).

The pillars of learning are built from the construction of knowledge with the guidance of the teacher during the activities developed in the theoretical classes, which constitutes the KNOWLEDGE domain. Subsequently, the acquisition and development of disciplinary competencies by learning areas should be promoted from the challenges developed in the simulation clinic, which corresponds to the domain of "KNOWING HOW TO DO". The training cycle closes with the development of internships in hospital centers where efforts are focused on strengthening the competencies of the professional BEING.

Participants

The study had the collaboration of a higher education institution to implement the SBL-in modality, selecting strategic courses that allowed participation in simulation activities.

Three criteria were taken into account: 1) location in the south of Colombia; 2) programs in the health area (medicine, nursing), humanities, engineering, and administration; and 3) current and sufficient agreements to carry out training practices with a highly complex health care institution. As for the students, it was decided that those taking the selected subjects would participate in SBL-in activities as part of the development of the program content. As for the professors, they were the ones who participated in the meetings to define the schedule, the scripts

and made the necessary modifications to the program content, together with the instructors of the Simulation Clinic (SC) and the professionals who interact with the students.

Simulation Sessions

The main characteristic of the SBL-in strategy is the interdisciplinary approach, therefore, students from all programs have a decisive role during each session. The CS instructors, who normally accompany the simulation of the health area students, also participated in these sessions, together with the professors of the selected courses. The representation of complex clinical cases, occurred in the health institution, allows each student to have specific challenges to solve from the expertise of their area and general challenges in which students from two or more different programs work collaboratively, developing critical thinking, to establish comprehensive actions in response to the situations they experience during the simulation.

Evaluation

The interdisciplinary simulation competencies are addressed during the briefing with the students so that they are aware of the objective of the SBL-in strategy, so that, after the activity, the instrument is applied by the instructors and professors. The following is a description of the measurement instruments (proprietary Likert-type instruments constructed and validated during the pilot test with Cohen's Kappa test) to assess the perception and impact of the programmed activities.

- Evaluation of interdisciplinary simulation skills: Instrument built from the programmatic contents of the strategic subjects of all programs.
- Student perceptions of interdisciplinary simulation activities: Instrument that explores students' acceptance of the intervention.
- Teachers' perceptions of interdisciplinary simulation activities: Instrument exploring teachers' acceptance of the intervention.
- Interviews with allied professors: Online format instrument, self-designed for open interviews with external experts who serve as references for the activities.

Scale: Strongly agree (5), Agree (4), Neither agree nor disagree (3), Disagree (2), Strongly disagree (1).

To carry out the process of measuring the impact of intervention on the development of generic and specific competencies during interdisciplinary simulation activities, objective evaluation strategies were employed (regular grades assigned by teachers, objective structured clinical examinations and knowledge evaluations). Finally, open interviews were conducted with teachers and external experts after the end of the observation period (two academic semesters).

Ethical Considerations

This research was carried out without discrimination of any kind, keeping data confidentiality, such as patient information due to the relevance of the challenges assigned to the different simulators, avoiding that the results could be related individually or institutionally. The information management protocols guarantee the principles of confidentiality of the data, both of the participants and of the patients whose information constitutes the challenges that served as the basis for the construction of the simulated clinical cases. The research was conducted

under the authorization of the Ethics/Bioethics and Scientific Research Committee of the UNINAVARRA on January 17, 2022.

Data Analysis

The Likert scale surveys allowed us to know the averages and trends related to participants' perception/appreciation/approval, data on which data on averages, standard deviation, and confidence intervals are presented. For evaluation systems that generate qualification, quantitative, measures of central tendency and results of correlation tests are also presented using Pearson's statistician after the normality hypothesis has been verified.

Results

Once permission has been obtained from the educational institution for the implementation of the strategy, the total number of strategic subjects per academic program (Medicine, Nursing, Laws, Business Administration, Environmental Engineering, Industrial Engineering) was determined by their theoretical-practical nature. 19 clinical services were structured, among them: external consultation, hospitalization, delivery and surgery rooms, intensive care units and procedural rooms, equipped with a total of 3 simulators of low fidelity, 4 of medium and 7 of high fidelity.

The selected challenges were clinical cases taken from the services of the health institution where medical and nursing students perform internships. For this reason, the simulation activities required an average of 3 medical students and one nursing student to develop the activities corresponding to patient care and they are joined by one student from each of the other programs to develop activities related to their respective disciplines. The sample consisted of 272 students belonging to different careers. 56% were in medicine, 18% in nursing, 5.1% in business administration, 4% in law, 7.7% in industrial engineering and 9.2% in environmental engineering. Below is a sample of the role results.

Roles

Medical students

56% of the total. They carried out the process of taking the patient's clinical history, requesting paraclinical tests and carrying out the patient's treatment, as required by the clinical case presented.

Nursing students

These constituted 18% of the participants. Their main role was to carry out the patient care plan (comprehensive care in the patient setting, drug administration, procedures and follow-up of patient safety issues).

Teaching

Challenge bank

The professors participating in the project were able to identify challenging situations in the health institution with which they have a teaching-service agreement. Each challenge was recorded in an online bank, which allowed the researchers to review the recorded information and identify the key points to establish the scripts for the practices and establish the evaluation mechanism for the proposed solution. The total number of challenges found was as follows:

Medicine: 100, Nursing: 68, Law: 26, Business Administration: 2, Environmental Engineering: 2 and Industrial Engineering: 2.

Interdisciplinary Simulation Activities

A total of 85 simulation sessions were carried out. Medical students had the highest participation (75% of activities), followed by nursing students (46%).

Curriculum

The didactic strategies were modified to respond to the TSP learning triad and, consequently, the hours allocated for interdisciplinary simulation activities were adjusted. From the beginning of the semester, students in the medical program put the TSP sequence into practice, since they receive a class on a particular topic, then go on to perform the immersive interdisciplinary simulation activities and finally carry out the assistance practices. The most significant change was the increase in the number of hours for interdisciplinary simulation. Table 1 shows the curricular modifications for the implementation of the ABS-in through the number of hours assigned before and after.

Course	Training practice (Hours)	SBL-in (Hours) (%*)	Proposed curriculum adjustment
Medicine			
Semiology	165	49 (30%)	increase 4 academic credits for each course
Internal Medicine I-II	165	49 (30%)	
Pediatrics	282	85 (30%)	
Gynecobstetrics	282	85 (30%)	
General Surgery	353	106 (30%	
Nursing			
Basic fundamentals of nursing	71	21 (30%)	Redistribution of hours
Nursing care in women's care, mother - gynecology and obstetrics	118	35 (30%)	+2 academic credits
Nursing care in day-care centers	118	35 (30%)	+2 academic credits
Nursing care in chronic diseases	118	35 (30%)	+2 academic credits
Nursing care in emergency diseases	118	35 (30%)	+2 academic credits
Administration of nursing care services	188	56 (30%)	Redistribution of hours
Business Administration			
Human Talent management	6	6 (100%)	Redistribution of hours
Laws			
Medical Law	6	6 (100%)	Redistribution of hours
Industrial Engineering			

Workshop and Maintenance	6	6 (100%)	Redistribution of hours
Environmental Engineering			
Solid wastes	6	6 (100%)	Redistribution of hours

Table 1. Distribution of the Hours Assigned To SBL-In Activities

Participants	N	Mean (SD)	positive %*
Medicine	152	4,26 (0,53)	72%
Nursing	49	4,3 (0,49)	67%
Business Administration	14	4,2 (0,48)	44%
Laws	11	4,4 (0,52)	82%
Industrial Engineering	21	4,3 (0,51)	67%
Environmental Engineering	25	4,3 (0,489)	76%
Total students	272	4,28 (0,506)	71%
Total professors	45	4.6 (0,55)	98,10%
* The percentage of positivity represents the number of participants who rated the activity with a score higher than 4.			

Table 2. Perception of Training Based on the ABS-In Strategy.

Evaluation

Regarding the development of interdisciplinary competencies, instructors and professors recorded an evaluation that reflected in the radar chart results, the highest peaks were in collaborative work, communication, troubleshooting and critical thinking. Medical students had already taken the three evaluation modalities before the intervention and, therefore, it is possible to compare the results with the post-intervention results) for the competencies of KNOWING - written knowledge test, DOING - OSCE and BEING - clinical competencies. After the intervention, all three aspects showed improvement, being more noticeable for the KNOWLEDGE competencies.

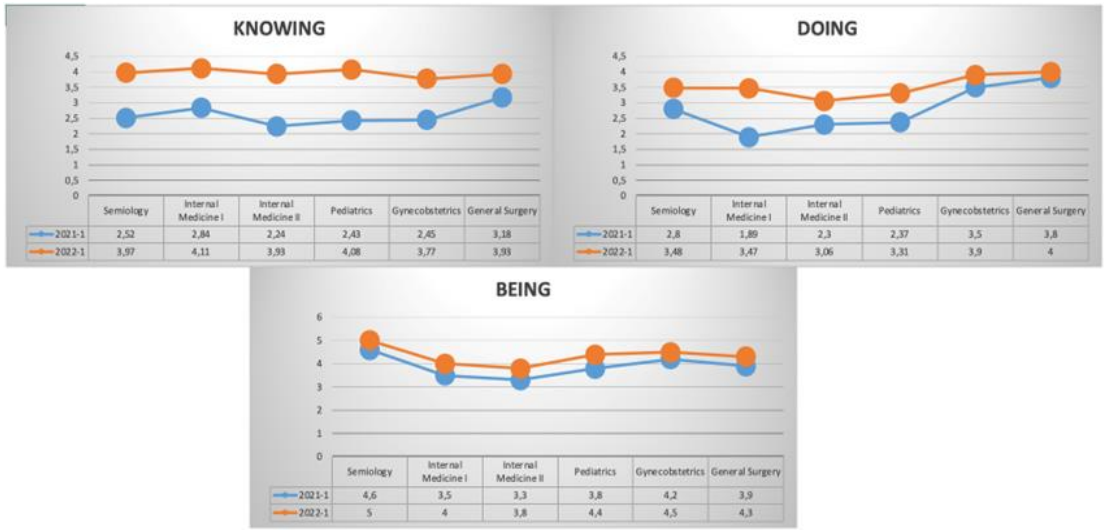

Figure 2. Comparative Results of the Quantitative Evaluations of Students.

Once the quantitative results were obtained, correlations were made (Pearson's statistic); it was found that between these variables only statistically significant findings were found for the development of competencies in the simulated scenarios with respect to the competencies in e training practice scenarios, and for the perception of the interdisciplinary simulation activity with respect to the competencies evaluated during the training practices.

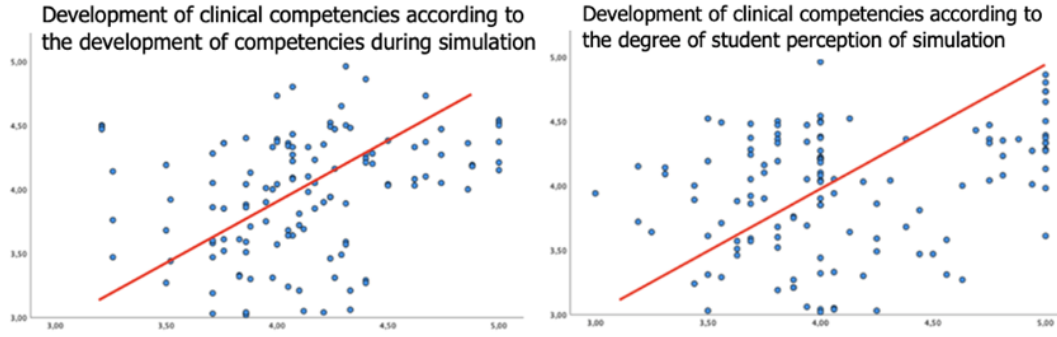

Figure 3.

Statistically significant correlations with respect to the competencies required for the development of training practices.

Discussion

This study shows the scope and limitations of the implementation of a didactic strategy based on simulation in a higher education institution through modifications in the teaching, curriculum and evaluation processes. The research of Zuñiga(17), in which they set up an interdisciplinary hospital simulation center through a simulated clinical service, corroborates the importance of the current study.

Similarly, the research by Austin et al. reported that the university under study undertook an extensive transformation of the undergraduate medical curriculum, in which they included a transition to clinical practice course with simulation-based teaching techniques such as the use of a multi-structured OSCE. (18) Teagle et al. point out that, practical courses and simulation are an effective and successful tool to facilitate the transition from medical student to physician-in-training by improving confidence, competence and, consequently, patient safety and quality of care.(19)

The implementation of the didactic strategy of simulated learning constitutes an opportunity for student growth that facilitates the early identification of problems in the professional field in controlled environments.

In this regard, Navarro and Chiappe reviewed research on the educational implementation of simulations in various professions, highlighting the importance of integrating simulation-based learning into higher education curricula to prepare students for the complex realities of the work environment.(20)

Faculty of health recorded majority participation in interdisciplinary simulation practices related to the plurality of subjects of theoretical-practical nature linked as strategic and the number of documented challenges. The above is consistent with the findings of several authors who report the positive impact of the implementation of ABS and the realization of interdisciplinary practices, only in related academic programs such as medicine and nursing, aimed at strengthening skills and competencies in frequent clinical emergency situations(21,22) without linking students from different areas of knowledge.

Third generation universities must adapt to the multisectoral difficulties of the environment through curricular changes that favor the teaching-learning processes(23,24). This coincides with Camacho et al.,(25) who propose the progressive transformation of simulated learning strategies through the incorporation of ICT for the appropriate development of the competencies of Knowing How to Be applicable in the formative clinical practice.(26,27) The SBL-in promotes the continuous improvement of the skills and competencies of undergraduate students.

The implementation of SBL from the undergraduate training processes actively strengthens the development of disciplinary competencies in the formative practice stage. On the other hand, the improvement in the evaluation results associated with the development of general and disciplinary competencies appropriate for the development of formative practices is perceived, mainly in the medical students. In general terms, the adequate perception of the students is related to the feeling of safety of the simulated environments, which is reflected in an adequate motivation for participation in interdisciplinary practices, and the development of collaborative work, problem solving, decision making and critical thinking skills. (28)

The institutional transformations necessary for the curricular incorporation of the SBL-in presented some limitations related to the challenges for some careers, the disparity of the evaluation models and the logistical difficulties related to the academic calendars of each program.

Other authors report no difficulties during the implementation of these strategies, probably related to the exclusive integration of health sciences students with challenges of a clinical nature with thematic content related to the situations of the training practice centers.(17,29)

Conclusions

The SBL-in strategy implemented in a higher education institution had a positive impact, allowing the practical articulation between students of health sciences and other programs. This didactic strategy is achieved thanks to the institutional commitment to achieve the necessary organizational adjustments for the curricular transformation as a guiding axis that allows the integral development of generic and disciplinary competencies.

In this research, only two limitations were identified: the lack of similar international references, interdisciplinary and immersive, that allow a more accurate comparison when performing the self-evaluation process.

The development of similar strategies in other higher education institutions is recommended, mainly for those that have health programs and simulated learning environments as a focus for the integral development of academic training In addition, new lines of research involving other emerging technologies (augmented reality, metaverse, artificial intelligence and robotics) were identified to achieve a greater impact on knowledge management. All this without neglecting the management of academic quality that guarantees an education that provides students with the real possibility of developing social and emotional skills that are intertwined with technological and research skills required to achieve the subcomponents of critical and systemic thinking and reasoning for complexity in the XXI century.

Author Contributions

All authors were involved in concept, design, collection of data, interpretation, writing, and critically revising the article. All authors approved the final version of the article.

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Data Availability and Sharing Policy: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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