Artigo Original

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WEB-BASED SIMULATION: A TOOL FOR TEACHING CRITICAL CARE NURSING

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The objectives of this study were to develop, to implement and to evaluate a web-based simulation for critical care nursing, as a tool for teaching nursing students at the undergraduate level. An adapted methodology was used to develop teaching material in a web-based learning environment, consisting of three evaluation phases (ergonomic, pedagogical and usability), carried out by web-designers/programmers, nursing teachers/nurses, and undergraduate nursing students. The research tools used were three different evaluation forms, based on a five-point Likert scale, which were applied after using the simulation. The results garnered from the forms show positive analyses in every evaluation, with special emphasis on the encouragement of learning in the pedagogical evaluation period. In the usability evaluation, the highlight was on the students' satisfaction in using the environment and how easy it was to navigate. This shows the feasibility of using this simulation to improve the learning process.

DESCRIPTORS: nursing informatics; internet; education, nursing

SIMULACIÓN UTILIZANDO LA WEB: UNA HERRAMIENTA PARA LA ENSEÑANZA DE ENFERMERÍA EN TERAPIA INTENSIVA

Este estudio tuvo por objetivos desarrollar, implementar y evaluar una simulación de terapia intensiva, utilizando la tecnología web, para la enseñanza de graduación en enfermería. Fue utilizada una metodología adaptada para la construcción de material de instrucción en ambiente de enseñanza web, compuesta por tres fases de evaluación (ergonómica, pedagógica y utilización), realizadas por webdesigners/programadores, docentes/enfermeros y alumnos del curso de graduación en enfermería. Como instrumentos de investigación, fueron aplicados tres diferentes formularios de evaluación, basados en la escala Likert de cinco puntos, después de la utilización de la simulación. Los resultados presentados en los formularios muestran análisis positivos en todas las evaluaciones, destacando en la evaluación pedagógica el estímulo al aprendizaje y en la evaluación de utilización la satisfacción de los alumnos al usar el ambiente y al constatar la facilidad del manoseo, traduciendo la indicación del uso de esa simulación en un proceso para mejorar la enseñanza y el aprendizaje.

DESCRIPTORES: enfermería informática; internet; educación en enfermería

SIMULAÇÃO BASEADA NA WEB: UMA FERRAMENTA PARA O ENSINO DE ENFERMAGEM EM TERAPIA INTENSIVA

Este estudo teve por objetivos desenvolver, implementar e avaliar uma simulação em terapia intensiva, utilizando a tecnologia web, para o ensino de graduação em enfermagem. Foi utilizada metodologia adaptada para construção de material instrucional em ambiente de ensino web, composta por três fases de avaliação (ergonômica, pedagógica e usabilidade), realizadas por webdesigners/programadores, docentes/enfermeiros e alunos do curso de graduação em enfermagem. Como instrumentos de pesquisa, foram aplicados três diferentes formulários de avaliação, baseados em escala Likert de cinco pontos, após a utilização da simulação. Os resultados apresentados nos formulários mostram análises positivas em todas as avaliações, destacando na avaliação pedagógica o estímulo ao aprendizado e na avaliação de usabilidade a satisfação dos alunos na utilização do ambiente e a facilidade de manuseio, traduzindo a indicação do uso dessa simulação para melhoria do processo ensino-aprendizagem.

DESCRITORES: informática em enfermagem; internet; educação em enfermagem

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INTRODUCTION

*T*he popularity of internet use has triggered initiatives to developing new approaches to health education. This allowed for implementing new interactive media along with new teaching methods.

Using computer tools in health teaching is justified by the complex information, and often in great amounts, that is required to be used in the decision-making process, and by the possibility that these tools offer as new forms of educational material, including sound, image, and video in an interactive manner.

The study of intensive care nursing is a great challenge for students. Besides facing the complex health condition of patients in this health care setting, the students must have basic knowledge of monitoring with equipment that translates the patients' clinical parameters, and understand the complexity implied by the health care demands, as well as to articulate a whole body of previously acquired and constantly increasing knowledge. The patient's characteristic of being in a critical health condition implies that teaching in this area should include the development of sharper perception skills and the ability to make fast and accurate decisions.

The clinical setting of critical care is usually that of a place with an intense work rhythm, in which patients are clinically unstable. Nonetheless, despite the various clinical situations that can occur in this unit, it is not always the case that students have the opportunity to experience either a common or critical clinical situation that would allow for a safer professional practice in the future. Furthermore, the professor does not have control over the types of experiences that the student will have, or the conditions under which abilities can be observed, learned, or practiced, which, together with the lack of the educational resources necessary for a deeper knowledge acquisition, can cause a lack of appropriate theoretical and logical support for the students' decision-making process.

In regard to teaching, the internet is very promising; resources can and should be further explored in nursing[1]. Educators should, therefore, be aware of the possibilities inherent in this technology, such as favoring the development of new products and processes, which could contribute to insert nursing into other scenarios.

Hence, with the aim to incorporate new teaching-learning approaches using computer resources, developing clinical simulations could be an innovative and complementary proposal for nursing education, allowing students to learn without taking the risks that could emerge as a consequence of inaccurate actions[2]. This development proposal also offers students the opportunity to use multimedia resources developed for this purpose.

The concern with promoting safety in health care has been continuously reinforced[3-4], since it implies high costs for patients who sustain injury as a result of the health care process[5]. In other words, using computer technology can contribute in the sense that it helps to improve practice and, thus, minimize the inherent risks, since there are no patients involved in this process. Another consideration is the innovation of teaching-learning strategies, allowing for a more comprehensive student evaluation, thus complementing the practical education with a better cognitive evaluation. Taking these factors into consideration, the study objective was to develop and analyze the application of a clinical simulation environment in critical care nursing, through the internet, with a view to offering the elements to improve educational quality in this area, and helping students to improve their critical thinking and questioning of the practice itself.

MATERIALS AND METHODS

This is a descriptive, applied study in the research field of Computers, Information Technology and Nursing and Health Communication, developed at the Center for Nursing Informatics at the Federal University of São Paulo (NIEn/UNIFESP). The project was approved by the UNIFESP Research Ethics Committee, and each subject was properly informed and signed the Free and Informed Consent Form, as per Resolution 196/96 of the National Health Council (CNS – Conselho Nacional da Saúde).

In regard to intellectual authorship, the authors of the tools used in the pedagogical evaluation[6-7] and usability evaluation[8] phases were contacted via e-mail to obtain their permission to use and adapt the respective tools.

The selected application domain was part of the theoretical content addressed in the *Nursing in surgical and emergency incidents* class, in the

Nursing Course at the Federal University of Santa Catarina. The selected evaluation themes were the evaluation of critical patients, acute respiratory insufficiency, mechanical ventilation, and thoracic drainage. The simulation presented, in general terms, a patient's preliminary data from the moment he was admitted to the Intensive Care Unit, a victim of a stab wound injury to his right hemithorax, causing acute respiratory failure and making mechanical ventilation necessary. With this initial information, the students selected which data they thought important for the evaluation, so that they could propose the nursing actions pertinent to the data they took into consideration.

To develop the environment, methodology adaptation was used to construct the teaching material in a web-based[9] teaching environment, consisting of six phases.

In the teaching design phase, definitions were created regarding the environment's pedagogical architecture, the educational goals, the theoretical content of the knowledge foundation, and the resources used, such as image and audio files.

In the computer modeling phase, the requirements for developing and implementing the environment were determined, and this phase included the use of various software: Dreamweaver® (HTML and PHP pages); Fireworks® (image edition), and Flash® (animations). The simulation consisted of dynamic web pages programmed in PHP (*script* 4.3) to construct the inference motor and the user's research interface, and a relational databank – MySQL 4.0. To execute the dynamic pages, an Apache® 2.0 server with web interface was used.

For the ergonomic evaluation, a tool was administered to make a technical evaluation of the developed environment. Four web-designers and programmers participated in this phase, who performed the evaluation by filling out an online form after ending the access to the simulation, which was done using a login and password created specifically for this purpose. The ergonomic evaluation tool consisted of 15 items distributed in three criteria: organization (4 items), presentation (5 items), and technical criteria (6 items). Each item presented a value scale with five answer categories: (1) bad, (2) regular, (3) good, (4) very good, and (5) excellent.

The purpose of the pedagogic evaluation phase was to validate the articulation of the theoretical content with the proposed knowledge foundation, and was performed by filling out an online form adapted and based on other tools[6-7]. The form was administered to a group of experts composed of four nursing professors and four intensive care nurses, who filled them out after they finished using the simulation. The evaluators had access to the website with the respective evaluation form, using a login and password defined specifically for this use. The pedagogical evaluation tool consisted of 44 items, distributed in three criteria: content evaluation (12 items), content organization and presentation (27 items), and evaluation of learning (5 items). Each item had five answer categories, in a Likert scale: (1) strongly disagree, (2) partially disagree, (3) undecided, (4) partially agree, and (5) strongly agree.

The implementation phase of the environment was performed after two previous evaluations and the adjustment of proposed changes; the simulation was then made available on the web server of the Nursing Department at the Federal University of São Paulo (http://www.unifesp.br/denf/NIEn/simula). The simulation consisted of a group of web pages with text and graphic descriptions of the clinical condition of a patient hospitalized in an Intensive Care Unit. These pages were linked but dynamic, and had access to a databank.

Finally, the purpose of the usability evaluation was to determine the participants' level of satisfaction, motivation and difficulties when using the environment. To do this, an adapted tool[8] was used, which the students filled out immediately after finishing the simulation, using the online form available on the same site. Subjects in this phase were 25 students from the 6th academic term of the Nursing Course at the Federal University of Santa Catarina, who were enrolled in the *Nursing in surgical and emergency incidents* class.

RESULTS

The data collected by administering the simulation evaluation tools were coded into an electronic spreadsheet and treated using SPSS® for Windows® (*Statistical Package for the Social Sciences*). Descriptive statistical analysis was applied to the databank variables (each item of the simulation with

students and professors), which included calculating the means and standard deviations.

Ergonomic evaluation

The organization criteria achieved a 4.43 mean, in which its items concerning the easiness of using the site, the layout logic and consistency in every page presented a variation of 0.25 under the objectivity of the layout.

The presentation criteria showed balance. Among its items, the harmony between the text and the pages' background and the appropriate use of graphic elements and animations achieved similar means (4.5) and were considered satisfactory. The other criteria, such as adequate color and font use, also achieved identical and higher means (4.75).

In regard to the technical criteria, its overall mean was 4.79. The items concerning adequate link functioning, graphic optimization for different band widths, working in different browsers, and page upload speed were considered excellent by the evaluators, achieving a mean of 5. The connection with the databank was considered very good (4.5), and so was multimedia resource functioning.

The ergonomic evaluation was extremely important because it allowed for the adjustment of several aspects that had not been foreseen in the preliminary version of the simulation, and were not part of the evaluation tool used.

The results achieved in this phase were considered satisfactory and, after making the suggested adjustments, the next evaluation phase was started.

Pedagogical evaluation

Most items in the content evaluation criteria (Table 1) received positive evaluations; that is, presented means above four (partially agree). There was unanimous agreement that the grammar used was appropriate, and the items with the highest means were the items concerning the information presentation at the appropriate level for students, the materials' encouragement towards leaning, and the website's limitations do not exceed its value, all of which achieved an identical mean (4.875±0.354). The only item with an unsatisfactory evaluation for the adopted criteria was information clarity and conciseness (mean 3.62±0.744).

Table 1 – Content evaluation criteria

Content evaluation	Mean	Standard deviation
1. The content is up-to-date	4.75	0.46
2. The information is presented in a clear and concise manner	3.625	0.744
3. Correct grammar use	5	0
4. The content is logically organized	4.125	0,991
5. The content is coherent with the target-audience	4.625	0.518
6. The information is presented at the appropriate level for students	4.875	0.354
7. There is coherence with the proposed goals	4.5	0.53
8. The material encourages learning	4.875	0.354
9. The learning goals are clearly defined	4.25	0.46
10. The material simulates reality well	4.375	0.518
11. The website limitations do not surpass its value	4.875	0.354
12. Permits learning from experience	4.625	0.518
Final means	4.542	0.631

As for content organization and presentation criteria (Table 2), the items concerning the text color adequacy, balance of the number of colors on each screen, and the quality of text, images, graphics, and video achieved maximum means, showing there was unanimous consensus.

Content division into small segments, using font with appropriate style and size, text readability, and the presentation of information that captured the students' attention were items that also achieved high and equal means (4.75±0.46).

The page upload speed and the user-friendly internet use (surfing) from page to page achieved identical means (4.625±0.518). The students' identification of the moment they had reached in the simulation achieved a mean of 4.5±0.53. Immediate feedback after the answer obtained a 4.375±0.518 mean. The item concerning the design overload on the student's memory did not receive a satisfactory evaluation (3.625±0.916).

Paradoxically, although the item that considered sound as an unnecessary alternative presentation form received a low evaluation (1.5±1.07), this result reinforced the importance of using sound in the simulation, because the low mean shows that most evaluators disagree that sound is an unnecessary alternative medium.

Table 2 – Content organization and presentation criteria

Content organization and presentation criteria	Mean	Standard deviation
1. The content is presented in a clear and comprehensible manner	4.25	0.46
2. The documentation for students is clear and sufficient	4.25	0.46
3. The content is divided into small segments	4.75	0.46
4. The simulation presents students with questions that do not interrupt the learning process	3.875	0.641
5. Internet surfing is user-friendly	4.625	0.518
6. The student always knows in which moment of the simulation they are	4.5	0.53
7. Immediate feedback is provided after the answer	4.375	0.518
8. The simulation permits students to check their performance	4.5	0.53
9. Interface is appropriate	4.125	0.835
10. The screens were developed in a clear and comprehensible manner	4.5	0.53
11. The information presentation captures the students' attention	4.75	0.46
12. The information presentation can stimulate memory	4	0.53
13. The design does not overload the students' memory	3.625	0.916
14. The space is well distributed on the screen	4.875	0.354
15. The fonts are of appropriate size and style	4.75	0.46
16. The text is easy to read	4.75	0.46
17. The text is in an appropriate color	5	0
18. There is balance in the number of colors on each screen	5	0
19. Text, image, graphic and video quality are good	5	0
20. The pictures presented are relevant for the information in the text.	4.25	0.89
21. Image use strongly supported the text provided	4	1.41
22. The video improved information presentation	4.25	1.16
23. The sound has good quality and improved information presentation	4	1.31
24. The sound is an unnecessary alternative form of presenting the information	1.5	1.07
25. Page upload speed is satisfactory	4.625	0.518
26. The horizontal scroll bars were not used	4.25	0.89
27. The information is organized in small and functional units	4.25	0.71
Final means	4.319	0.937

In the learning evaluation criteria (Table 3), using the simulation as an educational tool was strongly indicated (mean 4.625±0.518) and the ease of use and effectiveness in teaching achieved identical means (4.375±0.518). The ability to retain the simulation in the students' memory was positively evaluated (4.0±0.76). The simulation structure was considered broad, favoring students with average performance, who were able to fully understand and follow (4.0±0.93).

Table 3 – Learning evaluation criteria

Learning evaluation	Mean	Standard deviation
1. The simulation is easy to use	4.375	0.518
2. The simulation is teaching-efficient	4.375	0.518
3. Use of the simulation is easily retained in the students' memory; the casual student is able to return to it after some time without needing to re-learn how to use it	4	0.76
4. The structure is broad and students with average performance are able to follow it	4	0.93
5. The simulation is indicated to be used as an educational tool	4.625	0.518
Final means	4.275	0.679

The results obtained in the pedagogical evaluation were considered satisfactory for the simulation to be implemented with students. Although some of the proposed suggestions were important, not all of them could be considered before applying the tool with students, since they concerned making deep conceptual changes in the developed model.

Usability evaluation

The usability evaluation consisted of a form with 17 items, distributed in three criteria: general reaction to simulation use (5 items), evaluation of the screens (9 items), and learning (3 items). The items were distributed on a scale with five answer categories that varied according to the intensity of the evaluated item.

All items related to the criteria concerning the general reaction to the simulation (Table 4) achieved good evaluations. With high means (4.84±0.374), the students showed satisfaction towards using the simulation. The overall simulation-

use experience achieved a mean of 4.8±0.408, identical to the simulation usefulness (4.8±0.41), and the item concerning the encouragement towards the simulation received a 4.6 mean. The simulation was considered easy to use, with a 4.44 evaluation mean.

Table 4 – General simulation-use reaction criteria

General reaction to using the simulation	Mean	Standard deviation
1. Overall experience	4.8	0.408
2. Ease of use	4.44	0.51
3. Satisfaction of using	4.84	0.374
4. Encouragement to use	4.6	0.65
5. Usefulness	4.8	0.41
Overall means	4.696	0.496

In the screen evaluation criteria (Table 5), the colors used in the simulation were unanimously considered appropriate. The sound files were considered adequate (4.84±0.374) and so were the videos (4.48±0.77) and images (4.4±0.645). The on-screen text readability was considered high (4.6±0.5).

Table 5 – Screen evaluation criteria

Screens	Mean	Standard deviation
1. On-screen text readability	4.6	0.5
2. Web-surfing structure	4.76	0.435
3. Information organization	3.96	0.789
4. Sound file adequacy	4.84	0.374
5. Video file adequacy	4.48	0.77
6. Image adequacy	4.4	0.645
7. Color adequacy	5	0
8. Screen sequence	4.56	0.583
9. Page upload speed	4.8	0.408
Overall means	4.6	0.612

In the learning evaluation criteria, the item concerning the contribution of learning to using the simulation achieved a mean of 4.72±0.458. A satisfactory value was also observed for the level of contribution to learning (4.2±0.408). Nevertheless, the item concerning satisfaction with the performance in the simulation did not achieve a satisfactory value (3.56±1.157).

DISCUSSION

In the pedagogical evaluation, the obtained means show a positive contextualization of the content, in tune with the contemporariness and pertinence of its approach, considering the current state-of-the-art, as well as content coherence with the target audience and the course curricula. This shows the considerable proximity to the content of on-site learning, but preserves the features of web-based teaching.

Positive aspects in the pedagogical evaluation include the students' opportunity to make a self-evaluation of data searching and proposing critical patient care, in addition to encouraging learning. Other points that were highlighted were the use of good-quality video and sound, sending out positive encouraging messages to the user, and the simulation being innovative, with the potential to augment learning. As to the negative aspects, one evaluator reported that using a problem list is confusing and can prevent establishing adequate interventions to meet each need. It was also noted that the simulation was somewhat repetitive and long, and used abbreviations. The inability to return to initial data and interrupt the study and come back again later was also mentioned. Suggestions were made to provide content and format reviews of the interventions, using the International Classification for Nursing Practice, and developing a screen at the end of the simulation with the result from the three evaluations, so that the student could make a more visual evaluation of patient evolution.

Some of the positive aspects of the usability evaluation were: easy visualization, which makes students think and remember the content; easy to use and does not require advanced computer skills; fast feedback to the questions provides continued learning, encourages the perception of sounds and uses efficient sound and image resources for the evaluation. The negative aspects reported include the inability to 'return' to the previous evaluation to compare with the current one, and the presentation of some data difficult to evaluate because of forgetting reference values. The suggestions made were to create a help window (like literature references) and include a link to check reference values.

CONCLUSION

The ergonomic, pedagogic, and usability evaluations reveal an overall satisfactory analysis,

indicating the validity of this simulation tool to improve the teaching-learning process.

These study results were important to better understand the various aspects involved in the process of developing and using alternative educational technologies in undergraduate courses, as well as the students' response to this process, which showed the possible benefits, aspects that have been previously reported in other studies [10-11].

Using computer technology resources in the teaching-learning process implies the need to not only incorporate knowledge that is pertinent to the area, but also the need to search and improve concepts founded on software ergonomics and pedagogy with a view to development and further improvements. Emphasis should be given to the pedagogic issue rather than exclusively to technology *per se*[12].

Developing and using new educational approaches via the internet contribute by complementing on-site learning, as well as by creating the possibility of enhancing the teaching-learning process and progressively incorporating new technologies and resources into the teaching mode that is more in-tune with the society's educational needs. The fact that there are still only a few experiences involving the use of computer technology in nursing education shows that there is a need to develop a greater number of studies that compare the results and perform a more in-depth research.

Simply using educational software will certainly not solve every problem involved in the education aspects included in the teaching context. In fact, to reach a solution for these problems, it is necessary to make changes that do not only involve the professors, but also the educational process itself. Hence, this study showed the viability of developing a simulation primarily focused on web-based nursing undergraduate education, and it is a door to further study. Nursing education is going through rapid changes, which means it is necessary for educators to consider what is stated in the curricular guidelines, and also to encourage students towards independent study practices, with a view to their progressive intellectual and professional autonomy.

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