

Difficulties and Effectiveness of Low Fidelity Simulation in Teaching Practical Skills to Nursing Students in Selected Institutions in Nigeria

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Abstract

Introduction: Low fidelity simulation is a type of simulation that uses basic equipment and materials to replicate patient scenarios. The promotion of these skills is considered a necessary condition for nursing student performance in the nursing profession. This study assessed the difficulties and effectiveness of low fidelity simulation in teaching practical abilities to nursing students in selected nursing schools in Ibadan.

Methods: The study utilized a descriptive cross-sectional approach. A technique of random sampling was used to choose 172 respondents. A validated instrument was used for data collection. Analysis was done utilizing SPSS software version 25.0 software. The chi-square test was used in order to test the correlation among variables at a P value ≤ 0.05 .

Findings: The average age of the respondents appeared to be 23.4 ± 2.4 years. Majority (79.1%) of nursing students experienced high effectiveness with low-fidelity simulation in terms of competence development, clinical decision-making, monitoring of patient vitals, and emergency response. However, difficulties were encountered during the use of low-fidelity simulation, including a lack of understanding of accurate clinical judgments concerning actual patients (71.5%), and difficulty in understanding low-fidelity simulation (39.0%). Also, not entirely replicating an actual nursing role decision-making (80.2%) was an identified difficulty. There was no significant relationship association between the socio-demographic variables (years) and the identified difficulties experienced in the use of simplified simulation with reduced accuracy ($P = 0.08$).

Conclusion: The use of low fidelity simulation is highly effective in nursing education. Nevertheless, nursing students are faced more challenges in comprehending low-fidelity simulation. As a result, there is a requirement for continuous assistance and direction in low-fidelity simulation to enhance the students' understanding.

Keywords: Difficulties; Effectiveness; Nursing students; Low-fidelity simulation

Introduction

Simulation has been described by several researchers as activities that are imitations of reality and contain roleplaying mannequins or video clips with interactive elements that assist college students acquire knowledge and permit, they must exhibit decision-making, crucial questioning, the other talents [1]. Several forms that simulate had been recognized as a method that is used in nursing training. Nursing education has employed a variety of simulators, spanning from those with limited realism to excessive-constancy (high-fidelity) simulators. Low-constancy (low-fidelity) simulators encompass stationary models have been put to effective use by students for practicing psychomotor skills abilities in monitored surroundings [2].

Researchers have shown that with low-fidelity simulators, there are several difficulties experienced in their use [3]. One of the challenges that have been recognized pertains to securing the funding required for operating lifelike simulations [4]. Several funding-related challenges have discouraged certain nursing schools from integrating simulation experiences into their curricula. Other difficulties include insufficient human resources to perform the manikin's supervision, thereby making a restriction requiring simulation in nursing curriculum. Literature has shown that administrative support is lacking in low-fidelity simulator use that is, administrators don't plan for and acquire funding for equipment, adequate laboratory space, a coordinator of simulations and an IT support specialist [5]. All the aforementioned difficulties pose a threat. Simulation laboratories are costly with beds, manikins, intravenous pumps, vital sign equipment, heart monitors, and emergency equipment most frequently used to create a realistic

hospital scene. Time constraints are set to be a difficult to low-fidelity simulation, creating the scenario or choosing one created by the vendor is the first stage in simulation. It takes a lot of work to create scenarios that include the learning objectives, any necessary props or equipment, any supplies the learners might need throughout the simulation, and how the scenario will develop based on the learners' actions or inaction. [6]. Insufficient time to prepare for simulation. Lack of time to create instances and the amount of time needed for training were mentioned as obstacles to the use of simulation.

Simulators have been used by healthcare professional training programs to support student learning in a number of contexts and ways, despite the obstacles associated with their use [7]. Simulations have been used to measure student learning and their level of clinical competence. Simulators have also been used to help pupils when they need to be corrected and to teach new concepts.

Hence, the need to investigate the difficulties and effectiveness experienced in the use of low-fidelity simulations among nursing

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students in selected institutions is necessary.

The specific objectives of this study are to:

Assess the effectiveness of the use of low-fidelity simulation among nursing students in the selected institutions.

Identify the difficulties experienced in the use of low-fidelity simulation among nursing students in selected institutions

Research hypothesis

There is no significant relationship between the socio-demographic variables (level) and the identified difficulties experienced in the use of Low Fidelity Simulation by nursing students.

There is no significant relationship between the identified difficulties and the effectiveness of the use of low-fidelity simulation by students among selected schools.

Methodology

Study design

This is a cross-sectional descriptive survey to describe the difficulties and effectiveness of the use of low-fidelity simulation in teaching practical skills to nursing students in selected Institutions.

Study setting

This study was carried out at University College Hospital (UCH) Ibadan (Year 2 and 3 students of the School of Nursing) as well as year 200, 300, 400, and year 500 nursing students at the University of Ibadan. The University of Ibadan was founded on 17, November 1948. The institution is built on over 2,250 acres of land which were kindly rented for 999 years by the Ibadan chiefs and populace. University College Hospital (UCH) Ibadan was established to complement research and treatment of persons with numerous ailments-the College Hospital has several sections and departments that deal with different ranges/degrees of medical care. Year 2 and 3 comprises 83 students of the School of Nursing while nursing students at the University of Ibadan (year 200, year 300, year 400, and year 500) comprises 174 students.

Target population

The Year 2 and 3 students of the School of Nursing as well as Year 200, year 300, year 400 and Year 500 University of Ibadan nursing students were the main target.

Sampling technique

To distribute the questionnaires for this study, a simple random sampling technique was used. This was done by writing letters A and B, squeezed into pieces of paper. And a letter was randomly selected by the authors, to know those who will participate in the study. By this method, every student had an equal chance of being selected for the study.

Research instrument

For this study, the researcher used a self-designed questionnaire. The questionnaire was divided into three (3) sections which are;

Section A provided information on sociodemographic and socio-economic data. Section B provided information on the effectiveness of low-fidelity simulation. Section C provided information about the difficulties of low-fidelity stimulation

Data collection procedure

The data collection spanned three weeks. The questionnaire was

distributed through an online Google form, which was sent to the class WhatsApp group page with adequate follow-up. Informed consent was in the Google form. Instructions on how to fill the questionnaire were written in the beginning sections of the questionnaire and explanations were provided where necessary.

Method of data analysis

The data collected for this study was assessed for accuracy and completeness. Software IBM-SPSS version 25.0 was used for the analysis. Descriptive and inferential statistics are among the data analysis tools used. A frequency distribution table, mean, and standard deviation were utilized as descriptive statistics to assess, synthesise, and provide an answer to research questions 1, 2, and 3. The inferential statistics were performed using the Chi-square test of independence.

For the first objective in which a Likert Scale of 5-point score was used to identify the effectiveness of low fidelity simulation using a scoring system: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree. The scores were presented in a tabular form using frequency and percentage. The effectiveness of low-fidelity simulation was identified by their responses to the items in this section.

For the second objective, a Likert Scale of 5-point score was used to identify the difficulties of the use of low fidelity simulation; the scoring system that was used included: 5 = strongly agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree. The scores were presented in a tabular form in both frequency and percentage. Using the Chi-square test with a 0.05 p-value, associations between variables were examined.

Ethical considerations

Copies of the research proposal were submitted to the University of Ibadan and University College Hospital's ethical review board prior to the start of data collection. (UI/EC/23/0245). A copy of the letter of ethical approval was attached to the letter of introduction from the Head of the Nursing Department at the University of Ibadan, Ibadan to obtain entry permission for data collection from nursing students in University of Ibadan, Ibadan. The participants gave written informed consent before the commencement of the study. Information provided by each participant was strictly meant for academic purposes. The collected information was kept confidential. Therefore, participants were not required to provide their names or any identifier on the questionnaires to be completed. All participants were also asked for and given written informed consent before to the delivery of the questionnaire. The data gathering process is voluntary, and any participant who might desire to leave at any time has been advised to do so without fear of pressure or intimidation. Participation in the research did not incur pain or discomfort for the respondent; their time for participation was not required.

Validity and reliability of the instrument

An expert review was sought to validate the questionnaire. Also, comparing the items with the most recent and relevant literature addressed the structured questionnaire's content validity. Additionally, a theoretical framework was used to direct how the test's question items were structured. 10% of the sample size was used in a pilot study to gauge the instrument's internal dependability. It was 0.87 for the reliability coefficient.

Results

UCH: University College Hospital

Table 1 above presents the sociodemographic characteristics of

the respondents; more than half (52.9%) were between 23-28 years; based on their gender distribution, majority (82.0%) were females; as pertains to their academic level, about one-third (22.7%) were in 300 level, concerning their religious affiliation, two-third (65.9%) were Christians; and larger proportion (75.0%) were student of University of Ibadan while the remaining (25.0%) were UCH School of Nursing students (Table 1).

Table 2 presents the effectiveness of low-fidelity Simulation (mannequin); more than half (51.2%) strongly agreed and a few above one-third (32%) agreed that Low-Fidelity Simulation develops decision-making; about two-thirds (62.8%) agreed and over one-third (19.8) strongly agreed that low-fidelity simulation helps to be more knowledgeable in checking patient’s basic sign of life; more than half (55.6%) agreed and over one-third (19.8%) strongly agreed that low-fidelity simulation makes early patient deterioration easier to detect; more than half (54.7%) agreed and a few over one-third (27.9%) strongly agreed to the use of low-fidelity simulation for examination of clinical competence.

Table 3 presents the difficulties of the use of low-fidelity Simulation (mannequin); a few above one-third (34.9%) agreed and less than one-third (4.1%) strongly agreed to difficulty in understanding Low-Fidelity-Simulation (LFS); about two-thirds (70.3%) agreed and below one-third (6.4%) strongly agreed that non-inclusion of artificial

intelligence in LFS affected their understanding; more than half (61.0%) agreed and below one-third (11.0%) strongly agreed that LFS does not allow a scenario to replace actual patient encounters; more than half (54.7%) agreed and below one-third (14.5%) strongly agreed that LFS is not ideal for teaching both natural and assisted vaginal deliveries.

Hypothesis one

Ho-There is no significant relationship between the socio-demographic variables (level) and the identified difficulties experienced in the use of Low Fidelity Simulation by Nursing students at University College Hospital and the University of Ibadan School of Nursing.

From Table 4 the null hypothesis was accepted because there was no significant relationship between the identified difficulties with the use of low fidelity simulation among nursing students and their academic levels ($\chi^2=16.729$, $P=.081$, as $P>.050$), which was the relationship between socio-demographic variables (level) and the identified difficulties experienced in the use of low fidelity simulation.

Hypothesis two

Ho-There is no significant relationship between the identified effective usefulness of Low Fidelity Simulation among nursing students and the selected schools.

From Table 5 above on the relationship between the identified effective usefulness of Low Fidelity Simulation among nursing students and the selected schools, the null hypothesis was accepted as there was no significant relationship between the effective usefulness of low fidelity simulation and the selected school with ($\chi^2=0.187$, $P=.665$) as $P>.050$.

Hypotheses three

There is no significant relationship between the identified difficulties to the effectiveness and students at the University of Ibadan and those in the School of Nursing at University College Hospital, Ibadan, employ low-fidelity simulation techniques for educational purposes.

Discussion

Socio-demographic information of respondents

The study population primarily consists of young female students, with most being between the ages of 21-26 years and affiliated with Christianity. These demographic Characteristics are found useful for the purpose and are equally found similar to the demographic characteristics from the study of Rauhen. Additionally, the majority of participants were enrolled at the University of Ibadan, with a smaller proportion of students from the University College Hospital School of Nursing.

Table 1: Sociodemographic characteristics of respondents.

Variables	Categories	Frequency (n=172)	Percent (%)
Age (in years)	16 – 22	81	47.1
	23 – 28	91	52.9
	Mean ± SD	23.4 ± 2.4	
	Total	172	100
Sex	Male	31	18
	Female	141	82
	Total	172	100
Academic Level	200 Level	27	15.7
	300 Level	39	22.7
	400 Level	36	20.9
	500 Level	26	15.1
	Year 2	28	16.3
	Year 3	16	9.3
	Total	172	100
Religion	Christian	130	75.6
	Islam	42	24.4
	Total	172	100
Institution	UCH School of Nursing	43	25.0
	University of Ibadan	129	75.0
	Total	172	100

Table 2: Effectiveness of low-fidelity simulation.

Variables	Responses (n=172)				
	SA f(%)	A f(%)	N f(%)	D f(%)	SD f(%)
Low-fidelity simulation develops my decision-making ability.	88(51.2)	55(32.0)	9(5.2)	11(6.4)	9(5.2)
Low-fidelity simulation helps me to be more knowledgeable in checking for basic signs of life in a patient	34(19.8)	108(62.8)	11(6.4)	11(6.4)	8(4.7)
Early patient deterioration is easier for me to detect due to the low-fidelity simulation.	34(19.8)	96(55.6)	12(7.0)	22(12.8)	8(4.7)
I examined my clinical competence due to the use of low-fidelity simulation.	48(27.9)	94(54.7)	13(7.6)	11(6.4)	6(3.5)
Low-fidelity simulation helps me to apply what I learned from the case study.	50(29.1)	101(58.7)	5(2.9)	9(5.2)	7(4.1)
Low fidelity-simulation developed my reasoning skills	59(34.3)	87(50.6)	8(4.7)	10(5.8)	8(4.7)
Low-fidelity simulation gives me a better understanding of the ways and channels to follow when an emergency arises.	51(29.7)	91(52.9)	16(9.3)	7(4.1)	7(4.1)

Table 3: Difficulties regarding the use of low-fidelity simulation.

Variables	Responses (n=172)				
	SA f(%)	A f(%)	N f(%)	D f(%)	SD f(%)
Difficulty in understanding low-fidelity simulation.	7(4.1)	60(34.9)	9(5.2)	81(47.1)	15(8.7)
Low fidelity-simulation models do not include artificial intelligence which affected my practice most times.	11(6.4)	121(70.3)	14(8.1)	20(11.6)	6(3.5)
Low fidelity-simulation does not allow a scenario to replace actual patient encounters with a supervised clinical practice	19(11.0)	105(61.0)	11(6.4)	30(17.4)	7(4.1)
Low-fidelity simulations are not ideal for teaching both natural and assisted vaginal deliveries.	25(14.5)	94(54.7)	8(4.7)	39(22.7)	6(3.5)
Difficulties in understanding the importance of correct decision-making regarding a real patient.	17(9.9)	106(61.6)	17(9.9)	27(15.7)	5(2.9)
Feel that low-simulation exercises do not fully replicate a nursing role in real-life decision-making regarding a real patient.	32(18.6)	106(61.6)	9(5.2)	17(9.9)	8(4.7)

Table 4: Relationship between sociodemographic variables (level) and the identified difficulties experienced in the use of low-fidelity simulation.

Variables		Difficulties with the use of Low-Fidelity Simulation			x ²	df	P
		Disagreed	Neutral	Agreed			
Educational Level	200	10(37%)	2(7.4%)	15(55.6%)	16.729	10	0.081
	300	15(38.5%)	3(7.7%)	21(53.8%)			
	400	23(63.9%)	3(8.3%)	10(27.8%)			
	500	18(69.2%)	0(0%)	8(30.8%)			
	Year 2	19(67.9%)	1(3.6%)	8(28.6%)			
	Year 3	11(68.8%)	0(0%)	5(31.3%)			
	Total	96(55.8%)	9(5.2%)	67(39%)			

Table 5: Relationship between the identified effective usefulness of low fidelity simulation among nursing students and the selected schools.

Variables		Institution		x ²	Df	P
		School of Nursing	University of Ibadan student			
Effective usefulness of LFS among nursing students	Low Effectiveness	8(22.2%)	28(77.8%)	0.187	1	0.665
	High Effectiveness	35(25.7%)	101(74.3%)			
	Total	43(25%)	129(75%)			

The effectiveness of low-fidelity simulation

This present study revealed majority experienced a high level of effectiveness with Low-Fidelity Simulation while less than one-third experienced low effectiveness. This finding suggests that the majority of participants reported positive outcomes from low-fidelity simulation, including the enhancement of decision-making abilities, better comprehension of fundamental patient vital signs, and more effective identification of early patient deterioration are outcomes strongly aligned with the outcomes of Radhakrishnan. This study also illustrated the utilization of simulations to elevate the proficiency levels of nursing students. Similarly, Reilly and Spratt (2021) unveiled that aspiring nurses acknowledged the supportive role of simulations in fostering clinical competence ahead of their real-world clinical experiences.

Specifically, more than half of the participants agreed that low-fidelity simulation is effective in examining clinical competence, and over one-third strongly agreed with this statement. This finding is consistent with Bridges and Holcomb, the assertion that simulations integrating reflection or debriefing within the simulation encounter can establish a connection between theoretical knowledge and practical application, potentially enhancing learners' clinical judgment abilities, has been documented. Similarly, Siddall and McGaghie corroborated the effectiveness of high-fidelity simulation in evaluating the clinical proficiency of pediatric medical residents.

This implies that low-fidelity simulation could serve as a valuable means for evaluating the clinical competence of nurses and pinpointing areas necessitating enhancement. Furthermore, more than half of the participants agreed that low-fidelity simulation helps them apply what

was learned from case studies. In line with these findings, Petrusa, and Scalese, found out, by utilizing simulation encounters, nursing educators can recreate the clinical setting, thereby offering students a controlled yet authentic learning environment. This enables students to engage in the practice of diverse skills and the provision of care for a wide range of patients.

Thus, this finding suggests that low-fidelity simulation can be an effective method for reinforcing theoretical concepts and facilitating the transfer of knowledge to practice. In addition, over half of the participants agreed that low-fidelity simulation provides a better understanding of the ways and channels to follow when emergencies arise. This finding suggests that low-fidelity simulation can be an effective tool for improving nurses' ability to respond to emergencies and make critical decisions in high-stress situations.

Findings suggest that about two-thirds agreed and over one-third strongly agreed that low-fidelity simulation helps to be more knowledgeable in checking a patient's basic signs of life. Also, more than half agreed and over one-third strongly agreed that low-fidelity simulation makes early patient deterioration easier to detect. This finding highlights the potential of low-fidelity simulation for improving students' ability to recognize and respond to changes in patient status before they become critical. Findings in this regard corroborate Radhakrishnan who based on his quasi-experiment, found out the intervention group (a group that utilized low-fidelity simulation) Achieved better results in safety and fundamental assessment proficiencies. Similarly, Morgan discovered that the utilization of high-fidelity simulation for administering resuscitative medications demonstrated effectiveness, particularly in scenarios involving cardiac arrhythmias.

Difficulties experienced in using low-fidelity simulation

The outcomes of the current study indicate that certain nursing students encounter difficulties with the utilization of low-fidelity simulation. The most frequently mentioned challenge was an inadequate grasp of the significance of accurate decision-making within a genuine patient context, as reported by the participants. This observation could stem from the fact that simulations occur outside the authentic clinical environment, leading some students to not treat the simulation with the seriousness it requires [8]. This finding suggests that learners may not fully comprehend the implications of their actions in a simulated environment, and may not be fully prepared for the challenges of real-world patient care.

Another commonly reported difficulty was difficulty in understanding low-fidelity simulation, with participants reporting this challenge. Similarly, Feingold, found out merely fifty percent of the students held the belief that the knowledge gained through simulation would successfully translate into real-world clinical practice. This result implies that learners might necessitate extra assistance and direction to comprehensively grasp and extract benefits from low-fidelity simulation.

The current study's findings demonstrated that low-fidelity simulation exercises fall short of completely replicating the decision-making demands of a nursing role in real-life situations involving actual patients. This observation is in line with supportive evidence. Pittini identified the issue of realism when he conducted a study regarding teaching students how to perform an amniocentesis. This may limit the effectiveness of low-fidelity simulation in preparing learners for real-world clinical practice. If student nurses do not feel that the simulation exercises are realistic and relevant to their future practice, they may not fully engage with the learning process.

Finally, the study found that low-fidelity simulation is perceived as unideal for teaching both natural and assisted vaginal deliveries. This highlights the need for selecting appropriate simulation methods for specific learning objectives. If the simulation exercises are not perceived as relevant or effective for a particular skill or procedure, learners may not fully engage with the learning process or retain the knowledge and skills taught.

Discussion of hypotheses

Findings from this study revealed that difficulty to understand low fidelity-simulation among nursing students was significantly related to their academic levels ($\chi^2=16.729$, $P=.081$). Complaints of difficulties in understanding were significantly higher among those in the 200-level and 300-level. However, no significant association was reported between difficulty in understanding the significance of making accurate decisions when it comes to actual patient care, the feeling of personal stress during low fidelity simulation class, and their academic level as $P>.050$ in each case. This finding may be because the complaints of difficulties were a result of the level of experience, and knowledge of the students as supported by Patricia Benner's stages of clinical competence.

Findings from the second hypothesis tested indicated a notable correlation between low fidelity-simulation developing reasoning skills and the selected schools with ($\chi^2=0.187$, $P=.665$) at $P<.050$.

However, all other identified usefulness was not significantly related to the selected schools as $P>.050$ in each case. Also, the identified difficulties were not significantly related to the use of low-fidelity simulation among nursing students in selected schools as $P>.050$ in each case.

Overall, these findings suggest that academic level may affect nursing students' ability to understand low-fidelity simulation and that the usefulness of low-fidelity simulation in developing reasoning skills may vary across different schools.

Conclusion

Conclusively, the study revealed that the application of low-fidelity simulation is highly effective in nursing practice and education in Nigeria institutional setting. However, nursing students in the 200 and 300 years reported more difficulty in understanding low-fidelity simulation compared to their counterparts in other levels. Thus, there is a need for continuous support and guidance in low-fidelity simulation to improve nursing students' understanding and benefit from its usefulness.

Limitations

The study population could not be expanded to another geopolitical zone within the study country, which limited the applicability of the study's results to a broader context is limited. Also, the findings from this research might not be relevant to diverse healthcare establishments. Similar studies can be conducted utilizing broad research settings, also, further research is required to delve into the variables that impact the efficacy of low-fidelity simulation in nursing education, utilizing a qualitative methodology. This may include examining the impact of different teaching methods, the role of student motivation and engagement, and the impact of individual and cultural factors on learning outcomes. Research should be conducted to ascertain the long-term effects of low-fidelity simulation on clinical practice and learning for nursing students.

References

1. Baraud F, Tellier S, Astruc M (1997) Ion velocity in soil solution during electrokinetic remediation. *J. Hazard Mater* 56: 315-332.
2. Hong Ji, Weiqiu Huang, Zhixiang Xing, Jiaqi Zuo, Zhuang Wang, et al. (2019) Experimental study on removing heavy metals from the municipal solid waste incineration fly ash with the modified electrokinetic remediation device. *Sci Rep* 9: 8271.
3. Gisela Weibel, Urs Eggenberger, Dmitrii A Kulik, Wolfgang Hummel, Stefan Schlumberger, et al. (2018) Extraction of heavy metals from MSWI fly ash using hydrochloric acid and sodium chloride solution. *Waste Manag* 76: 457-471.
4. Khan A, Khan AAP, Asiri AM, Khan I (2017) Facial synthesis, characterization of graphene oxide-zirconium tungstate (GO-Zr(WO₄)₂) nanocomposite and its application as modified microsensor for dopamine. *J Alloy Compd* 723: 811-819.
5. Jurate Virkutyt, Mika Sillanpää, Petri Latostenmaa (2002) Electrokinetic soil remediation—critical overview. *Sci Total Environ* 289: 97-121.
6. Zhiping S, Hui Z, Yunhong Z (2010) Polyimides: Promising energy-storage materials. *Angew Chem Int Ed* 49: 8444-8448.
7. Cavallaro G, Lazzara G, Milioto S (2010) Dispersions of Nanoclays of Different Shapes into Aqueous and Solid Biopolymeric Matrices. *Extended Physicochemical Study. J Surf Colloids* 27: 1158-1167.
8. Lee J, Cameron I, Hassall M (2019) Improving process safety: what roles for digitalization and industry 4.0? *Process Saf Environ Prot* 132: 325-339.