USING SIMULATION FOR ENHANCING STUDENT LEARNING IN EMBRYOLOGY CORE COURSE DURING THE PRECLINICAL PHASE AT KING ABDULAZIZ UNIVERSITY

Wafaa S. Ramadan[1,2], Rasha A. Alshali*[1], Azra Kirmani[3], Malak T. Malaekah[1], Sherifa M. Alamri[1], Alaa A. Farsi[4], Bashayer A. Alkhathlan[1]

[1]Department of Clinical Anatomy, Faculty of Medicine, King Abdulaziz University, Saudi Arabia; [2]Member of Clinical Skill and Simulation Center (CSSC), King Abdulaziz University, Saudi Arabia; [3]Department of Physiology, Faculty of Medicine, King Abdulaziz University, Saudi Arabia; [4]Department of Anatomy, Faculty of Medicine, Jeddah University, Saudi Arabia

Abstract

Students in the preclinical phase of medical curricula need motivation and participation enhancement for better performance and long term learning. The aim of this study was to evaluate the effectiveness of integrating simulation sessions with traditional lectures in the embryology core course in basic science. Second year male and female students in faculty of medicine were involved in this study. Obstetric, fetal and placenta models were used to simulate the process of placental delivery and examination of umbilical cord, placenta and amnion. Assessment was done through a checklist to test the achieved intended learning outcomes in addition to a structured questionnaire to evaluate their satisfaction. The collected data were analyzed. Results revealed that students strongly agreed on their ability to identify surfaces of the placenta, types of umbilical cord knots in addition to examining and tying off umbilical cord. The perception of the students and the rate of satisfaction was higher in females than in males, but the majority of both agreed that it was an enjoyable and satisfactory learning experience and demanded similar sessions in the future. Students' engagement performance can assist to improve the quality of the traditional theoretical environment.

Keywords: Simulation, Skill labs, Basic science, Embryology, Medical education.

Manuscrito recibido: 24/05/2025
Manuscrito aceptado: 02/07/2025

*Corresponding Author: Dr. Rasha A. Alshali, Department of Clinical Anatomy, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia. PO 42806, Code: 21551

Correo-e: r.alshali@yahoo.com

Introduction

Traditionally, medical schools' curricula start with basic sciences which offer didactic lectures and limited clinical training (Sheakley et al. 2016). During the preclinical years, teaching is mainly lecture-based, which would turn the students into passive listeners with limited critical thinking, leading to less motivation and interest to learn (Zinski et al. 2017). The medical school curriculum at King Abdulaziz University (MBBS) follows the same discipline in which the preclinical phase involves basic sciences in the first 2 years where lectures, sessions of self-directed learning, tutorials and (practical sessions) are the main teaching strategies. This is followed by three years devoted to clinical practice.

A concrete understanding of basic sciences is vital for the successful completion of clinical phase of medical education (Woods et al. 2006). Therefore, it is mandatory to improve quality of basic science teaching techniques for better preparedness of medical students for the clinical phase. Despite the rise in student-centered approaches to teaching as in problem based learning and self-directed learning, yet the lecture remains the firm constant skeleton of teaching in medical education (Stapleton et al. 2015).

Curriculum developers aim at establishing a learning environment with efficient and sufficient medical knowledge, skills and professionalism (Anderson and Kanter 2010). This has led to continuous content changes (Bransford et al. 1999). However, the motivational factor was always underestimated although it is confirmed that self-motivation affects person's outcome more than learning with different approaches (ten Cate, Kusurkar, and Williams 2011).

Based on the motivational theory "Self Determination Theory (SDT), simulation-based medical education (SBME) and bedside teaching, have the ability to enhance the motivation of medical students (Deci and Ryan 2000). As Medical students are frequently exposed to a high level of stress, with a large academic load, busy schedules, and other stressful factors, motivation strength is an essential need for better academic performance (Cortes and Lopez-Serna 2021). Hence, motivation-enhanced teaching should be considered in medical curricula (Kusurkar et al. 2012).

Learning communities also emphasized on positive engagement in educational environment where students can actively learn (Shochet et al. 2019).

When faculty and students engage outside the classroom, students attain different grades of motivation, and carry out different learning techniques (Jang 2008). This display of wide range of behaviours and experiences affects student outcomes, is designated as 'engagement'. Engagement is a paramount skeleton for learner retention, but estimating engagement can be difficult (Stephenson et al. 2020).

Yet, previously, Fredricks, Blumenfeld, and Paris (2004) presented 3 domains for engagement; behavioural, cognitive and emotional. The behavioural engagement includes participation and alertness, the cognitive engagement is evident when students value the application of topic to future practice and are motivated to learn and practice more (Trowler 2010) while the emotional engagement is referred to students' feeling of enjoyment of the session or being bored and angry (Alrashidi, Phan, and Ngu 2016). Simulation can trigger emotions by planning situations that will evoke the feelings that are likely to be met in real situation, so that students will pass through those emotions and hence encode the knowledge (Choi et al. 2017).

Simulation is a broad term that means a presentation of a virtual situation of a real world to realize educational achievements through realistic learning. This makes learning more interesting, meaningful and improves critical thinking, clinical analysis and intellectual problem solving (Al-Elq 2010). Furthermore, the inclusion of simulations during this phase may help students in gaining ethical and technical clinical skills, providing better execution, gaining self-confidence, being better motivated for learning about the subject, and in increasing their interest in being more engaged in clinical based sessions (Sheakley et al. 2016; Makransky et al. 2016; Lateef 2010; Al Khasawneh et al. 2021). Recently, Honary (2021) confirmed that absence of participation results in no uptake and hence there is no expectancy for long term learning.

The present work involved the second-year male and female students in medical college at King Abdulaziz University. Simulation sessions were performed at the Clinical Skills and Simulation Centre (CSSC) at King Abdulaziz University Hospital (KAUH), which is a specialized training center for medical students, nurses and health care professionals. The aim of this study was to engage the students in active learning strategies, such as simulation, with the traditional lectures of embryology to evaluate its effect on achieving the intended learning outcome, and to assess the perception of the students about the experience.

Methods

Study setting

This study was carried out at the Faculty of Medicine, KAU, Jeddah. It involved second year MBBS students' batch of 202-2024 that comprised 384 female and male students. The lecture was conveyed to them in classrooms and the simulation setting was held at the CSSC, KAUH, Jeddah. Approval of unit of Biomedical Ethics Research committee at KAU was confirmed (286-19).

Preparation

The curriculum for second year medicine introduces basic medical science for students mostly in didactic lectures on campus and online. Classical Embryology lectures included information on the fetal membranes; the placenta, umbilical cord and the amnion. This particular topic was chosen to be included in the simulation experience. Students were also supplied with videos on similar simulation sessions. Several meetings were held with the faculty members involved and the intended learning outcomes were clarified.

Sessions at the CSSC

Students were divided according to gender into 2 groups. Each group was further subdivided into smaller groups 12 students each to ensure students' benefit of training. In the CSSC at KAUH, each subgroup occupied a room that was well equipped with aprons, disposable gloves, pregnancy model, a placenta model simulating a real human placenta in texture, size and with an umbilical cord and amniotic membrane attached. This is in addition to an obstetric model and a model of a term fetus. The 3 dimensional models were used to create a simulation session like the procedure of placental delivery before which the umbilical cord was examined and tied off. This was followed by examination of the placenta and the amnion that allows practical skill involvement.

At the beginning of the session, faculty members introduced the students to the skill lab policies before they demonstrated the steps of tying off the umbilical cord, delivering the placenta from the obstetric model, and giving detailed comment on their examination. Students were given enough time to observe and were allowed to ask questions to clear up any doubts concerning the demonstrated procedure. This was followed by individual student performance of the required skills. Students were obliged to follow rules for the infection control

Students' evaluation

Students' evaluation was done through an assessment checklist and oral discussion on the performed examination to ensure that the student learning outcomes for the session were achieved. The checklist was designed based on the curriculum learning outcomes and reviewed by quality, academic and accreditation unit at KAU. The points included in the checklist were to value applied infection control in clinical examination session, as wearing apron and gloves, examine the umbilical cord for false and true knots, practice where and how to clamp the umbilical cord, distinguish and examine the fetal and maternal surfaces of the placenta, examine the amnion. Faculty members evaluating individual student procedure gave feedback for steps performed.

Then, the students were asked if they were interested to attend similar sessions and if the experience was enjoyable and satisfactory. This was also correlated to the written exam performance, the satisfaction index on the achievement of the intended learning outcome, of knowledge and skill domains of the curriculum calculated by the quality, academic and accreditation unit.

Questionnaire

One week after finishing the simulation experience, a structured questionnaire was distributed to the students, involving a three–item Likert scale "from strongly agree to disagree". Questionnaire was tested for reliability (internal consistency) by Cronbach's alpha using SPSS software version 20 and it was = 0.787. As for the validity, construct validity was reviewed by quality, academic and accreditation unit at KAU and compared with other published works of experts in the field.

Statistical analysis

The collected data from the questionnaire were analysed using the software SPSS version 20. For analysis, Cross –tabulation and Independent – sample T test methods were used. The data were expressed as mean ± standard deviation (SD).

Results

In response to the distributed questionnaire among a total of 384 medical students in the second year in comparison to the years before, 160 responses from both male and female students were received. It comprised 54.7% females and 45.3% males. In addition to the percentages for the different variables, a quantitative analysis was done to reveal the statistical difference between male and female respondents as shown in table (1).

In the present study, 100% of female and 88.90% male students strongly agreed on valuing the infection control measures applied in simulation session by wearing an apron and gloves.

100% of the female and 94.40% of the male students strongly agreed on successfully examining the umbilical cord for true and false knots. They could differentiate between them and give reasons to justify their answers.

The skill of clamping the umbilical cord was more successfully experienced among the female students (90.60%) than in the male students (80.60%). During clamping the umbilical cord, the student palpated the fetal end of the cord to exclude the presence of umbilical hernia then they clamped the cord two inches away from the fetal umbilicus. These steps were evaluated, discussed for underlying theoretical basis by faculty members.

All of the female and male students (100%) strongly agreed on their ability to identify both maternal and fetal surfaces of the placenta. Regarding examining the maternal surface for the cotyledons, only 1.10% of the females and 5.60% of the males revealed no experience while 2.30% female and 2.80% male did not agree. Interestingly, the majority of the students, 96.6% of the females and 91.70% of the males strongly agreed on experiencing the skill and even gave the underlying pathological conditions that may be encountered. .

Concerning the examination of the amnion, only a minority of the female students did not agree (2.80%) or were neutral (1.80%), while 8.10% of the males did not acquire the experience.

The perception of the students and the rate of satisfaction was higher in females than it was in males. 98.90% of the female considered it an enjoyable and satisfactory learning experience and 100% demanded similar sessions in the future. In contrast, 81.90% of the males enjoyed the experience and only 79.80% were interested to attend another session.

By the end of the course, satisfaction index (SI) for the knowledge and skill domains were calculated. It was 4.15 for the knowledge domain and 4.45 for the skill domain, whereas the year before was 3.58 and 3.15 respectively. Regarding the achievement of the intended learning outcomes (ILOs) the SI was 4.15 in comparison to 3.56 the year before.

Discussion

In the present study, the second year medical students were engaged in a simulated experience related to one of the embryology core course lectures. The aim of the study was to evaluate the effect of engagement of the students in a simulation session during the preclinical phase on the achievement of the intended learning outcome and whether it affected their emotional, behavioural and learning domains. Both male and female students were involved in the experience.

Previous studies revealed a strong relationship between simulation based education and the learning outcomes. Kirkpatrick's model of four levels of evaluation placed the participant reaction to intervention in level 1, the degree to which learning occurs in level 2, behavioral changes following learning in level 3 and finally the impact of learning on patient outcome in level 4 (Forest 2016). It was reported that using simulation leads to higher participant satisfaction, increased knowledge and improved performance (McGaghie et al. 2010). Previous reports revealed that the percentage of failure in certifying examinations and board certification status were associated with the degree of appreciation of basic knowledge attained in the preclinical years of medical school education (Gonnella 1993). Later, Traynor et al. (2010) reported that (simulation) sessions helped students to improve retention of the gained knowledge, enhance acquiring skills and gain confidence Also, it enhanced communication skills in teamwork.

In this study, 3 levels of Kirkpatrick's model were achieved. Students' reaction to the intervention, their motivation to attend similar sessions and achievement of the intended learning outcomes of the session were satisfactory.

Moreover, the findings of Franc-Law's study in 2010, revealed that medical students' satisfaction with simulated-based curriculum was high (Franc-Law et al. 2010). They scored 8 of 10 on a Likert scale when asked to rate the experience. These results are in accordance with the results in the present work, where the majority of both female and male students successfully appreciated all the intended learning outcome at the end of the simulated session.

Stephenson et al. (2020) described a two-domain framework for engagement assisted by previous theories (Astin 1984). It comprised internal and external factors for the learner's engagement. Internal factors comprised emotional engagement and cognitive out-of-class engagement which focused on learner inner feelings; learner's enjoyment and the motivation to learn. Whereas the external factors included behavioral engagement and cognitive in class engagement which included participating, listening and having his attention fully engaged in the presented material (Trowler 2010; Pickering and Swinnerton 2019).

In the present study, engagement of students whether internal or external was successfully achieved as seen by the satisfaction score among females (100%) and male (79.80%) respondents who strongly agreed to attend more similar sessions. In addition, majority of female (98.90%) and (81.90 %) male respondents found that the simulated session was an enjoyable learning experience. Moreover, students revealed enthusiasm during the simulation session and asked to repeat the procedure several times. It was also emphasized that the more students were engaged the higher course satisfaction and achievement of course learning objectives (Burch et al. 2015).

In another similar work, Agha et al. reported that satisfaction rate of female students was higher than males regarding the simulation-based learning at King Saud (Agha, Alhamrani, and Khan 2015). In Sweden, a research was done by Lindh Falk, Hammar, and Nyström (2015) revealed that positivity of female students towards training in an inter-professional practice in a hospital unit

was higher than their counterpart.

Simulation-based teaching has certified to be an effective tool in pre-clinical undergraduate teaching. The successful outcomes of simulation in the pre-clinical years of medical education showed numerous opportunities to establish a satisfactory simulation-based education in the first two years of medical school, as observed in other similar studies (Chakravarthy et al. 2011; Jabaay et al. 2020).

Limitation of The Study

The number students participated in the clinical simulation experience 384 male and female students. The sample size was calculated according to the formula (z2 x p x q)/L2 where L was put at the level of 0.07, p=0.5 and q=0.5. The questionnaire was distributed to all students but only 160 were included in the data as we excluded the incomplete questionnaires.

Conclusion

The simulation-based learning together with lecture-based teaching is a favorable and valuable learning strategy in the basic sciences of medical curriculum. Interestingly, this linked the gap between the embryology topics and its clinical application. Students had the opportunity to apply basic theoretical knowledge in a safe environment. Moreover, the achieved intended learning outcomes clearly included not only mere embryological features, but also the congenital anomalies that may be encountered and alter the normal configuration. Students' engagement performance can assist to improve the quality of the traditional theoretical environment.

Acknowledgement

The authors wish to thank Professor Abdulaziz Boker, General Supervisor of CSSC, Mr. Haitham Abdulmajeed, Senior Tech and all members of the CSSC at KAUH for their extreme cooperation.

Statement of Declaration

All authors state that there is no conflict of interest and nothing for declaration.

Notes On Contributors

WAFAA S. RAMADAN, MBBS, MMSc, MD, Prof. of Anatomy and embryology, Faculty of Medicine, King Abdulaziz University, KSA. She teaches medical, dental, and allied sciences students, incorporating early clinical applications in anatomical education. Her research interest includes therapeutic application of stem cells and natural herbs in vivo and in vitro.

RASHA A. ALSHALI, MBBS, M.SC, Ph.D an associate professor who has skills in human anatomical dissection, teaching talents and developing new teaching strategies to integrate clinical skills in basic sciences, she is interested in experimental animal research.

AZRA KIRMANI, MBBS, MD, Assistant Professor, Dept. of Physiology, Faculty of Medicine, King Abdulaziz University, Jeddah K.S.A. She teaches physiology to undergraduate, postgraduate medical students and undergraduate students from allied sciences. Passionate about medical education. Research interests include diabetes, obesity, and degenerative disorders. Strong proponent of low-carb diet for health.

MALAK T. MALAEKAH, MD, A lecturer in the Department of Anatomy, Faculty of medicine, king Abdulaziz University, KSA. She teaches anatomy to medical, dental and allied sciences students. Her research interest is in clinical embryology and medical education.

SHARIFA ALAMRI, MBBS. She is a demonstrator in Department of Anatomy, faculty of Medicine, King Abdulaziz University, Jeddah, KSA. She teaches anatomy to medical, dentistry and allied health students. She conducts PBL sessions to medical student. Her research interest includes clinical embryology and integration of technology in anatomical education

ALAA A. FARSI, MBBS. She is a demonstrator in Department of Anatomy, faculty of Medicine, Jeddah University, Jeddah, KSA. She teaches anatomy to medical, dentistry and allied health students. Her research interest includes clinical embryology and integration of technology in anatomical education.

BASHAYER A. ALKHATHLAN, MBBS, is a teacher assistant in Anatomy Department, King Abdulaziz University, KSA. She teaches anatomy to medical students and contributes to teaching histology. Her research interest is in medical education and reproductive medicine.

References

1. Agha, S., A. Y. Alhamrani, and M. A. Khan. 2015. 'Satisfaction of medical students with simulation based learning', Saudi Med J, 36: 731-6.
2. Al Khasawneh, Esra, Judie Arulappan, Jansi Rani Natarajan, Savithri Raman, and Chandrani Isac. 2021. 'Efficacy of Simulation Using NLN/Jeffries Nursing Education Simulation Framework on Satisfaction and Self-Confidence of Undergraduate Nursing Students in a Middle-Eastern Country', SAGE open nursing, 7: 23779608211011316.
3. Al-Elq, Abdulmohsen H. 2010. 'Simulation-based medical teaching and learning', Journal of family and Community Medicine, 17: 35.
4. Alrashidi, Oqab, Huy P Phan, and Bing H Ngu. 2016. 'Academic Engagement: An Overview of Its Definitions, Dimensions, and Major Conceptualisations', International Education Studies, 9: 41-52.
5. Anderson, M Brownell, and Steven L Kanter. 2010. 'Medical education in the United States and Canada, 2010', Academic Medicine, 85: S2-S18.
6. Astin, Alexander W. 1984. 'Student involvement: A developmental theory for higher education', Journal of college student personnel, 25: 297-308.
7. Bransford, John, John D Bransford, Ann L Brown, and Rodney R Cocking. 1999. How people learn: Brain, mind, experience, and school (National Academies Press).
8. Burch, Gerald F, Nathan A Heller, Jana J Burch, Rusty Freed, and Steve A Steed. 2015. 'Student engagement: Developing a conceptual framework and survey instrument', Journal of Education for Business, 90: 224-29.
9. Chakravarthy, B., E. Ter Haar, S. S. Bhat, C. E. McCoy, T. K. Denmark, and S. Lotfipour. 2011. 'Simulation in medical school education: review for emergency medicine', West J Emerg Med, 12: 461-6.
10. Choi, Wayne, Ollivier Dyens, Teresa Chan, Mariles Schijven, Susanne Lajoie, Mary E Mancini, Parvati Dev, Li Fellander-Tsai, Mathieu Ferland, and Pamela Kato. 2017. 'Engagement and learning in simulation: recommendations of the Simnovate Engaged Learning Domain Group', BMJ Simulation and Technology Enhanced Learning, 3.
11. Cortes, Omar, and Norberto Lopez-Serna. 2021. 'Evaluation of the determinants that affect academic performance on first-year medical students', MedEdPublish, 10.
12. Deci, Edward L, and Richard M Ryan. 2000. 'The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior', Psychological inquiry, 11: 227-68.
13. Forest, E. 2016. 'Kirkpatrick Model: Four levels of learning evaluation', Retrieved January, 26: 2017.
14. Franc-Law, J. M., P. L. Ingrassia, L. Ragazzoni, and F. Della Corte. 2010. 'The effectiveness of training with an emergency department simulator on medical student performance in a simulated disaster', CJEM, 12: 27-32.
15. Fredricks, Jennifer A, Phyllis C Blumenfeld, and Alison H Paris. 2004. 'School engagement: Potential of the concept, state of the evidence', Review of educational research, 74: 59-109.
16. Gonnella, Joseph S. 1993. 'Assessment measures in medical school, residency, and practice: the connections', Acad Med, 68.
17. Honary, Ethan. 2021. Course Design Strategy: The Art of Making People Learn (Skills Converged Publishing).
18. Jabaay, Maxwell J, Dario A Marotta, Stephen L Aita, Dianne B Walker, Leah O Grcevich, Victor Camba, James R Nolin, James Lyons, and John Giannini Jr. 2020. 'Medical Simulation-Based Learning Outcomes in Pre-Clinical Medical Education', Cureus, 12.
19. Jang, Hyungshim. 2008. 'Supporting students' motivation, engagement, and learning during an uninteresting activity', Journal of Educational Psychology, 100: 798.
20. Kusurkar, Rashmi A, Gerda Croiset, Karen V Mann, Eugene Custers, and Olle Ten Cate. 2012. 'Have motivation theories guided the development and reform of medical education curricula? A review of the literature', Academic Medicine, 87: 735-43.
21. Lateef, Fatimah. 2010. 'Simulation-based learning: Just like the real thing', Journal of Emergencies, Trauma and Shock, 3: 348.
22. Lindh Falk, Annika, Mats Hammar, and Sofia Nyström. 2015. 'Does gender matter? Differences between students at an interprofessional training ward', Journal of interprofessional care, 29: 616-21.
23. Makransky, Guido, Mads T Bonde, Julie SG Wulff, Jakob Wandall, Michelle Hood, Peter A Creed, Iben Bache, Asli Silahtaroglu, and Anne Nørremølle. 2016. 'Simulation based virtual learning environment in medical genetics counseling: an example of bridging the gap between theory and practice in medical education', BMC medical education, 16: 1-9.

24. McGaghie, William C, S Barry Issenberg, Emil R Petrusa, and Ross J Scalese. 2010. 'A critical review of simulation-based medical education research: 2003–2009', Medical education, 44: 50-63.

25. Pickering, James D, and Bronwen J Swinnerton. 2019. 'Exploring the dimensions of medical student engagement with technology-enhanced learning resources and assessing the impact on assessment outcomes', Anatomical sciences education, 12: 117-28.

26. Sheakley, Maria L, Gregory E Gilbert, Kim Leighton, Maureen Hall, Diana Callender, and David Pederson. 2016. 'A brief simulation intervention increasing basic science and clinical knowledge', Medical education online, 21: 30744.

27. Shochet, Robert, Amy Fleming, James Wagner, Jorie Colbert-Getz, Monica Bhutiani, Kevin Moynahan, and Meg Keeley. 2019. 'Defining learning communities in undergraduate medical education: a national study', Journal of medical education and curricular development, 6: 2382120519827911.

28. Stapleton, G, K Price, S Sneddon, and C Huser. 2015. 'Improving Student Engagement in Lectures: The 'Flipped Lecture'in Medical Education'.

29. Stephenson, Christopher R, Sara L Bonnes, Adam P Sawatsky, Lukas W Richards, Cathy D Schleck, Jayawant N Mandrekar, Thomas J Beckman, and Christopher M Wittich. 2020. 'The relationship between learner engagement and teaching effectiveness: a novel assessment of student engagement in continuing medical education', BMC medical education, 20: 1-8.

30. ten Cate, Olle Th J, Rashmi A Kusurkar, and Geoffrey C Williams. 2011. 'How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE guide No. 59', Medical teacher, 33: 961-73.

31. Traynor, Marian, Anne Gallagher, Lorna Martin, and Susan Smyth. 2010. 'From novice to expert: Using simulators to enhance practical skill', British Journal of Nursing, 19: 1422-26.

32. Trowler, Vicki. 2010. 'Student engagement literature review', The higher education academy, 11: 1-15.

33. Woods, Nicole N, Alan J Neville, Anthony J Levinson, Elizabeth HA Howey, Wieslaw J Oczkowski, and Geoffrey R Norman. 2006. 'The value of basic science in clinical diagnosis', Academic Medicine, 81: S124-S27.

34. Zinski, Anne, Kristina TC Panizzi Woodley Blackwell, F Mike Belue, and William S Brooks. 2017. 'Is lecture dead? A preliminary study of medical students' evaluation of teaching methods in the preclinical curriculum', International journal of medical education, 8: 326.