The role of Moodle-based surgical skills illustrations using 3D animation in undergraduate training

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Background. Teaching undergraduate surgical skills using plain models without detailed anatomy and text presentations lacks detail, and there is a need to explore other teaching methods.

Objective. To establish whether there is a difference in the satisfaction level and understanding between students taught using 3D animation v. traditional methods.

Methods. This was a randomised comparative study conducted over 1 year. Participants were third- and fifth-year undergraduate medical students who provided informed consent. They were randomly assigned to the 3D animation and traditional teaching groups. The animated procedures, the pre- and post-tests and the survey were hosted on Moodle. The difference between pre- and post-test scores is termed the impact score. The independent samples *t*-test was used to determine the significance of the difference in the impact scores of the two groups.

Results. Forty-five fifth-year students participated in 3 skills illustrations and 45 third-year students participated in 2 skills illustrations, giving a total of 225 data points. 3D animation teaching is associated with better understanding than traditional teaching ($t(223)=6.701$; $p<0.001$) (experimental group, mean 3.11; control group, mean 1.51). Traditional teaching was given a median rating of 5 (good) and a mode of 4 (average) v. a median and a mode of 8 (excellent) for 3D animation teaching on a scale of 1 - 10 (worst - superb). However, the combination of the two teaching methods was given a mode and a median of 10 (superb). All students recommended the adoption of 3D animation.

Conclusion. Students have a better understanding and higher satisfaction levels when taught using 3D animation.

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According to the recent literature, multimedia teaching is more effective than conventional teaching.[1] Studies demonstrated that video-based surgical skills training improves knowledge retention, understanding, acquisition of surgical skills and satisfaction levels compared with conventional teaching.[2-5] Video-based teaching reduces the amount of verbal input needed during surgical skills illustration and also reduces learning time.[5]

Training of surgical procedures requires teaching modalities that are elaborate and easy to understand. The teaching modality should relay details of the procedure in a way that closely resembles real-life scenarios anatomically, such as motion graphics in the form of 3D animation.[1,6] The animation of surgical procedures can be available to students through learning management systems (LMS) such as Moodle to create a learner-driven teaching platform. Moodle, with its resources and activities (e.g. quizzes, surveys, assignments, chats, gradebooks and back-end databases), would make surgical training, continuous assessment and student feedback more effective. The end product of such a design is a multimedia virtual classroom of surgical procedure illustrations delivered to the student via Moodle. When such a resource has been developed and produced, it can be used over years without wear and tear. It is my (MJM) opinion that low- and middle-income countries need to harness the power of organised, multimedia virtual classrooms in medical training, which may appeal to the current generation of medical students.[1]

This research proposes that surgical skills illustrations using 3D animation on a Moodle platform could improve students' understanding and satisfaction levels.

Background of undergraduate surgical rotations

The newly established Faculty of Medicine, University of Botswana, graduated its first cohort of undergraduate medical students in 2014. The medical undergraduate programme (MB BS) comprises 5 years of training divided into two phases. Phase I consists of the premedical sciences, followed by phase II – the clinical phase. Phase I covers the first 2 years of training, while phase II covers the last 3 years. Surgical specialty rotations occur during phase II. Students rotate through general surgery during the third year (Surgery I) and fifth year (Surgery III) of training.

The curriculum includes the teaching of practical surgical skills; this is where the challenges lie. We use plain models (those with limited anatomical detail) and text presentations as our teaching aids for surgical skills teaching. We currently do not have procedure-customised models to illustrate the principles and details of each procedure. These models are expensive to acquire and maintain. If acquired, they ultimately need to be replaced owing to wear and tear during demonstrations. The use of lectures and plain models without anatomical detail to teach practical surgical skills is referred to as traditional teaching methods in this article. The abovementioned challenges prompted the researchers to propose 3D animation illustrations as an option worth exploring. None of the departments in the Faculty of Medicine uses 3D animation as a teaching method. The aim of the study was to compare 3D animation with traditional teaching; the latter uses lectures and plain models as teaching tools.

Methods

This was a 1-year (May 2017 - June 2018), randomised comparative study conducted in the Department of Surgery, Faculty of Medicine, University of Botswana. Students were briefed regarding the study when they started their rotation at the department, and those who were interested registered with the moderators in their own time and not during the briefing session. Participants (third- and fifth-year students) voluntarily consented to participate. Those who did not participate attended the routinely scheduled traditional teaching sessions of surgical skills according to the curriculum. Five surgical skills procedures, 2 from the third-year and 3 from the fifth-year curriculum, were animated. For the production of illustrative videos, we used 3D animation software (3DS Max, USA) to create surgical skills animation, and an Adobe Creative Cloud package for postproduction processing for animation. These videos were hosted on a Moodle platform of the university network and access was controlled via logging in. The students are familiar with the use of Moodle.

On arrival of students at the computer laboratories, they were randomly assigned to group A (traditional teaching group) and group B (3D animation teaching group). A simple randomisation method involving computer-generated random numbers was used to assign participants. The traditional method involved the teaching of surgical skills using lectures and demonstrations on plain models, while the 3D animation group watched illustrative videos produced from 3D animation of surgical skills. Each of the groups was in a separate computer-laboratory section where they completed a standard multiple-choice pretest quiz. Each group had a session moderator. After the pretest, the 3D animation group watched a video illustration of a surgical skill that lasted 8 minutes, followed by a standard multiple-choice post-test hosted on Moodle. After completing the post-test, group B joined group A for the routinely scheduled traditional teaching session, which all students had to attend according to the curriculum. After this session, group A completed a 10-minute standard post-test, while group B waited. Up to this point, each group had done a pretest, an intervention (3D animation teaching or traditional teaching) and a post-test. After completing the post-test, group A was given the opportunity to watch the 3D animation video; therefore, both groups experienced the two teaching methods. Students then completed an online survey in the form of a feedback questionnaire to assess their level of satisfaction. The pre- and post-test assessments were summative and did not contribute towards their surgical rotation marks. Summative assessments evaluate student learning, knowledge, proficiency or success at the conclusion of an instructional period. In contrast, formative assessments occur throughout the instructional period, and seek to improve student achievement of learning objectives through approaches that can support specific student needs. The procedure animations, the pre- and post-tests and the survey questionnaire were hosted on Moodle, and results were captured on the back-end database. The researcher fulfilled the administrator role on Moodle and was able to grant or deny access to study materials. The tests, videos and survey questionnaires were made available only to attendees by the administrator during the illustration sessions. Intercostal drain insertion, suprapubic catheter insertion and central venous access were animated for fifth-year medical students, and urethral catheterisation and nasogastric tube insertion were animated for third-year students. Each procedural training occurred at a scheduled date, with the sequence of randomisation, pretest, intervention, post-test and survey repeated for each procedure (Fig. 1).

Statistics

For both study groups, the difference between the post-test and pretest scores – the impact score – was determined.

The independent samples *t*-test was used to determine the significance of the difference between the impact scores of the two groups. Descriptive statistics were used to describe feedback from the students. SPSS version 25 (IBM Corp, USA) was used for data analysis.

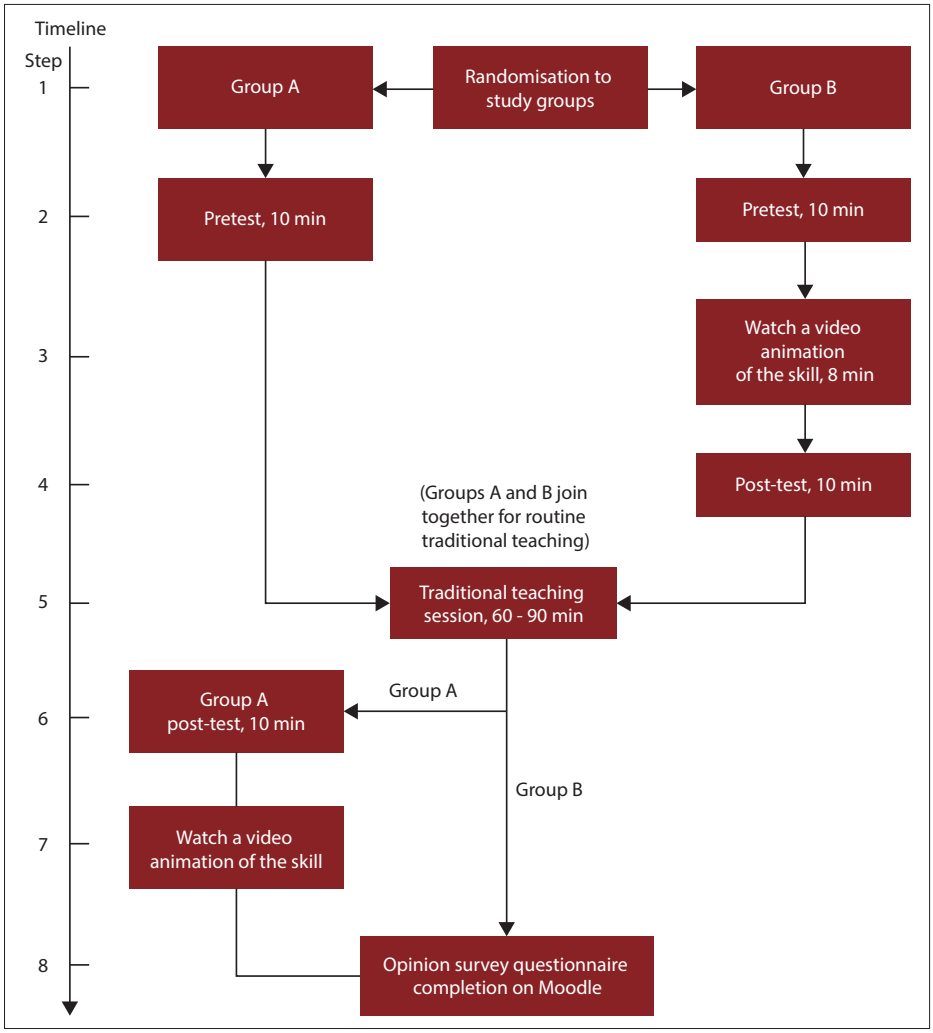

Fig. 1. Diagrammatic representation of study design. (A = traditional teaching group; B = 3D animation teaching group.)

Ethical approval

The study received ethical approval from the University of Botswana Institutional Review Board (ref. no. UBR/RES/IRB/BIO/017). Informed consent was obtained from the participants.

Results

Forty-five third-year medical students participated in two procedure illustrations, giving 90 data points (45 × 2), while 45 fifth-year medical students participated in three procedure illustrations, yielding 135 data points (45 × 3). The total data points at the end of the study were 225, with 113 from the animation group and 112 from the traditional teaching group. This implies that there were 113 impact scores in group B and 112 impact scores in group A. The pre- and post-tests were marked out of 10. The mean impact scores in groups B and A were 3.1 and 1.5, respectively (Table 1).

Levene's test for equality of variance confirmed that the two study groups were similar and homogenous enough to have the means of the impact scores compared meaningfully (Table 2). To determine whether the difference in the mean impact scores of the two study groups was significant, we used the independent samples *t*-test. We found that the animation group had a significantly higher impact score than the traditional teaching group ($t(223)=6.701$; $p<0.001$) (experimental group, mean 3.11; control group, mean 1.51) (Table 2). This implies that students taught using 3D animation have a better understanding than those taught using traditional teaching methods.

At the end of each session a survey was conducted to obtain feedback from the participants, as well as to determine their satisfaction levels with the two teaching modalities. Students were asked to rate 3D animation and traditional teaching methods on a Likert scale of 1 - 10 (worst - superb). Students gave the traditional teaching method a median rating of 5 (good) and a mode of 4 (average) v. a median and a mode of 8 (excellent) for the 3D animation teaching method. However, students gave the combination of the two teaching methods a median and a mode of 10 (superb) (Fig. 2).

At the end of each surgical skills illustration session, students were asked to choose the best method of teaching: traditional teaching alone, animation teaching alone, or a combination of the two teaching methods. No student chose traditional teaching alone, 5.3% chose the 3D animation method alone, and 94.7% chose the combination of the two teaching modalities.

At the end of each surgical skills illustration session, students were asked to choose their recommendation level for the adoption of 3D animation teaching from the following options: not recommend, not sure, recommended and highly recommended. No student chose not recommend or not sure. Students recommended the adoption of the 3D animation teaching method (6.7%), while a much higher percentage highly recommended its adoption (93.3%).

Table 1. Descriptive statistics of the impact score for the two study groups

	Group statistics		
	Group	***n***	**Mean (SD)**
Impact scores	3D animation	113	3.11 (1.86)
	Traditional teaching	112	1.52 (1.69)

SD = standard deviation.

Discussion

Motion graphics in the form of 3D animation with its visual cues draw more attention and are a good teaching tool with a potential role in surgical skills training.[1,6-13] The literature suggests that there is significant knowledge gain, shorter learning time, and higher satisfaction levels when students are taught using 3D animation v. traditional methods.[1,6,8-10] This is consistent with the findings in our study in which the improvement in the test score (impact score) was statistically significant in the 3D animation group compared with the traditional teaching group ($p<0.001$). The aspect of shorter learning time was also evident in our study, in which the longest animation video was 8 minutes compared with the traditional teaching method, which reached a maximum of 90 minutes. 3D animation has also been used to enhance and annotate real surgical videos via postproduction processing.[13] Hence, the 3D animation annotation technique defines another dimension of its use in surgical skills training. Studies have shown a difference in comprehension levels of candidates who receive 3D animation teaching v. traditional teaching.[14,15] The design of some of these studies may not explain the impact of the teaching methods too well, as they did not have pre- and post-tests to measure an intervention-attributable impact score.[16] The inclusion of pre- and post-tests in the study design seeks to isolate the existing baseline knowledge before intervention from the acquired new knowledge after intervention. Our study design sought to eliminate this confounding factor by using an impact score as a measure of understanding. One study, however, found no statistically significant difference in test scores after accounting for baseline/pretest scores ($p=0.33$).[15] This study compared traditional methods with 3D computer models in the instruction of hepatobiliary anatomy.

The higher satisfaction level with the 3D animation teaching method was also expressed in other studies.[16-19] In one study, the difference in students' understanding in either of the groups was not statistically significant; however, students nonetheless expressed higher satisfaction levels with 3D animation teaching methods.[15] This may suggest that students preferred 3D animation for other reasons and not necessarily because it improves their level of understanding.

In our study, students were also asked to choose the best teaching method from three options: traditional teaching alone, 3D animation alone or a combination of the two teaching methods. Students chose the combination of the two as their preferred teaching method, followed by 3D animation teaching rather than traditional teaching, suggesting that there is something they would want to retain from the traditional teaching method. Unfortunately, in our survey design we did not ask students to give

Table 2. Independent samples *t*-test of impact scores for the two groups

		Levene's test for equality of variances		*t*-test for equality of means			
		f	**Sig**	***t***	***df***	**Sig (2-tailed)**	**Mean difference**
Impact scores	Equal variances assumed	0.77	0.38	6.70	223.00	0.00	1.59
	Equal variances not assumed			6.70	221.40	0.00	1.59

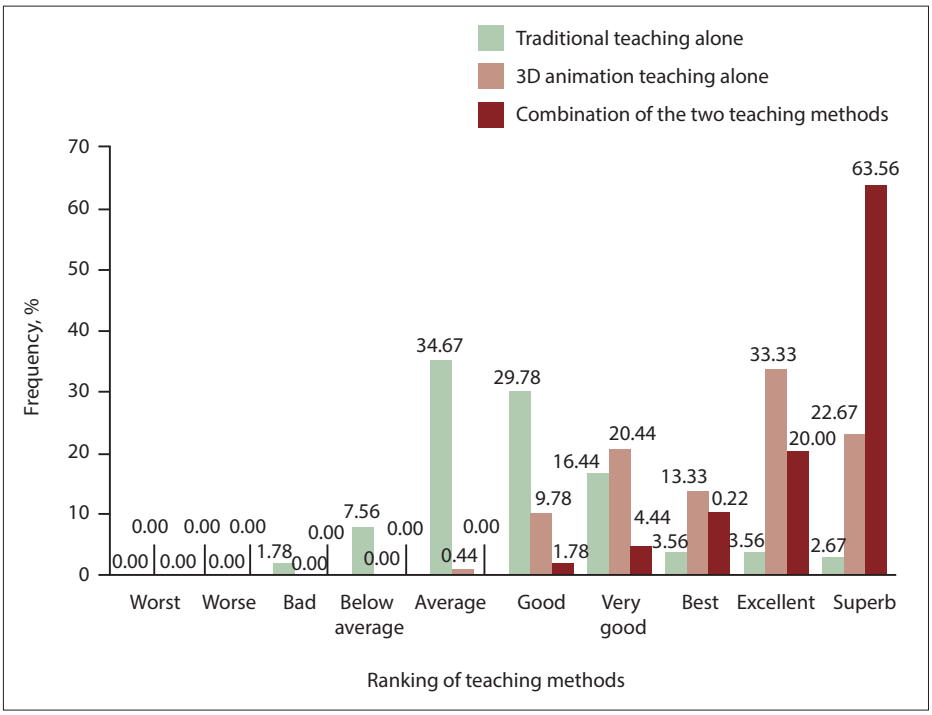

Fig. 2. Medical students' rating of the teaching methods.

reasons for their choices. These findings suggest that 3D animation should augment and not replace traditional teaching methods – a finding reflected in a number of studies.[16,17,19]

Other studies, which measured knowledge retention and improvement in skills development, found no statistically significant differences between students taught using either of the two teaching methods,[18] while some studies came to the opposite conclusion.[19]

Study limitations

The authors acknowledge the possibility of cross-contamination during the 90 minutes of traditional teaching of students. The same standard tests were used for both groups; hence the concern. We tried to minimise this by having moderators present during the sessions. The summative nature of the test may not have allowed the assessment of all aspects of learning. A formative assessment method is suggested in future studies.

Conclusion

Students have a better level of understanding and satisfaction when taught using 3D animation than with the traditional method. However, students considered a combination of the two modalities to be the best way of teaching. To inform how the augmentation of the two teaching modalities should be structured for a higher efficacy, a further study would be required to establish why students unanimously preferred a combination of the teaching methods. The cost-effectiveness assessment and ultimately validation of this teaching tool are milestones to be achieved. 3D animation is a viable and effective teaching tool, which appeals to learners. When learning resources using 3D animation are hosted on platforms such as Moodle, their access is extended beyond the formal classroom. This has the potential to alleviate the shortage of faculty in low- and middle-income countries. We recommend the adoption of 3D animation as a teaching tool in medical education.

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