BMC Medical Education

RESEARCH Open Access

Video based on the combination of animation and modules is effective in teaching suture technologies to novices without faculty involvement: a new surgical video course

Meng Cheng[1*], Xinle Wang[1], Man Zhang[2], Sainan Li[1] and Cuizhi Geng[1]

Abstract

Background While video-based instruction has been employed to teach a range of surgical skills, most videos rely on modular demonstrations, which restrict students' comprehension of human tissue structures and their control over intricate procedural details.

Methods This study described the development, implementation, evaluation, and results of a novel video curriculum based on modular demonstrations combined with animated simulations. Participants were randomly assigned to three groups using a simple lottery-based randomization method, and the efficacy of this novel curriculum was established through pre-and post-teaching outcome analyses.

Results Compared to traditional education and modular-video groups, the combination of modules and animations significantly boosted post-course scores for all suturing techniques except Cushing (CS), Connell (C), and Purse String Sutures (PSS).

Conclusions The video approach that merges modules with animation proves effective in teaching suturing techniques without faculty intervention. Compared with modular-based video, the addition of animated simulation video has certain advantages in distance education.

Keywords Surgical education, Animation, Video-based learning, Video education, Suture, Participant satisfaction

*Correspondence:
Meng Cheng
49001714@hebmu.edu.cn
[1]Hebei Breast Center, The 4th Hospital of Hebei Medical University, 169 Tianshan Street, Shijiazhuang 050011, P.R. China
[2]Dean's office, The 4th Hospital of Hebei Medical University, Shijiazhuang, P.R. China

Introduction

Medicine is a field where practice makes perfect, and mastering basic operations is crucial in medical education. The traditional teaching approach often relies on lectures and demonstrations, leaving students as passive listeners and dampening their enthusiasm for learning [1]. Moreover, limited class hours hinder repetitive practice, further affecting the quality of education. The COVID-19 pandemic has only exacerbated these challenges, making distance self-directed education programs more essential than ever [2, 3]. Consequently, multimedia teaching has become the new trend, replacing conventional classroom lectures.

Video-based teaching has proven effective for imparting various surgical skills [4–6]. Trainees can learn and practice at their own pace through multimedia platforms, enjoying flexible and iterative learning opportunities. Research shows that video-based learning of basic surgical skills is as effective as faculty instruction across different settings [7, 8]. However, most videos are based on training modules like simulators and skin models, which can limit students' understanding of human tissue structures and their control over operational details, thereby restricting the development of clinical thinking [9].

The introduction of animation simulation video is a powerful aid and supplement to the operation demonstration [10–12]. These dynamic visuals offer superior spatial display and process decomposition, igniting students' interest and enhancing the overall teaching experience [13, 14].

In this report, we delve into the creation, implementation, evaluation, and outcomes of a novel video curriculum that combines modular demonstrations with animated simulations. This course is designed to teach pre-clinical medical students the essential skill of suturing.

Methods

Video design

We developed a novel curriculum with three sets of tutorial videos, covering a total of 12 suturing techniques (detailed in Table 1). Each video averages 48 s in length, ranging from 32 to 60 s. These videos include an introduction to the suturing methods, practical skills tips, and a dynamic blend of module-based stitching steps combined with animated simulations. This approach vividly showcases each suturing technique's steps and key points, making it an engaging and effective learning tool.

When creating the videos, we adhered to a structured syllabus, starting with easy-to-learn basic skills before introducing more complex suturing methods built upon these foundations. This progressive approach ensures mastery of all common suturing techniques. The video production is bifurcated into two main parts. The first part involves on-site shooting with a video recorder, capturing a surgeon demonstrating sutures on a silicone skin model training module. The second part entails animation designers crafting animations based on these live demonstrations and explanations. In the final video output, both the live demonstrations and their animated counterparts for each suturing technique are presented together, offering a comprehensive learning experience.

Each video focused on hand movements, complemented by training module demonstrations and detailed animations. This approach makes it easier to emphasize crucial details such as puncture sites, depth, needle angles, suture directions, and tissue hierarchies during stitching (Fig. 1). The cross-sectional views in the animations closely mimic human tissue structures, bringing students closer to clinical realities and enhancing their intuitive understanding of surgical techniques' key points and practical applications.

Course design

In April 2022, we recruited 60 preclinical medical students from Hebei Medical University, all aspiring to

Table 1 Names and abbreviations of 12 suture methods

Suture methods		Abbreviation
Simple suture	Simple Interrupted Suture	SIS
	Simple Continuous Suture	SCS
	Ford Interlocking Suture	FIS
	Cruciate (Cross Mattress) Suture	CMS
Everting suture	Vertical Mattress Suture	VMS
	Horizontal Mattress Suture	HMS
	Continuous Horizontal Mattress Suture	CHMS
Inverting suture	Lembert Suture	LS
	Halsted Suture	HS
	Cushing Suture	CS
	Connell Suture	C
	Purse String Suture	PSS

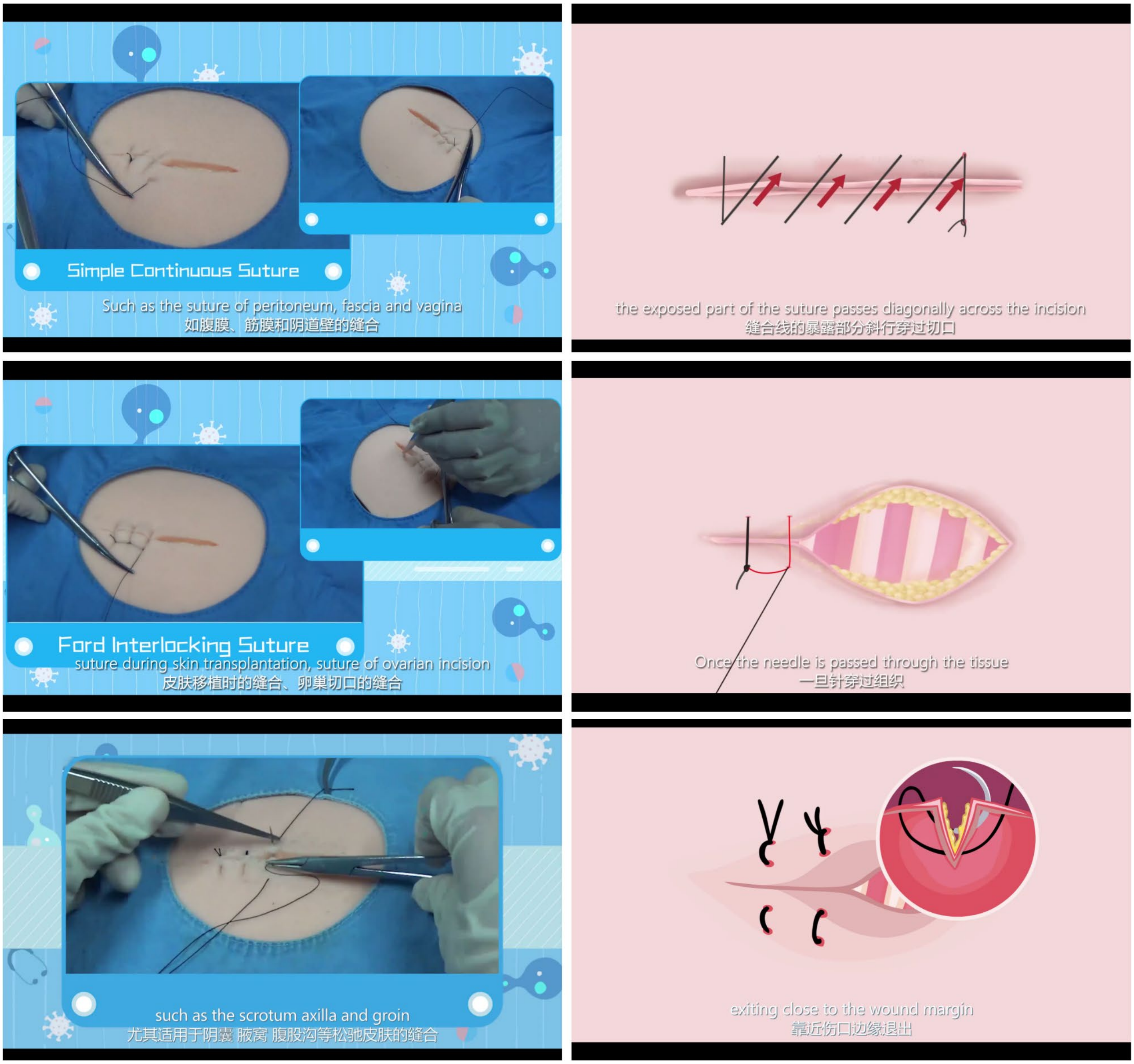

Fig. 1 Screen captures of the new teaching video

pursue a surgical career. These participants, with no prior suture training, were first required to complete a pre-intervention questionnaire. They were then randomly assigned to three groups via a simple lottery method: the Module and Animation Combination Group (MA), the Module Video Group (MV), and the Traditional Education Group (TE).

For groups MA and MV, the course was structured into two stages. The first stage was classroom teaching, about 90 min (two class hours). The teacher began by giving a brief introduction to the video content before launching into the playback of the videos one by one. After each suturing demonstration, students were allocated 4 to 12 min for practice, depending on the complexity of the stitch. During this practice period, the video could be replayed as needed, but students couldn't move on to the next stitching technique without completing the current one. The teacher's role during this time was strictly supervisory, with no guidance provided.

The second stage consisted of 80 min of independent practice. On the seventh day following the initial classroom session, students returned to the classroom to practice each suturing method seven times independently. Throughout this period, they had the flexibility to replay the videos as often as needed. The teacher's involvement was limited to supervision, devoid of any instructional guidance. Outside of this designated time, students were not permitted to engage in further practice. The decision to have students perform each suturing technique seven times was informed by prior research indicating that trainees' performance typically plateaus after seven to nine practice attempts [15]. This approach ensures that students reach a level of proficiency where additional repetitions offer diminishing returns in skill improvement.

For group TE, the course was also divided into two stages: classroom teaching and independent practice, mirroring the video-based group in terms of class hours. In the first stage, the teacher introduced the suturing methods using a module-based video similar to that used in group MV, followed by individual demonstrations of each technique.

After each set of suture demonstrations in the first stage, students practiced while receiving guidance from the teacher. In the second stage, they independently practiced each suture technique seven times in the classroom, with teachers available to provide guidance. Following the final practice session for each group, a post-test was conducted, requiring students to complete 12 sutures. A modified assessment tool, based on the ACS/APDS Surgery Resident Skills Curriculum Global Rating Scale, was employed, and students were graded on a scale of 0 to 100 for their overall performance across all sutures.

Additionally, two self-assessment questionnaires on suturing techniques were administered before and after the course (Supplemental Table 1), alongside a post-course satisfaction survey regarding the video content (Supplemental Table 2). Utilizing a Likert scale of 5, responses of 4 points or above signified approval and satisfaction. Informed consent was secured from all participants, with the entire study protocol overseen and approved by the Ethics Committee of Hebei Medical University (No. SCXK2020-0025).

Statistical analysis

Data were presented as mean ± standard deviation (SD) and analyzed using t-tests and ANOVA. A p-value of less than 0.05 was considered statistically significant. Spearman's rank correlation coefficient (ρ) was used to assess the relationship between self-evaluation and post-course test scores. All statistical calculations were conducted using Microsoft Excel and SPSS software (version 21; SPSS Inc., Chicago, IL).

Results

The average age of the students was 23 years, with a gender distribution comprising 28 females and 32 males. By comparing pre-course and post-course self-evaluations, each student demonstrated a significant improvement in self-assessed competency across all 12 suturing techniques. Figure 2 illustrates the average score enhancement for these skills, revealing a median increase in self-ratings from 1.85 to 3.84.

To investigate the disparities in students' suturing skill enhancement across various teaching methodologies, we subtracted pre-class self-evaluation scores from post-class ones to analyze the differences. In the majority of suturing techniques (SCS, VMS, HMS, CHMS, LS, and HS), Group MA exhibited significantly higher score improvements compared to the other two groups. When contrasted with Group TE, the instructional approach integrating modular demonstrations and animated simulations proved markedly superior in boosting post-course scores for all suturing methods except SIS, FIS, CMS, and PSS. However, this advantage did not manifest when comparing Group MV with Group TE (Table 2). These findings suggest that standalone simulation struggles to yield effective teaching outcomes for most suturing skills, while the combination of animated demonstrations or teacher guidance significantly facilitates skill acquisition.

Additionally, we assessed the variations in completing 12 sutures post-course across the three groups (Fig. 3B). The results revealed no statistically significant difference between Group MA and Group TE; however, both outperformed Group MV.

By comparing the exercise times of different video-based groups, we observed that Group MA's practice duration was significantly shorter than that of Group MV (Fig. 3A).

To verify the relationship between students' self-evaluations and their post-course test results, we conducted a consistency test. The findings revealed a positive correlation between self-evaluations of the 12 common suturing techniques and the test outcomes (Table 3). This indicates that students' self-assessments during practice can partially reflect their learning effectiveness and accurately mirror their self-confidence. As widely recognized, appropriate self-confidence can significantly enhance skill acquisition.

Discussion

Traditional instruction in fundamental surgical procedures primarily relies on lectures and demonstrations, necessitating substantial practice facilities and consuming considerable teaching time for surgeons [1, 16, 17]. It's impractical to expect surgeons, already burdened with demanding schedules, to dedicate extensive time to teaching. Distance learning can serve as a valuable supplement to medical education. Research has demonstrated that video-based instruction effectively imparts basic surgical skills, such as suturing and knot tying, to novices in the medical field [6–8, 18, 19]. The incorporation of instructional videos can alleviate some of the pressures on educators. Even without expert supervision, video-based learning facilitates substantial technical improvement and knowledge retention among students [7, 18]. However, currently, most videos primarily consist

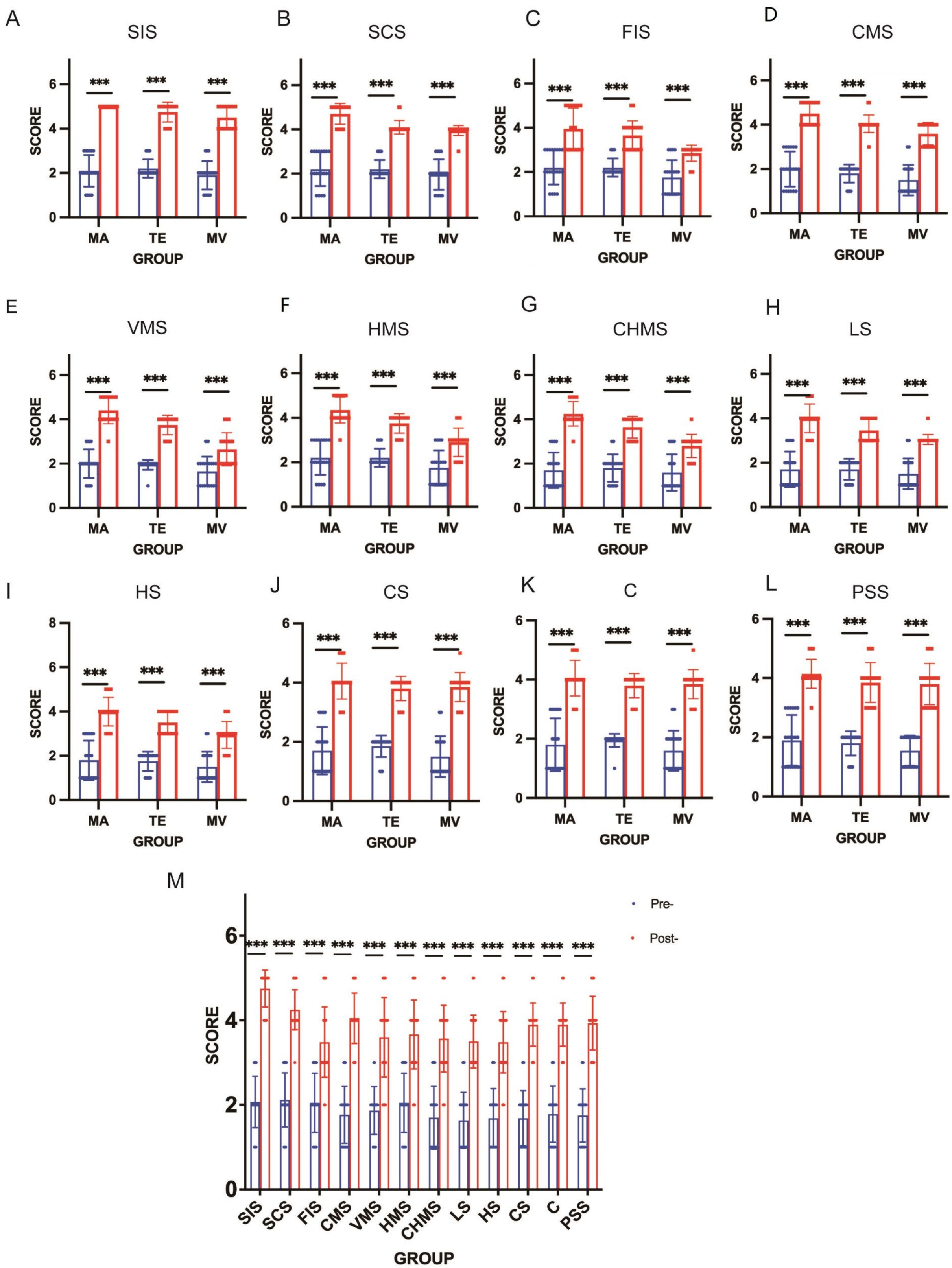

Fig. 2 **A-L** The average score improvement of all 12 skills in different groups. **M** The average score improvement of all 12 skills in all students

Table 2 Differences in post class self-evaluation improvement among different teaching methods

Score(post minus pre)		Mean	Std. Error Mean	Std. Deviation	Range of score(post minus pre)		*P*		
					Low	High	MA vs. TE	MA vs. MV	TE vs. MV
SIS	MA	2.90	0.161	0.718	2	4	0.123	0.134	0.794
	TE	2.55	0.153	0.686	1	3			
	MV	2.60	0.112	0.503	2	3			
SCS	MA	2.50	0.115	0.513	2	3	< 0.001	0.016	0.574
	TE	1.90	0.069	0.308	1	2			
	MV	2.00	0.162	0.725	1	3			
FIS	MA	1.75	0.099	0.444	1	2	0.055	0.001	0.084
	TE	1.45	0.114	0.510	1	2			
	MV	1.10	0.161	0.718	0	2			
CMS	MA	2.50	0.154	0.688	2	4	0.182	0.050	0.350
	TE	2.25	0.099	0.444	2	3			
	MV	2.10	0.124	0.553	1	3			
VMS	MA	2.40	0.134	0.598	1	3	0.001	< 0.001	< 0.001
	TE	1.80	0.092	0.410	1	2			
	MV	1.00	0.145	0.649	-1	2			
HMS	MA	2.15	0.150	0.671	1	3	0.008	< 0.001	0.055
	TE	1.55	0.153	0.686	0	2			
	MV	1.15	0.131	0.587	0	2			
CHMS	MA	2.55	0.170	0.759	1	4	0.013	< 0.001	0.021
	TE	1.85	0.209	0.933	0	3			
	MV	1.20	0.172	0.768	0	2			
LS	MA	2.30	0.105	0.470	2	3	0.007	< 0.001	0.373
	TE	1.75	0.160	0.716	1	3			
	MV	1.55	0.153	0.686	0	2			
HS	MA	2.20	0.138	0.616	1	3	0.040	0.002	0.227
	TE	1.75	0.160	0.716	1	3			
	MV	1.45	0.185	0.826	1	3			
CS	MA	2.35	0.131	0.587	1	3	0.040	1.000	0.055
	TE	1.95	0.135	0.605	1	3			
	MV	2.35	0.150	0.671	1	3			
C	MA	2.25	0.160	0.716	1	3	0.047	1.000	0.032
	TE	1.85	0.109	0.489	1	3			
	MV	2.25	0.143	0.639	1	3			
PSS	MA	2.25	0.160	0.716	1	3	0.418	1.000	0.418
	TE	2.05	0.185	0.826	1	3			
	MV	2.25	0.160	0.716	1	3			

MA: module and animation combination group, MV: module video group, TE: traditional education group

of modular demonstrations, leaving students in a passive reception mode. Enhancing student engagement and improving teaching efficacy has thus become a challenging issue.

Animation simulations captivate students' interest more effectively due to their vibrant visuals and engaging nature. They have also demonstrated advantages in illustrating abstract concepts and detailing complex procedures [10–12]. As depicted in the cross-sectional views, the animation simulation of human tissue closely mirrors clinical realities, enabling students to more intuitively grasp the essential points and practical applications of surgical techniques.

Compared to previous studies, our research delves deeper into the subject. For instance, Summers et al. demonstrated that video-based teaching surpasses traditional methods in training medical students for suturing and knotting skills [20]. Schittek Janda et al. examined the influence of non-interactive video materials on learning and confirmed that this training model yields positive learning outcomes and skill retention [21]. In our research, we compared modular-based videos with traditional teaching methods and found inconsistent teaching efficacy across different suturing techniques. Video-based instruction alone couldn't supplant traditional teaching. However, when we incorporated animations into video

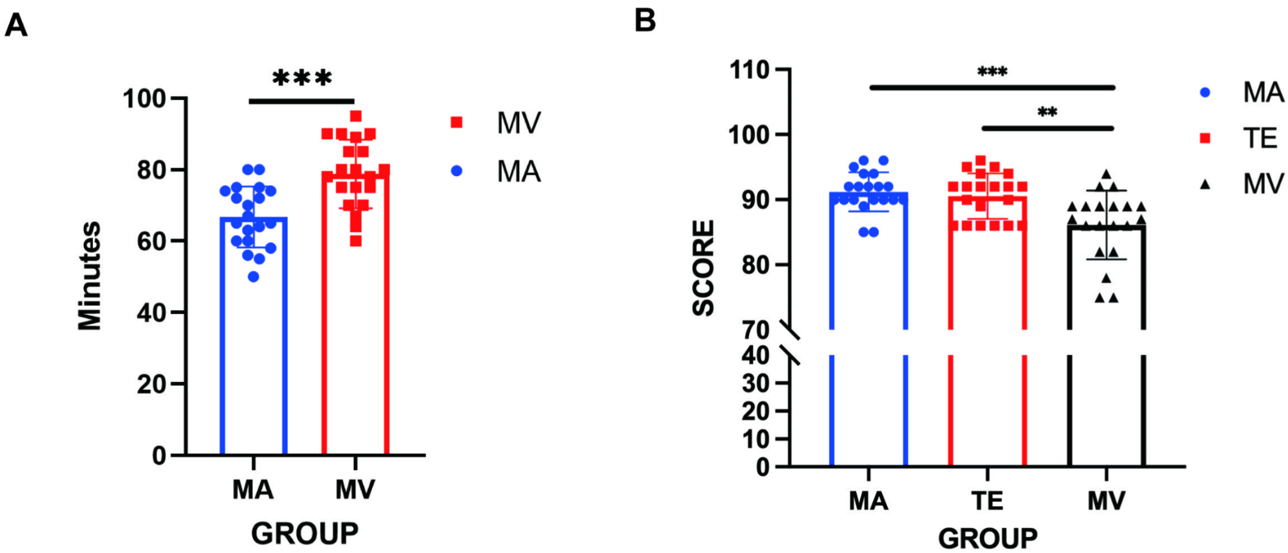

Fig. 3 **A** The exercise time of group MA is much shorter than group MV. **B** There was no statistical difference in the after-course test between group MA and group TE, but both were better than group MV

Table 3 Correlation between self-evaluation and after-course test

	SIS	SCS	FIS	CMS	VMS	HMS	CHMS	LS	HS	CS	C	PSS
Post Test score	0.256*	0.380**	0.482**	0.318*	0.524**	0.496**	0.512**	0.612**	0.743**	0.338**	0.338**	0.426**

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

teaching, it showed significant advantages over traditional methods for most suturing techniques. Thus, while video-based teaching holds promise, the quality of the video content is equally vital.

The results show that video based on combination of module and animation can more effectively teach suture skills to novices in preclinical medicine. Compared with modular-based video, students spent less time in practice and had a better grasp of the operations. This may be related to the advantages of animation video in the display of details. It can enable students to better understand the depth of stitching through cross section, avoid problems such as occlusion in actual operation, and make the key points and difficulties more prominent.

Some studies have weakened the importance of teacher guidance in basic skills training, and indicated that autonomous video training provides the same retention rate of basic skills as expert guidance [7, 18]. Our research reveals that a video series blending animation with modules achieves a learning outcome in suturing skills comparable to traditional teaching methods. Introducing animation into these videos not only satisfies the pedagogical criteria of conventional instruction but also offers distinct advantages in the majority of suturing techniques. Moreover, an analysis of the alignment between self-assessments and suturing tests demonstrated that students can proficiently evaluate their learning progress during autonomous practice, echoing findings from prior studies [8]. Interestingly, we discovered that three closely related suturing techniques (Cushing, Connell, and Push String Sutures) all fall under continuous suturing parallel to the wound. Our research suggests that modular and animated video courses don't exhibit significant advantages for these three methods, potentially due to their high repetitiveness. Video-based learning offers students the flexibility to learn at their own pace, enabling repeated viewing and practice, thereby transcending traditional classroom time constraints. The design of such training videos can effectively mitigate teaching limitations during extraordinary times. Should in-hospital training become challenging, these distanced and independent learning modules can help bridge the gap [2, 3]. Amidst this ever-evolving landscape, medical education must navigate the pressures that could curtail in-person instruction.

Nevertheless, our research has its share of limitations. The suturing tests involved only one evaluator, and some assessment criteria were subjective. Moreover, these skills were performed on models; it remains uncertain whether students can replicate their performance in clinical settings. Notably, we selected surgically inclined volunteers to minimize dropouts due to disinterest, which may not fully represent the learning outcomes of the entire student body. Additionally, while this experimental design aims to emulate remote teaching, using a uniform skin model for practice might differ from the individualized teaching aids each student would use in actual remote learning, potentially influencing the exercise outcomes. Further studies are warranted to address these aspects.

Conclusions

In conclusion, the video approach that merges modules with animation proves effective in teaching suturing techniques without faculty intervention. Compared with modular-based video, the addition of animated simulation video has certain advantages in distance education.

Supplementary information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-06915-3.

Supplementary Material 1

Acknowledgements

The Academic Affairs Office of the 4th Hospital of Hebei Medical University must be thanked for their kind help in the video shooting process.

Author contributions

Meng Cheng organized the recording of the video, performed the statistical analysis and drafted the manuscript. Cuizhi Geng participated in the design of the study and critically revised the manuscript. Xinle Wang and Man Zhang recruited the students and assisted with teaching and data collection. All authors read and approved the final manuscript.

Funding

This work was supported by the Hebei Medical University [grant numbers 2020YBZDX-1]. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data availability

Data included in article.

Declarations

Ethics approval

All procedures were supervised and approved by the Ethics Committee of Hebei Medical University (No. SCXK2020-0025). The study was performed in accordance with the Declaration of Helsinki (as revised in 2013).

Human ethics and consent to participate

Not applicable.

Consent for publication

Not applicable.

COI/Disclosures

The authors have no related conflicts of interest to declare.

Clinical trial number

Not applicable.

Received: 8 October 2024 / Accepted: 24 February 2025
Published online: 10 March 2025

References

1. Kulaylat ANMS, Kenning EM, et al. Surgical education and training at the crossroads between medical school and residency. Bull Am Coll Surg. 2014;99:24e9.
2. Rose S. Medical student education in the time of COVID-19. JAMA. 2020;323(21):2131–2.
3. Mousa AY, Broce M. The impact of COVID-19 on vascular training. J Vasc Surg. 2020;72(1):380–1.
4. Norris S, Papillon-Smith J, Gagnon LH, Jacobson M, Sobel M, Shore EM. Effect of a surgical teaching video on resident performance of a laparoscopic Salpingo-oophorectomy: A randomized controlled trial. J Minim Invasive Gynecol. 2020;27(7):1545–51.
5. Pilieci SN, Salim SY, Heffernan DS, Itani KMF, Khadaroo RG. A randomized controlled trial of video education versus skill demonstration: which is more effective in teaching sterile surgical technique?? Surg infect. (Larchmt). 2018;19(3):303–12.
6. Jowett N, LeBlanc V, Xeroulis G, MacRae H, Dubrowski A. Surgical skill acquisition with self-directed practice using computer-based video training. Am J Surg. 2007;193(2):237–42.
7. Nousiainen M, Brydges R, Backstein D, Dubrowski A. Comparison of expert instruction and computer-based video training in teaching fundamental surgical skills to medical students. Surgery. 2008;143(4):539–44.
8. Kumins NH, Qin VL, Driscoll EC, Morrow KL, Kashyap VS, Ning AY, et al. Computer-based video training is effective in teaching basic surgical skills to novices without faculty involvement using a self-directed, sequential and incremental program. Am J Surg. 2021;221(4):780–7.
9. Prinz A, Bolz M, Findl O. Advantage of three dimensional animated teaching over traditional surgical videos for teaching ophthalmic surgery: a randomised study. Br J Ophthalmol. 2005;89(11):1495–9.
10. Flores RL, DeMoss P, Klene C, Havlik RJ, Tholpady S. Digital animation versus textbook in teaching plastic surgery techniques to novice learners. Plast Reconstr Surg. 2013;132(1):e101–9.
11. Hartney N, Dooley D, Nagle C. Using animation to teach breastfeeding physiology: a proof of concept study. Int Breastfeed J. 2021;16(1):21.
12. Reindl KM, White AR, Johnson C, Vender B, Slator BM, McClean P. The virtual cell animation collection: tools for teaching molecular and cellular biology. PLoS Biol. 2015;13(4):e1002118.
13. Hegarty M, Sims VK. Individual differences in mental animation during mechanical reasoning. Mem Cognit. 1994;22(4):411–30.
14. Hoyek N, Collet C, Di Rienzo F, De Almeida M, Guillot A. Effectiveness of three-dimensional digital animation in teaching human anatomy in an authentic classroom context. Anat Sci Educ. 2014;7(6):430–7.
15. Dubrowski A. Performance vs. learning curves: what is motor learning and how is it measured? Surg Endosc. 2005;19(9):1290.
16. Klingensmith ME, Brunt LM. Focused surgical skills training for senior medical students and interns. Surg Clin North Am. 2010;90(3):505–18.
17. Wade TJ, Lorbeer K, Awad MM, Woodhouse J, DeClue A, Brunt LM. Outcomes of a proficiency-based skills curriculum at the beginning of the fourth year for senior medical students entering surgery. Surgery. 2015;158(4):962–71.
18. Xeroulis GJ, Park J, Moulton CA, Reznick RK, Leblanc V, Dubrowski A. Teaching suturing and knot-tying skills to medical students: a randomized controlled study comparing computer-based video instruction and (concurrent and summary) expert feedback. Surgery. 2007;141(4):442–9.
19. Rogers DA, Regehr G, Howdieshell TR, Yeh KA, Palm E. The impact of external feedback on computer-assisted learning for surgical technical skill training. Am J Surg. 2000;179(4):341–3.
20. Summers AN, Rinehart GC, Simpson D, Redlich PN. Acquisition of surgical skills: a randomized trial of didactic, videotape, and computer-based training. Surgery. 1999;126(2):330–6.
21. Schittek Janda MBA, Mattheos N, Nebel D, Wagner A, Nattestad A, et al. Computer-mediated instructional video: a randomized controlled trial comparing a sequential and a segmented instructional video in surgical hand wash. Eur J Dent Educ. 2015;9:53–8.

Publisher's note