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SonoGame – more than just a game: Evaluation of an ultrasound training platform

SonoGame – mehr als nur ein Spiel: Evaluation einer Ultraschall-Trainingsplattform

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ABSTRACT

Purpose Ultrasound examination is a vital imaging tool in medicine, yet opportunities for comprehensive theoretical and practical training during medical education are limited. Effective ultrasound education requires both theoretical knowledge and hands-on practice. To address this, we developed SonoGame, a gamified platform designed to teach ultrasound skills to medical students. SonoGame provides a step-by-step introduction to ultrasound imaging and aims to improve skills such as image orientation, spatial visualization, and hand-eye-coordination through mini-games using geometric objects. This study evaluates the impact of SonoGame training on ultrasound skills.

Materials and Methods In this prospective, single-center study, 56 medical students, the majority of whom had no prior ultrasound experience, were randomly assigned to either a control group or a SonoGame group. The SonoGame group trained with the platform in four 30-minute sessions over 4 weeks, while the control group received no training. Ultrasound skills were assessed in both groups before and after the training period.

Results The SonoGame group showed significant improvement in ultrasound skills, particularly with complex anatomical structures, compared to the control group. Participants in the SonoGame group also reported increased familiarity and confidence with sonography, viewing SonoGame as a valuable tool in their training.

Conclusion SonoGame is an effective supplement to conventional ultrasound education, enhancing the skills necessary for ultrasound examinations in medical students.

ZUSAMMENFASSUNG

Fragestellung Die Ultraschall-Untersuchung ist ein zentrales bildgebendes Verfahren in der Medizin, doch fehlen oft flächendeckende Übungsmöglichkeiten während der Ausbildung. Neben theoretischem Wissen sind praxisnahe Hands-On-Übungen für den Erwerb von Ultraschall-Fähigkeiten unerlässlich. SonoGame, eine gamifizierte Lernplattform, wurde entwickelt, um Medizinstudierenden diese Fähigkeiten schrittweise zu vermitteln. SonoGame zielt darauf ab, die Orientierung im Ultraschallbild, die räumliche Vorstellungskraft und die Hand-Auge-Koordination durch spielerische Übungen mit geometrischen Objekten zu verbessern. Ziel dieser Studie war es, die Wirksamkeit von SonoGame in der Ultraschall-Ausbildung zu bewerten.

Materialien und Methodik In dieser prospektiven, unizentrischen Studie wurden 56 Medizinstudierende überwiegend ohne praktische und berufliche Ultraschall-Erfahrung randomisiert in eine Kontroll- und eine SonoGame-Gruppe eingeteilt. Die SonoGame-Gruppe nutzte die Plattform 4 Wochen lang in 4 Trainingseinheiten à 30 Minuten, während die Kontrollgruppe kein Training erhielt. Die Ultraschall-Fähigkeiten beider Gruppen wurden vor und nach dem Trainingszeitraum bewertet.

Ergebnisse Die SonoGame-Gruppe zeigte im Vergleich zur Kontrollgruppe eine signifikante Verbesserung der Ultraschall-Fähigkeiten, insbesondere bei komplexen anatomi-

schen Strukturen. Zudem berichteten die Teilnehmenden der SonoGame-Gruppe von einer erhöhten Vertrautheit und Sicherheit im Umgang mit der Sonografie.

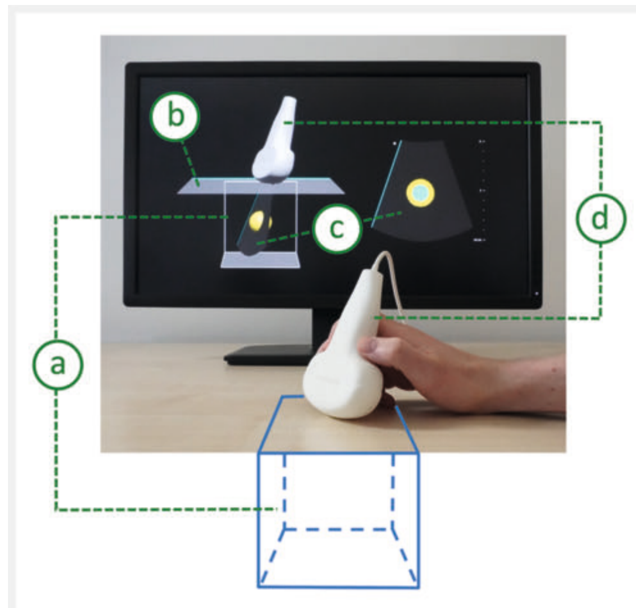
Zusammenfassung SonoGame ist eine wertvolle Ergänzung zur traditionellen Ultraschall-Ausbildung und unterstützt die Entwicklung wichtiger Ultraschall-Fähigkeiten bei Medizinstudierenden.

Introduction

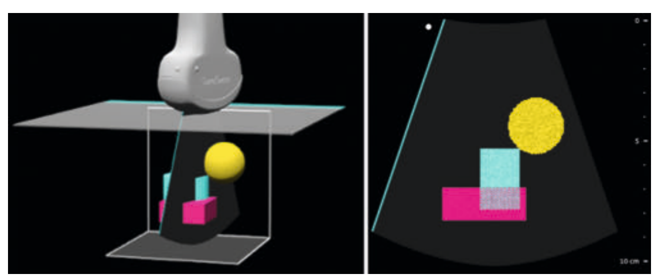
Ultrasound imaging is essential in modern healthcare. It facilitates early diagnosis, precise monitoring, and informed decision-making. It enhances patient safety by guiding physicians during invasive procedures [1, 2, 3]. Mastery of ultrasound requires a solid grasp of anatomy and pathology as well as hand-eye-coordination and visuospatial skills for cross-sectional imaging [4, 5]. Traditional training methods include didactic teaching, live demonstrations, and supervised practice on ultrasound models as well as patients [6, 7, 8, 9]. Simulation-based training, along with the assessment of learning outcomes, is increasingly being integrated into ultrasound education and medical training [9, 10].

Innovative educational approaches are crucial to overcome training challenges [6, 8, 10, 11]. Gamification elements – such as challenges, feedback, repetition, achievements, and rewards – can boost motivation and skill acquisition [12, 13]. SonoGame is designed for ultrasound beginners, focusing on fundamental cross-sectional imaging and interpretation skills through basic geometrical structures rather than anatomical ones. This approach eliminates the need for prior anatomical knowledge. SonoGame incorporates feedback, repetition, and a reward system to enhance skill development. By integrating gamification, SonoGame aims to make learning engaging and effective, promoting active participation and deeper understanding [14, 15].

We present a prospective, randomized study evaluating SonoGame's effectiveness with respect to improving ultrasound skills among medical students. This study seeks to advance training methods, thereby benefiting both students and patients.



▶ **Fig. 1** Illustration of the basic principle of the ultrasound simulation in SonoGame. **a**: virtual examination volume (on the screen and underneath the table), **b**: virtual table surface indicator, **c**: virtual slice image, **d**: 3 D-printed probe controlling the in-game probe.



▶ **Fig. 2** Left: Virtual probe with view of the examined volume (here: objects not hidden); Right: Live cross-sectional image created by the probe.

Material & Methods

SonoGame

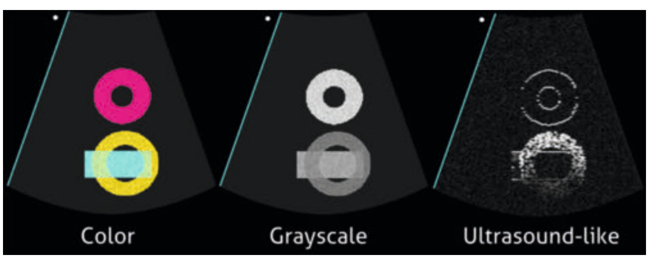
SonoGame consists of mini-games that challenge trainees to examine, identify, and recreate cross-sectional images of a virtual volume beneath the tabletop containing geometric objects. To do so, the trainee uses a 3 D-printed probe to create cross-sectional images (▶ **Fig. 1**). The probe is equipped with a motion tracker that continuously reports its position and rotation to the game. This data is used to simulate a virtual probe on the screen that behaves just like the 3 D-printed probe in the user's hand. By moving the 3 D-printed probe like a real ultrasound probe, the trainee can generate slice images from artificial volumes (▶ **Fig. 2**).

An overview of the setup is shown in ▶ **Fig. 3**. A game controller with a joystick and 9 buttons is used as input device. A square marker on the table (▶ **Fig. 3e**) indicates the scannable area beneath which the virtual volume is located, akin to the virtual surface indicator (▶ **Fig. 1b**).

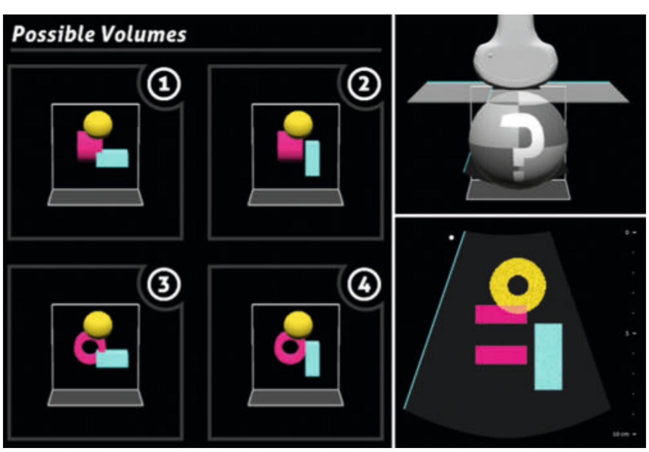
Mini-games

In SonoGame, there are 3 types of mini-games: *identify object* games, *identify slice* games, and *recreate slice* games. Each mini-game offers various difficulty levels and 3 visualization modes: color, grayscale, and ultrasound-like (▶ **Fig. 4**). The different difficulty levels vary in complexity of the examined structures (e. g.,

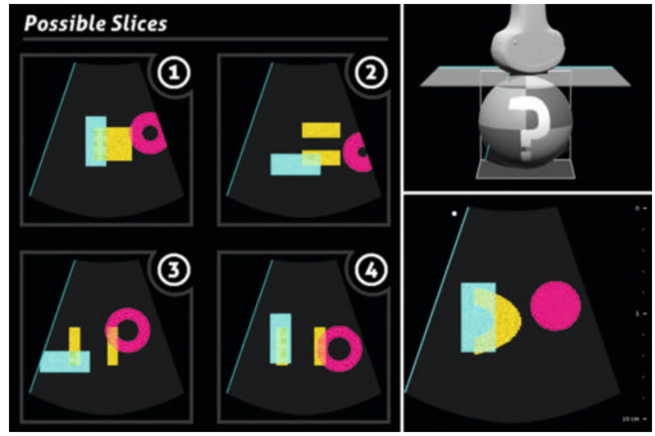
► **Fig. 3** Overview of the SonoGame setup. **a**: game screen, **b**: game controller, **c**: motion tracking system, **d**: 3 D-printed probe, **e**: marker indicating the surface of the examination volume.



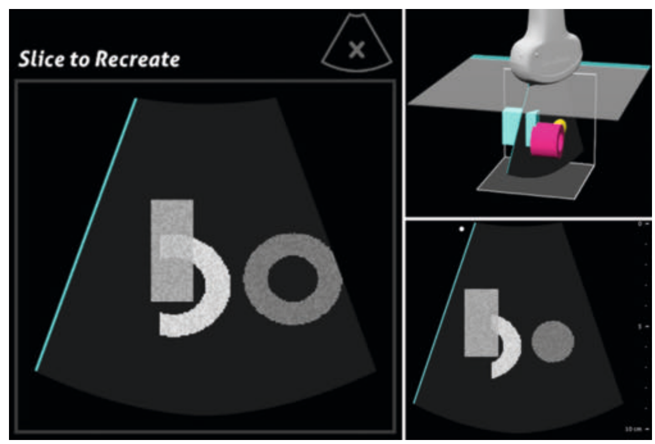
► **Fig. 4** Different visualization modes for the virtual cross-sectional image.



► **Fig. 5** Mini-game *Identify Object*. Left: response options (1–4, different spatial arrangements of the same objects). Top right: virtual volume with objects hidden by a sphere. Bottom right: current cross-section of the hidden objects.



► **Fig. 6** Mini-game *Identify Slice*. Left: response options (4 given cross-sectional images). Top right: virtual volume with objects hidden by a sphere. Bottom right: live cross-sectional image of the hidden objects.



► **Fig. 7** Mini-game *Recreate Slice*. Left: cross-sectional image to recreate. Top right: virtual volume (in this case objects revealed to the trainee). Bottom right: live cross-sectional image of the virtual volume.

shape or orientation) or difficulty of the probe movement required to solve the given tasks.

Identify Object: Users examine an unknown volume and identify objects based on 4 response options (► **Fig. 5**), training them to infer object shapes from cross-sectional images.

Identify Slice: From 4 response options, users select the cross-sectional image that belongs to the currently examined volume (► **Fig. 6**), enhancing their ability to interpret 2D slices in a 3D-space.

Recreate Slice: Users replicate a given cross-sectional image (► **Fig. 7**). Variants include feedback-based correction, confirmation without feedback, and recreating 2 orthogonal planes.

Course of the game

The trainee follows a structured campaign of mini-games with increasing difficulty and different visualization modes (► **Fig. 8**). After a tutorial, the trainee starts the first mini-games and earns

▶ **Fig. 8** Example of a game campaign (excerpt).

medals by completing them. Collecting medals unlocks additional mini-games. This campaign structure, progressing from easy to more difficult challenges, aims to improve the learning experience and motivate trainees through gamification elements like medals and new stages.

Study design

A randomized prospective study evaluated the effectiveness of SonoGame as a supportive tool for ultrasound training for medical students in clinical training. The primary objective was to assess SonoGame's impact on the ultrasound skills of students without prior ultrasound education. The study spanned 4 weeks (▶ **Fig. 9**).

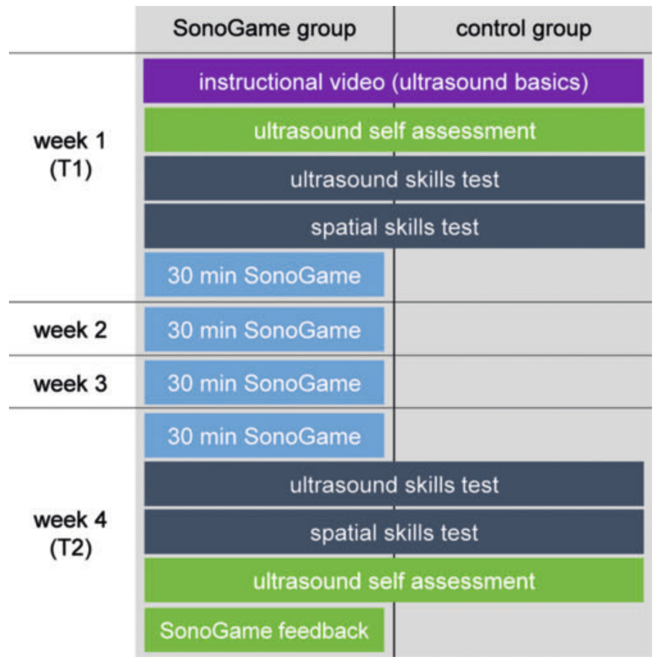
56 participants (34 females and 22 males) were recruited for the study. All participants were graduate medical students, and the large majority had received no prior teaching nor had professional experience with ultrasound. They were randomly assigned to either the SonoGame group (n = 28) or the control group (n = 28). One participant of the SonoGame group was excluded for personal reasons.

All participants watched a 5-minute instructional video on ultrasound imaging, then underwent an ultrasound skills test and a spatial abilities test. They also completed a self-assessment questionnaire on their ultrasound skills and provided feedback on the video. The questionnaire also collected data on gender, clinical semester, and prior ultrasound experience.

Subsequently, the SonoGame group completed four 30-minute training sessions over 4 weeks, while the control group received no further training. The progress of each participant was preserved between SonoGame sessions. After the intervention, both groups took the same tests to assess changes in ultrasound skills and spatial abilities, and completed a self-assessment questionnaire. The SonoGame group also provided feedback on the training platform.

Ultrasound skills test (UST): Participants were shown exemplary ultrasound pictures of 3 anatomical structures on 2 predetermined planes with increasing degrees of difficulty: the bladder, the aorta, and the thoracodorsal bundle. Then they examined a peer and depicted the structures on the 2 planes. The time to create these images was recorded, and an experienced clinician evaluated and recorded the accuracy of the images.

Spatial skills test: The Santa Barbara Solids Test (SBST) [16] was used to measure the participants' spatial skills. It features 30 questions where participants match a cross-sectional image to a 3D-shape intersected by a plane. Previous research links spatial ability, such as inferring cross-sections, to ultrasound skills [4, 5]. An improved SBST score in the SonoGame group compared to the



▶ **Fig. 9** Overview of the course of study.

control group may indicate enhanced ultrasound skills from SonoGame training.

Ultrasound self-assessment: Participants' perceptions of ultrasound skills were assessed using a self-evaluation questionnaire with statements on their familiarity with ultrasound and the role of hand-eye-coordination. Responses were recorded on a 5-point Likert scale from agree (1) to disagree (5).

SonoGame feedback: This questionnaire, which was given only to the SonoGame group, used a 5-point Likert scale to assess the impact of SonoGame on confidence, ultrasound skills, and enjoyment. It also collected feedback on perceived positive and negative aspects, and suggested improvements.

Quantitative data were analyzed using the Wilcoxon-Mann-Whitney test to compare groups. T1 and T2 questionnaire differences were assessed using the paired Wilcoxon-Mann-Whitney test. Significance was set at 5 %.

The study adhered to ethical standards, with informed consent and ethics committee approval. It was sponsored by the German Society of Ultrasound in Medicine (DEGUM).

Results

No significant difference ($p > 0.05$) was found regarding the number of clinical semesters attended in the SonoGame (min. = 1, max. = 9, median = 3) versus the control group (min. = 1, max. = 8, median = 4). In the control group, 64 % were female (18 females, 10 males), while the percentage of females in the SonoGame group was 56 % (15 females, 12 males). Prior, non-professional ultrasound experience was reported by 5 participants of the control group and 4 participants of the SonoGame group.

Spatial skills test: At baseline (SBST, T1), no significant difference was found between groups. Both improved significantly from T1 to T2 ($p < 0.001$), but intergroup differences remained non-significant (▶ **Fig. 10**).

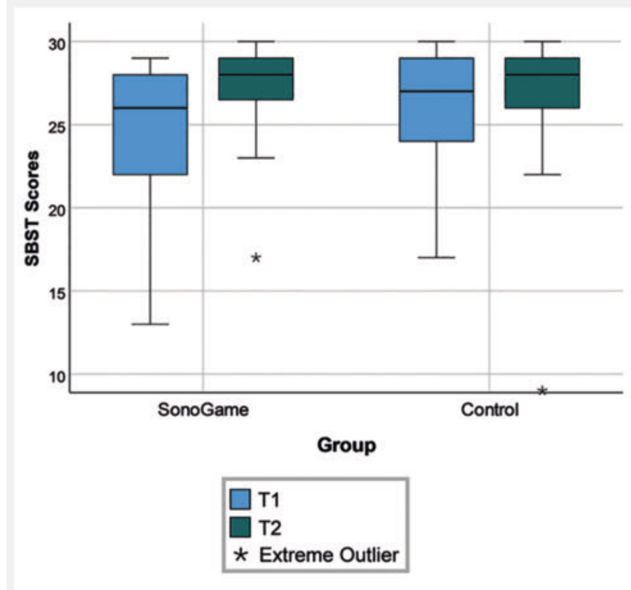
Ultrasound skills test: At the initial assessment (T1), the SonoGame group scored significantly lower than the control group ($p = 0.029$). After 4 weeks of training, the SonoGame group showed greater improvement in UST scores ($p < 0.001$) (▶ **Fig. 11**). When analyzing specific anatomical structures (the bladder, the aorta, and the thoracodorsal bundle), participants in the SonoGame group exhibited enhanced proficiency in scanning both planes of the bladder and the aorta accurately. The most notable improvement was seen in the thoracodorsal bundle (▶ **Table 1**).

Both groups required less time to visualize structures at T2 than at T1. Due to missing data, 1 control group participant was excluded from the task completion time analysis. The SonoGame group improved by an average of 38.0 seconds (SD = 38.5), while the control group improved by 27.7 seconds (SD = 48.5), though this difference was not significant. Detailed times are shown in ▶ **Table 2**, and UST task completion time changes are shown in ▶ **Fig. 12**.

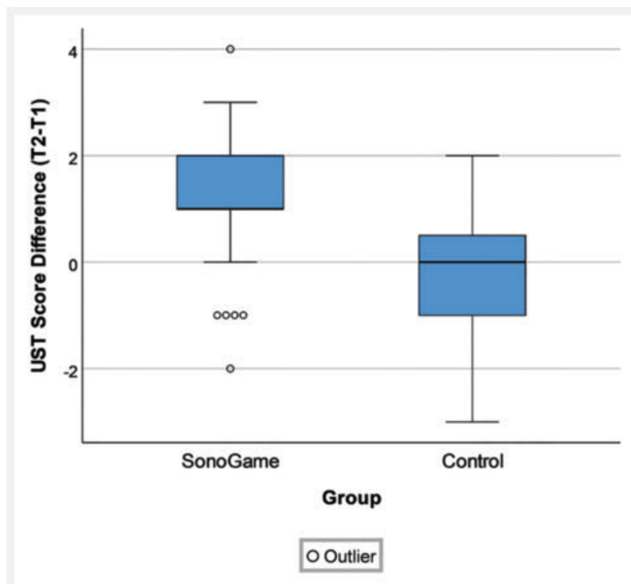
Ultrasound self-assessment: Both groups found the instructional video helpful with regard to explaining sonography's physical and practical aspects (M = 2.4, SD = 1.0) and comprehensible (M = 1.3, SD = 0.5) on a 5-point Likert scale (1 = agree, 5 = disagree).

The self-evaluation questionnaire showed no significant differences between groups at T1. Both groups agreed at the beginning and at the end of the study (T1 and T2) on the importance of skills training (T1: M = 4.6, SD = 1.1; T2: M = 4.3, SD = 1.3, larger indicates more importance) and hand-eye-coordination (T1: M = 1.2, SD = 0.4, T2: M = 1.2, SD = 0.5, smaller indicates more importance). Significant differences were noted between groups with regard to their improvement from T1 to T2. After the training with SonoGame, the SonoGame group felt more familiar with sonoanatomy ($p = 0.002$) and ultrasound technology ($p = 0.009$) and reported better spatial orientation ($p = 0.010$) and scanning skills ($p = 0.004$). No significant change in the control group's opinions from T1 to T2 was found. An overview can be found in ▶ **Table 3**.

SonoGame feedback: Results can be found in ▶ **Table 4**. All but 1 of the 27 SonoGame participants (96.3 %) stated that all minigames were comprehensible without further explanation.



▶ **Fig. 10** Boxplots depicting the SBST scores of both groups at the initial (T1) and the final (T2) assessment.



▶ **Fig. 11** Boxplots depicting the change in UST scores of both groups from the initial (T1) to the final (T2) assessment.

Discussion

Ultrasound is one of the most crucial tools for physicians. Just as the stethoscope is a standard instrument used by physicians, ultrasound is now used by almost all clinicians as a complementary tool to examine inside the human body. It is also an important part of many surgical and non-surgical interventions [1, 17, 18]. In order to improve and promote ultrasound skills, standardized practices are already recommended by ultrasound societies [19, 20, 21]. The value of ultrasound skills is also known in the medical

▶ **Table 1** Results showing scores of the ultrasound skills test (rounded scores).

Anatomical structure	Group	Mean score (SD)		
		T1	T2	T2–T1
Bladder	SonoGame	1.4 (0.6)	1.6 (0.6)	0.2 (0.9)
	Control	1.6 (0.6)	1.4 (0.7)	–0.2 (0.8)
Aorta	SonoGame	1.6 (0.5)	1.8 (0.4)	0.2 (0.6)
	Control	1.5 (0.5)	1.6 (0.5)	0.1 (0.7)
Thoracodorsal bundle	SonoGame	0.7 (0.6)	1.3 (0.6)	0.6 (0.8)
	Control	1.1 (0.4)	0.9 (0.7)	–0.3 (0.8)
All	**SonoGame**	**3.7 (1.1)**	**4.7 (1.0)**	**1.1 (1.4)**
	Control	**4.2 (0.9)**	**3.9 (1.3)**	**–0.3 (1.3)**

▶ **Table 2** Results showing task completion times of the ultrasound skills test (rounded times).

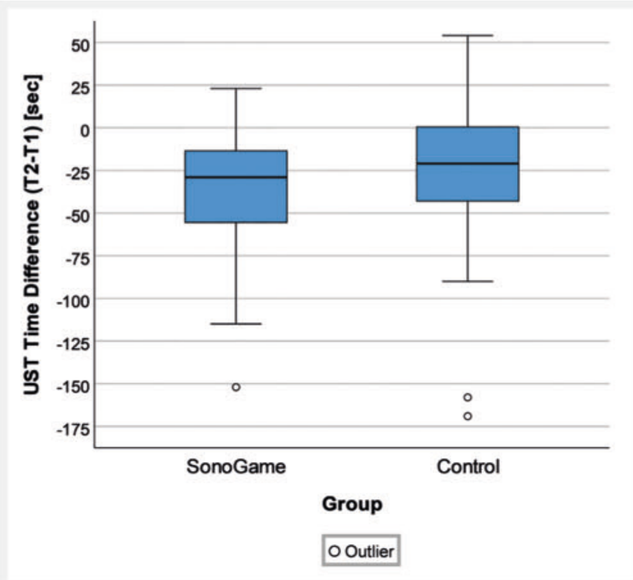
Anatomical structure	Group	Mean task completion times in seconds (SD)		
		T1	T2	T2–T1
Bladder	SonoGame	29.2 (25.2)	12.6 (9.1)	–16.6 (21.2)
	Control	29.0 (26.8)	19.6 (17.4)	–9.4 (23.1)
Aorta	SonoGame	21.6 (22.0)	13.5 (9.5)	–8.0 (18.3)
	Control	25.5 (31.3)	19.9 (18.6)	–5.6 (18.2)
Thoracodorsal bundle	SonoGame	39.3 (31.7)	26.9 (24.7)	–13.4 (21.6)
	Control	37.5 (31.8)	24.9 (27.3)	–12.6 (33.4)
All	**SonoGame**	**90.0 (62.7)**	**52.0 (37.8)**	**–38.0 (38.5)**
	Control	**92.0 (69.7)**	**64.3 (52.8)**	**–27.7 (48.5)**

student community [7, 20, 21, 22]. To advance these skills, medical schools provide a range of courses and skills labs [7, 11]. While these courses are usually designed to teach sonography in a particular field of medicine [7, 11, 23], the training of foundational skills, such as spatial orientation, 3 D- to 2 D-transfer, and hand-eye-coordination, is essential [7, 10, 11, 22, 23, 24]. These types of training programs are highly valued among the students [7, 8, 10, 25]. This eagerness was also demonstrated by the majority of the participants in our study, as they agreed on the importance of ultrasound skills training during medical education.

There was no significant difference between groups with regard to SBST score improvement from T1 to T2. SonoGame may not strongly affect the spatial abilities measured by SBST. But a considerable number of participants started with relatively high scores, leaving little room for improvement, and therefore reducing potential group differences. Such initial high scores have also been shown in other studies with students of STEM degree programs [26, 27]. In addition, the fact that both groups improved from T1 to T2 could be due to a learning effect from the SBST itself, reducing the possibility to detect improvements due to training measures even more.

Dual-plane scanning of anatomical structures is indispensable for the comprehensive assessment of 3-dimensional anatomical configurations. Scanning different ultrasound planes of different anatomical structures provided a challenge for the participants. The bladder was supposed to be the easiest to scan correctly, and thus no great improvement was shown or expected in either group. The aorta, although considered more difficult, was scanned correctly more often than the bladder at T1 and T2. The most advanced anatomical structure to scan turned out to be the thoracodorsal bundle of nerves and vessels in the axilla. It also provided an additional challenge with its diagonal axis in comparison to the other anatomical structures scanned in the study. Among all the tasks, the SonoGame group showed the most improvement when scanning this difficult structure. As the SonoGame training also consisted of many different objects in different shapes and the participants were asked to scan these objects in unconventional planes, they were able to prepare themselves for a real-world application.

Since the participants in the control group achieved significantly more points on the initial UST (T1) than the participants of the SonoGame group, the control group had less potential to improve. It could be argued that the greater improvement in ultrasound skills measured in the SonoGame group compared to the control group was influenced by this effect. However, increasing the initial score of each participant of the SonoGame group by the average score difference between the control group and the SonoGame group at T1 would still lead to a significantly greater improvement (T1 to T2) for the SonoGame group, compared to the control group (p = 0.014). The effect of SonoGame is, therefore, still significant when taking this estimate into account.



▶ **Fig. 12** Boxplots depicting the change in UST time in seconds of both groups from the initial (T1) to the final (T2) assessment.

Interestingly, the measured ultrasound skills of the control group decreased slightly from T1 to T2. This effect might have been due to the introductory video having a temporary positive influence at T1. An additional explanation could be a lower reliability of the UST so that a fluctuation of 0.3 points per structure might be within the range of measurement accuracy.

The SonoGame training program was predominantly rated very positively. It was particularly appreciated for improving probe handling and the ability to orient oneself within the ultrasound image.

As seen in various other studies [6, 7, 8, 11, 14, 22], there is an increased willingness to learn ultrasound skills during medical education [17], as the participants in our study also confirmed. SonoGame, as a supportive training tool, was rated by the vast majority of students as recommendable and, perhaps more importantly, as fun. Another strength of SonoGame as a supportive training tool is the fact that no professional teacher or instruction is required – due to the high level of self-descriptiveness. Furthermore, since only geometric objects and no anatomical structures are examined in SonoGame, no prior knowledge is required. Students can train with SonoGame independently of a rigid curriculum.

While our study shows promising results, it has notable limitations. One key issue is the imbalance in the number of female and

▶ **Table 3** Statements and results of the self-evaluation questionnaire (translated from German).

Statement (1: agree, 5: disagree)	Group	Mean at T1 (SD)	Mean at T2 (SD)	p-value of the group differences (T2-T1)
Statements (the smaller the mean, the better)				
1: I feel familiar with ultrasound technology.	SonoGame	3.1 (1.0)	2.5 (0.6)	p = 0.009
	Control	3.0 (0.9)	2.9 (0.8)	
2: I can depict anatomical structures using ultrasound.	SonoGame	2.9 (0.8)	2.0 (0.6)	p = 0.004
	Control	2.8 (0.8)	2.6 (0.7)	
3: Hand-eye-coordination plays a crucial role in sonographic examinations.	SonoGame	1.2 (0.4)	1.1 (0.4)	p = 0.161
	Control	1.2 (0.4)	1.2 (0.4)	
Negated Statements (the larger the mean, the better)				
4: I cannot orient myself spatially on an ultrasound image.	SonoGame	3.4 (0.9)	4.1 (0.7)	p = 0.010
	Control	3.4 (0.7)	3.4 (1.0)	
5: I cannot orient myself anatomically on an ultrasound image.	SonoGame	3.6 (0.7)	4.0 (0.7)	p = 0.096
	Control	3.4 (0.8)	3.4 (0.9)	
6: I do not feel familiar with sonoanatomy.	SonoGame	2.5 (0.9)	3.7 (0.7)	p = 0.002
	Control	2.6 (1.0)	2.9 (1.0)	
7: I cannot depict anatomical structures in different sectional planes in space.	SonoGame	3.3 (1.0)	4.0 (0.7)	p = 0.099
	Control	3.1 (1.0)	3.3 (1.1)	
8: Sonographic skills training is not an important part of medical studies.	SonoGame	4.3 (1.5)	4.2 (1.4)	p = 0.568
	Control	4.8 (0.6)	4.4 (1.2)	

▶ **Table 4** Statements (translated from German) and results of the SonoGame feedback by the SonoGame group. *Mean of 1 = 100 % average agreement; mean of 5 = 0 % average agreement.

Statements (1: agree, 5: disagree)	Mean	SD	Average agreement*
Statements (the smaller the mean, the better)			
Learning with SonoGame was fun.	1.7	0.9	82.4 %
I would recommend SonoGame to others.	1.6	1.0	84.3 %
I would like to practice more with SonoGame.	2.0	1.3	74.1 %
SonoGame helped me to familiarize myself with ultrasound equipment technology.	2.2	1.3	69.4 %
Learning objectives regarding ultrasound skills were clearly defined.	2.6	1.1	59.3 %
Negated Statements (the larger the mean, the better)			
My knowledge of sonography has not improved as a result of SonoGame.	4.0	1.0	24.1 %
SonoGame did not help me to improve my orientation on the ultrasound image.	4.3	0.9	18.5 %
SonoGame did not help me with handling the ultrasound probe.	4.3	1.0	16.7 %

male participants, reflecting the voluntary nature of the study and current trends in medical education where female students are more prevalent. Another limitation was the absence of intervention for the control group, as they did not receive any instruction during the period in which the SonoGame group underwent the training. Future research could compare the effectiveness of the SonoGame approach with that of traditional teaching methods and could benefit from larger, more balanced groups and extended follow-up periods to better understand SonoGame's long-term effects on ultrasound skills. Additionally, investigating how skills learned through SonoGame transfer to real-world clinical settings is an important area for future research.

Participants in this study were not compensated, which may have attracted particularly motivated individuals. The applicability of these results to other student populations remains untested. The novelty of game-based training might also have contributed to heightened participant motivation.

Previous research highlights that students often struggle with self-confidence when learning new skills. Studies suggest that practicing in a low-risk environment significantly boosts confidence and proficiency [7, 13, 22, 25]. Our findings align with this, since participants who used SonoGame rated their ultrasound skills higher than those in the control group. This suggests that SonoGame not only enhances technical skills but also boosts confidence. Feedback from participants further supported this, with many expressing a desire to deepen their ultrasound knowledge and viewing SonoGame as an effective tool for this purpose.

Conclusion

This randomized prospective study suggests that SonoGame is a viable and effective tool for ultrasound training among medical students. The SonoGame group showed significant improvement in scanning skills, especially with complex structures like the thoracodorsal bundle. This indicates SonoGame's potential to enhance fundamental ultrasound proficiency and improve training in medical education. By applying gamification, SonoGame engages students in ultrasound-related training tasks to improve hand-eye-coordination, 3 D- to 2 D-visualization skills, and spatial orientation in sonoanatomy. It can also help with ultrasound imaging becoming less intimidating and more approachable for students. As medical education evolves, exploring innovative tools like SonoGame could lead to a more engaging learning experience. Further research and collaboration among educators, students, technologists, and clinicians are crucial to fully realize the benefits of gamification in ultrasound training.

Informed Consent Statement

Informed consent was obtained from all subjects involved in this study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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