Usability, Ergonomics, and Educational Value of a Novel Telestration Tool for Surgical Coaching

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Abstract

Background: Telementoring studies found technical challenges in achieving accurate and stable annotations during live surgery using commercially available telestration software intraoperatively.

Objective: To address the gap, a wireless handheld telestration device was developed to facilitate dynamic user interaction with live video streams. This study presents the usability results of a first-generation handheld wireless telestration platform.

Methods: A prototype was developed with four core hand-held functions: 1) free-hand annotation, 2) cursor navigation, 3) overlay and manipulation (rotation) of ghost (avatar) instrumentation, 4) hand-held video feed navigation on a remote monitor. This device uses a proprietary augmented reality (AR) platform. Surgeons and trainees were invited to test the core functions of the platform by performing standardized tasks. Usability, ergonomics, and educational value were evaluated with 5-point Likert scale surveys and a validated System Usability Scale (SUS).

Results: Ten subjects (9 surgeons, 1 trainee; 5 male, 5 female) participated. Participants agreed or strongly agreed that it was easy to perform annotations (90%; neutral=0%), video feed navigation (85%; neutral=15%), and manipulation of ghost (avatar) instruments on the monitor (60%; neutral=33%). With regards to ergonomics, 40% of participants agreed or strongly agreed (neutral=40%) that the device was physically comfortable to use and hold. These results are consistent with open ended comments made on the device's size and weight. The average SUS was 70 (median 75, interquartile range [63-84]) indicating an above average usability score. Participants responded favorably on the device's potential educational value, particularly for postoperative coaching (agree=60%; strongly agree=40%).

Conclusions: This study presents the preliminary usability results of a novel first-generation telestration tool customized for use in surgical coaching. Favorable usability and potential educational value were reported. Ultimately, such tools can be incorporated into pedagogical models of surgical coaching to optimize feedback and training.

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ABSTRACT

BACKGROUND –

Telementoring studies found technical challenges in achieving accurate and stable annotations during live surgery using commercially available telestration software intraoperatively. To address the gap, a wireless handheld telestration device was developed to facilitate dynamic user interaction with live video streams.

OBJECTIVES –

This study aims to find the perceived usability, ergonomics, and educational value of a first-generation handheld wireless telestration platform.

METHODS –

A prototype was developed with four core hand-held functions: 1) free-hand annotation, 2) cursor navigation, 3) overlay and manipulation (rotation) of ghost (avatar) instrumentation, 4) hand-held video feed navigation on a remote monitor. This device uses a proprietary augmented reality (AR) platform. Surgeons and trainees were invited to test the core functions of the platform by performing standardized tasks. Usability and ergonomics were evaluated with a validated System Usability Scale (SUS) and a 5-point Likert scale survey, which also evaluated the perceived educational value of the device.

RESULTS –

Ten subjects (9 surgeons, 1 senior resident; 5 male, 5 female) participated. Participants strongly agreed or agreed (SA/A) that it was easy to perform annotations (SA/A 90%; neutral=0%), video feed navigation (SA/A 85%; neutral=15%), and manipulation of ghost (avatar) instruments on the monitor (SA/A 60%; neutral=33%). With regards to ergonomics, 40% of participants agreed or strongly agreed (neutral=40%) that the device was physically comfortable to use and hold. These results are consistent with open ended comments made on the device's size and weight. The average SUS was 70 (median 75, interquartile range [63-84]) indicating an above average usability score. Participants responded favorably on the device's perceived educational value, particularly for postoperative coaching (agree=60%; strongly agree=40%).

CONCLUSION –

This study presents the preliminary usability results of a novel first-generation telestration tool customized for use in surgical coaching. Favorable usability and perceived educational value were reported. Future iterations of the device should focus on incorporating user feedback and additional studies should be conducted to evaluate its effectiveness for improving surgical education. Ultimately, such tools can be incorporated into pedagogical models of surgical coaching to optimize feedback and training.

Keywords

Augmented Reality, Surgical Training, Telestration, Surgical Training Technology, Minimally invasive Surgery

Declaration of interests

The development of the telestration platform was provided through a collaborative research agreement between Haply Robotics Inc. and the co-investigators AO and AM. The development work provided by Haply Robotics Inc. consisted of the hardware development of the telestration tool prototype and the control software and user interface development.

Acknowledgement

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Role of the funding source

The UHN Foundation and Haply Robotics Inc. were not involved in the study design; in the collection, analysis, and interpretation of data; in the writing of the manuscript; and in the decision to submit the paper for publication.

INTRODUCTION

Telementoring studies found technical challenges in achieving accurate and stable annotations using commercially available telestration software intraoperatively [1-3].

The first challenge is the dynamic nature of the video feed; there are frequent laparoscopic camera movements, field of view changes, and deformation of anatomic structures due to mobilization and retraction of anatomical structures and maneuvering the camera positions [4,5].

Mitigation strategies during coaching activities included freezing the video and converting it to still image [6]. This is not practical for real-time intraoperative coaching by surgeons and greatly increases time spent on the activity to stop and restart the session during annotation.

Previous usability studies which used telestration [6-8] employed a trackpad/mouse or touchscreen during annotation mode and found that the trackpad/mouse performed best in the delineation of structures, while the touch screen was superior in conveying directional information [7]. One study compared the usability of similar telestration devices with conventional interfacing devices such as a computer-mouse and a tablet-stylus [9]. With the advancement of technology in the gaming world, new virtual reality (VR)/augmented reality (AR) systems have emerged as a viable solution for the development of a system for telestration.

To address the educational gap for teaching minimally invasive procedures, a wireless handheld telestration device was developed to facilitate dynamic user interaction with live video streams. This study examines the usability of a first-generation handheld wireless telestration platform.

Continuing professional education activities such as surgical coaching provide opportunities for continued acquisition of new techniques and professional expertise.

Telestration is a technique for teaching whereby instructors annotate over images or videos to enhance the learning experience for surgical trainees [10]. This technique has shown promise for improving surgical skills more effectively than traditional verbal coaching across a broad range of metrics including faster task completion, reduced coaching time, better surgical performance, and greater trainee confidence [7, 11-13]. Previous telestration studies have highlighted the importance of mentor-mentee communication in surgical training [7, 12, 14].

In the setting of laparoscopic surgery, the learning curve for trainees tends to be greater as the surgical field cannot be directly visualized or palpated as in open surgeries and directly pointing at surgical display screens for teaching and coaching activity raises concerns of sterility. Instead, feedback and guidance are typically verbally described without the ability to make direct reference, which may lead to greater trainee confusion, miscommunication, and ultimately reduced efficacy of the teaching process. This is especially relevant with the shift to minimally invasive surgeries, which provide numerous benefits to patients over open surgeries [15]. Given the benefits of telestration seen for trainees and the adoption of minimally invasive surgery for increasingly more complex procedures, it is critical to develop better tools to improve the acquisition of these skills.

To augment the coaching experience, a wireless handheld telestration tool was developed to better address dynamic on-demand teaching requirements both intraoperatively during a procedure and postoperatively on a recorded surgical video. This study presents the usability results of a first-generation handheld wireless telestration platform.

METHODS

Hardware Design

A wireless handheld telestration device prototype, hereon referred to as the Pen, was designed and manufactured to enable the user (i.e., surgeon coach) to interact with the surgical display field during coaching activities in both intraoperative and postoperative settings. This prototype uses a proprietary AR platform.

Figure 1. Telestration Device

The Pen consists of two main parts: (1) a motion tracker mounted to (2) a 3-D printed controller. The motion tracker and the controller have separate charging systems and on/off buttons. The controller has three buttons with various functions, a trigger, and a Maryland grasper handle to create a more realistic user experience. The Pen weighs 152.76g.

Software Design

The four core functions of this video-based coaching platform are:

1. Free hand annotation;
2. Cursor navigation;
3. Overlay and manipulation of ghost (avatar) instruments, and;
4. Hand-held video feed navigation.

These functions may be completed on a live or recorded video feed. To achieve these core functions, the telestration software menu (Figure 2C) allows the user to choose from three interactive tools: a laser pointer for cursor navigation and annotation (Figure 2B), and two virtual avatar instruments for dynamic coaching and positioning instructions: one for laparoscopy (designed to resemble a Maryland Grasper) and one for open surgery (designed to resemble a needle driver) (Figure 2).

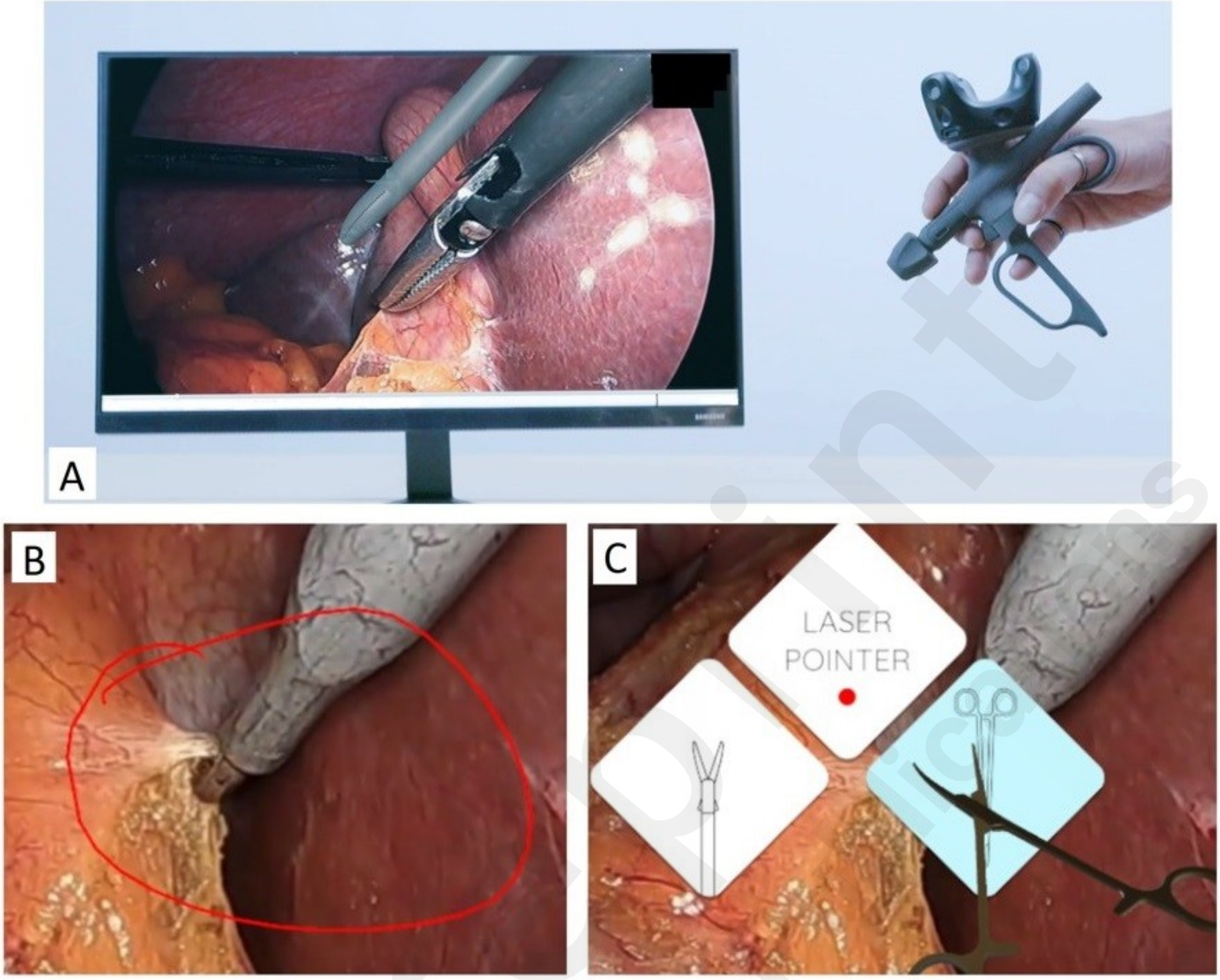

Figure 2. A) Telestration device used for video-based coaching; B) Annotation feature demonstration; C) Telestration software menu options.

System Platform Integration

The telestration platform integrates a legacy guidance and tracking system using: Vive (HTC Corporation, Xindian, New Taipei, Taiwan) and; SteamVR (Valve Corporation, Kirkland, Washington, United States).

The tracker unit is mounted onto the telestration Pen's hardware (Figure 1). The tracker has multiple diodes which detect the infrared signals emitted by the SteamVR lighthouse units. Lighthouse units are externally powered devices mounted at locations of high visibility around the physical space to detect and track the telestration device's movements by the user. The number of lighthouse units are determined by the size of the room where the telestration Pen is implemented. A total of 2 lighthouse units were placed 1.5 meters apart to achieve optimal performance as per manufacturer's instructions (Figure 3). The Steam VR system appears to designate one lighthouse as the primary source of data and another as a secondary source [16]. Figure 3 illustrates the room set up.

The orientation of the lighthouses in relation to the object being tracked is crucial to the accuracy of the system. The tracking accuracy is greatest with the Pen positioned orthogonal to it. The maximum distance between the lighthouse and the tracker is the maximum distance to work effectively is 7 meters [16].

Therefore, for this study, a total of 2 lighthouse units were placed 1.5 meters apart to achieve optimal performance as per manufacturer's instructions (Figure 3).

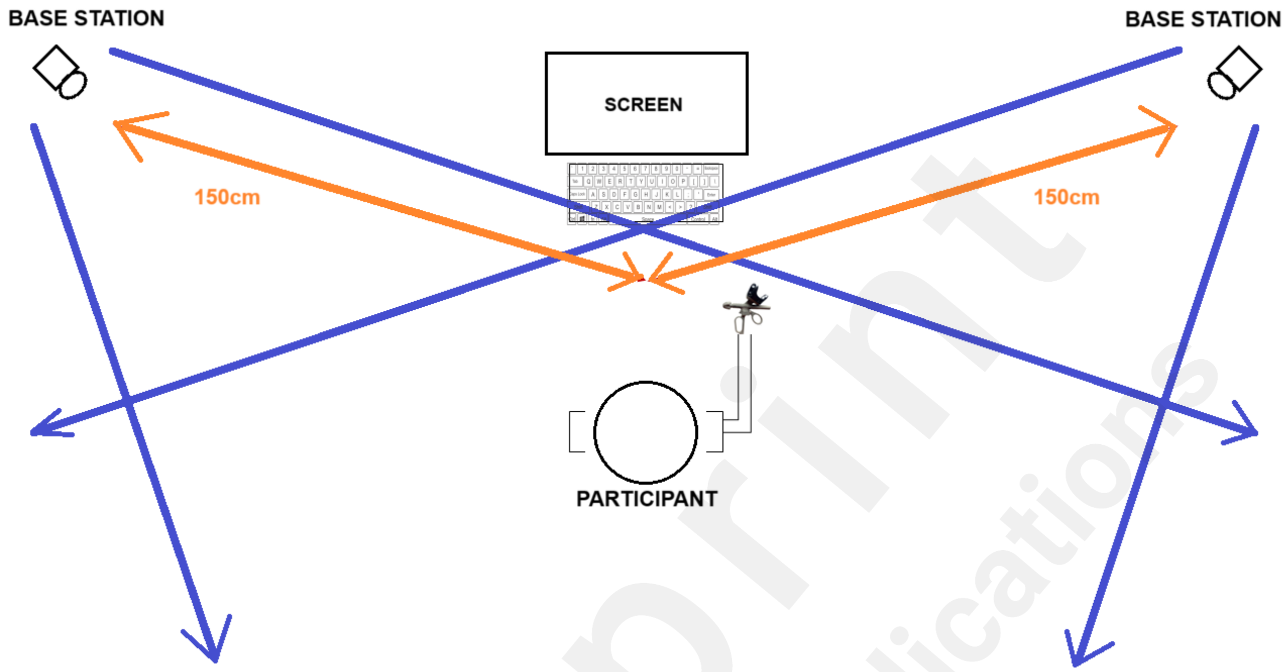

Figure 3. Usability Study Room Set-up
The lighthouse units ("base stations") emit infrared light which is detected by diodes present on the tracker and this information is converted to positional data by Steam VR software.

Usability Study Design

The International Organization of Standardization (ISO) defines usability as "the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [17]. Testing a device with end users is essential for a comprehensive evaluation of its usability. Therefore, the usability study was conducted in three phases (pre-survey, usability testing, post-survey) and included an informal debrief at the end of the session.

Participants

All physicians who play a role in surgical education were given the opportunity to participate. Participants were surgeons and surgical trainees recruited from a multi-cite academic teaching hospital in Toronto, Ontario, Canada. Informed consent was taken prior to the start of the study.

The study was approved by University Health Network's (UHN) Research Ethics Board.

Data Collection

Phase 1 (Pre-survey)

A short questionnaire was administered to gather baseline information regarding demographics and prior experience with VR and telestration technologies.

Phase 2 (Usability testing)

The functional capability of the telestration device was designed by surgeon educators based on the needs they noted in real world coaching situations. Scenarios were then prepared to evaluate the four core functions of the device in those situations. A study facilitator guided participants through the scenarios in a representative simulated environment. Examples of tasks include starting the device, menu selection, tool navigation and overlay, annotating and drawing, moving video playback/pause, and so on. A complete list of tasks is outlined in Table 1.

Phase 3 (Post-survey)

Participants completed the System Usability Scale (SUS) after testing was completed [18]. This scoring system compiles the responses from a series of 10 questions that cover topics including device complexity, ease of use, learning curve required, and user confidence [19]. In addition to this, a questionnaire was developed by the researchers to gather the attitudes and opinions of the participants on the usability, satisfaction, ergonomics, ease of task completion, confidence, and the perceived educational value of the device, using a 5-point Likert scale.

Procedure

Prior to start, the study room was set up as shown in Figure 3, the VIVE tracker was calibrated to the room using SteamVR. A member of the research team was the study facilitator. Participants began the session by completing the pre-survey (phase 1). Next, the participants were asked to hold the device like a laparoscopic grasper. The facilitator trained the participant on the functionality of the device and provided the participants with a quick tip sheet to reference during the usability test.

Participants were asked to select a video of a laparoscopic cholecystectomy that was provided for this study's purpose. Participants were then asked to calibrate the controller by following the instructions on the screen. Participants were first asked to use the telestration device while standing to emulate its use in an operating room, followed by a seated position for an office or boardroom setting. The facilitator guided the participant to complete tasks in Table 1, testing the four core functions of the device in a standing position and end the video on completion. Upon study completion, participants completed phase 3 of the study.

Table 1. Tasks for telestration function assessment.

Function	Instruction
Standard Tasks	
App Launch and Device Calibration	Participants were asked to start a pre-selected video displaying certain clips from a laparoscopic cholecystectomy
Play/Pause Video Feed	Participants were asked to play and pause the video at certain points throughout the session
Video Feed Navigation	
Fast Forward and Rewind	Participants were asked to fast forward and rewind the video to

	predetermined points of the video throughout the session
Overlay and Manipulation of Ghost Avatar Instrument	
Menu-Instrument Selection	Participants were asked to open the menu and select for either the laser pointer or the grasper multiple times throughout the session
Rotate Grasper Tip	Participants were asked to rotate the grasper tip
Open and Close Grasper Tip	Participants were asked to open and close the grasper tip
Freehand Annotation	
Annotation	Participants were asked to open and close the grasper tip
Erase Annotation	Participants were asked to annotate where they would perform a dissection at a specific moment of a procedure and to circle the cystic duct

Outcomes

Outcomes measured in the study were perceived usability, ergonomics, overall satisfaction, and the perceived educational value of the telestration device.

Data Analysis

Descriptive statistics were used, and qualitative variables were reported as frequencies and percentages.

The results of the SUS were analyzed according to the scoring procedure documented in Brooke (1995) [18]. A product with a SUS score greater than 70 is considered to have above average usability [19].

RESULTS

Phase 1 Demographics

A total of nine surgeons, and one senior resident (n=10) participated (males: 5; females: 5). The average age of participants was 36.4 years (SD 6) with a mean of 7 years of practice (SD 6.41). All participants reported being right-handed. The majority of participants (70%, 7 out of 10) reported no previous telestration system experience. Only one participant reported having received training with a surgical VR system prior to this study. Most participants (50%, 5 out of 10) reported not using VR and gaming consoles in the last 12 months (30% monthly, 3 out of 10; 20% rarely, 2 out of 10).

System Usability Scale (SUS)

The study average SUS was a 70 with a median of 75 (interquartile range [63-84]).

Overall Satisfaction

Participants were asked to rate their overall satisfaction using a 5-point Likert scale where 10% of participants (1 out of 10) were completely satisfied, 50% (5 out of 10) were very satisfied, 20% (2 out of 10) were moderately satisfied, and 20% (2 out of 10) slightly satisfied.

Ergonomics

When asked about the intuitiveness of the device, most participants agreed (A) or strongly agreed (SA) the device was intuitive (50%, 5 out of 10), 40% (4 out of 10) felt neutral (N), and 10% (1 out of 10) disagreed (D) or strongly disagreed (SD). Ergonomics was further assessed by asking participants to respond specifically regarding the Pen’s physical comfort (40% (4 out of 10) SA/A, 40% (4 out of 10) N, 20% (2 out of 10) D/SD), the weight of the Pen (60% (6 out of 10) SA/A, 40% (4 out of 10) D/SD), and the ability to use the physical features (buttons and trigger) (40% (4 out of 10) SA/A, 30% (3 out of 10) N, 30% (3 out of 10) D/SD).

Participants were also asked if they preferred completing the study tasks while in a seated or standing position. Four participants preferred to be seated, three preferred to be standing, and three had no preference at all. When asked about their confidence for completing the tasks correctly, 90% (9 out of 10) and 80% (8 out of 10) strongly agreed or agreed that they correctly completed the tasks seated and standing, respectively.

Open Ended Survey Responses

Participants were asked to discuss features of the Pen and telestration system that they felt were design strengths as well as areas of improvement (Table 2). Of the eight participants that responded, three participants reported the ability to annotate on the screen as a good feature of the device. Regarding areas for improvement, six participants indicated to have the location of the buttons moved.

Table 2. Open feedback responses from the participants regarding the virtual reality system.

What three things are good about the virtual reality system?	***What three things can be improved in the virtual reality system?***

Hands-on teaching, not invasive, may be widely used	Button placement, precision, ergonomics
It allows you to draw on the image on the screen, it allows you to demonstrate the orientation of instruments, it allows you to fast forward and rewind	The actual instrument itself (the weight of it, location of buttons), the directionality of fast forward/ rewind (to make it more intuitive), the function of the hand holds
Felt accurate in terms of location of pointer, intuitive to use, realistic feeling	Location of buttons
Great response time, useful for annotation, innovative	Calibration of pen not in line with pen, instrument heavy and hard to hold for small hands to reach the top buttons
teaching	Fulcrum on table
easy to use	Calibration, weight, function of finger loops
Ability to annotate, erase and select instruments	Ergonomics (handle is not needed), buttons are not easy to use, tracking sensor drift
Relatively easy to use after a short guidance, it is cool and innovative, less stressful	The [Pen] is a little uncomfortable, the pen is heavy, when sitting it is hard to see the animation for the Maryland

Post-survey satisfaction responses

Participants were asked to rate their level of agreement to statements on the standard tasks performed in the study (Table 3).

The majority of participants (60%, 6 out of 10) found the setup tasks (launching the video and device calibration) easy to complete, while 30% (3 out of 10)of participants found it difficult and 10% (1 out of 10) felt neutral. On the other hand, 90% (9 out of 10) of participants agreed that fast-forwarding and rewinding, as well as annotating, were easy, and 100% (10 out of 10) of participants agreed that erasing annotations was easy.

Table 3. Ease of use in completing tasks testing the device's various functions

Function	Agree or Strongly agree	Neutral	Disagree or Strongly disagree

Standard Tasks			
Difficulty Completing Initial Setup: Launch and Calibration	30%	10%	**60%**
Play/Pause Video Feed	**80%**	20%	0%
Video Feed Navigation			
Fast Forward and Rewind	**90%**	10%	0%
Overlay and Manipulation of Ghost Instrument			
Menu- Instrument Selection	**70%**	30%	0%
Rotate Grasper Tip	40%	**50%**	10%
Open and Close Grasper Tip	**70%**	20%	10%
Freehand Annotation			
Annotation	**90%**	0%	10%
Erase Annotation	**100%**	0%	0%

Confidence Levels (Pre versus Post Study Comparison)

Participants were asked to rate their confidence on the system features at baseline and post-study using a scale of 1 to 5, where 1 is not confident and 5 is very confident.

Set up and Training

Participants were also asked to rate their level of confidence on their technical ability to independently set up a VR or gaming system in the post study. The majority of participants (60%, 6 out of 10) rated their confidence for system set up a 4 out of 5, while 20% (2 out of 10) rated it a 5 out of 5, and another 20% (2 out of 10) rated it a 3 out of 5. In addition, the majority of participants felt that the system training completed by the facilitator was adequate (80%, 8 out of 10), with 20% (2 out of 10) of participants felt the training period was too short. Lastly, the majority rated the quality of the training provided for study purposes as (excellent 10%, 1 out of 10; very good 60% 6 out of 10; good 30%, 3 out of 10).

Navigation

The majority of participants reported a confidence rating of 4 at baseline for navigating accurately and realistically (confidence of 5: 10%, 1 out of 10; confidence of 4: 80%, 8 out of 10; confidence of 3: 10%, 1 out of 10), which then increased to a rating of 5 post-study (confidence of 5: 50%, 5 out of 10; confidence of 4: 40%, 4 out of 10; confidence of 3: 10%, 1 out of 10). No participant reported a confidence of 2 of less in either the pre-study or post-study.

Instrument Overlay

The greatest positive change (40% increase) between pre and post study in confidence rating was present for the overlay of the virtual tool. Confidence ratings for this category pre-study were (confidence of 5: 10%, 1 out of 10; confidence of 4: 40%, 4 out of 10; confidence of 3: 40%, 4 out of 10; confidence of 2: 0% 0 out of 10; confidence of 1: 10%, 1 out of 10), while post-study were (confidence of 5: 10%, 1 out of 10; confidence of 4: 80%, 8 out of 10; confidence of 3: 10%, 1 out of 10; confidence of 2: 0%, 0 out of 10; confidence of 1: 0%, 0 out of 10).

Annotations

Confidence level for performing annotations were highly rated both highly both pre (confidence of 5: 20%, 2 out of 10; confidence of 4: 70%, 7 out of 10; confidence of 3: 10%, 1 out of 10) and post study (confidence of 5: 40%, 4 out of 10; confidence of 4: 60%, 6 out of 10).

Video Feedback

Regarding video feed playback/pause reviewing functions, confidence levels remained unchanged pre to post study (confidence of 5: 30%, 3 out of 10; confidence of 4: 60%, 6 out of 10; confidence of 3: 10%, 1 out of 10).

Select and Change Tools

Lastly, while no participant felt very confident selecting or changing tools in the pre-study (confidence of 5: 0%, 0 out of 10; confidence of 4: 70%, 7 out of 10; confidence of 3: 30%, 3 out of 10), 30% of participants (3 out of 10) rated that they felt very confident to select or change tools in the post-study phase (confidence of 5: 30%, 3 out of 10; confidence of 4: 50%, 5 out of 10; confidence of 3: 20%, 2 out of 10). When participants were also asked their level of agreement about the ease of switching between virtual tools, 70% of participants (7 out of 10) strongly agreed or agreed that it was easy to do and 30% of participants (3 out of 10) felt neutral about it.

Educational Value

Participants were asked to rate the perceived educational value of the device using a 5-point Likert agreement scale. All participants agreed that they would use this device for post-operative coaching, while only 50% of participants (5 out of 10) agreed that they would use the device in an intraoperative setting. Additional questions were asked regarding the use for educational purposes described in Figure 4.

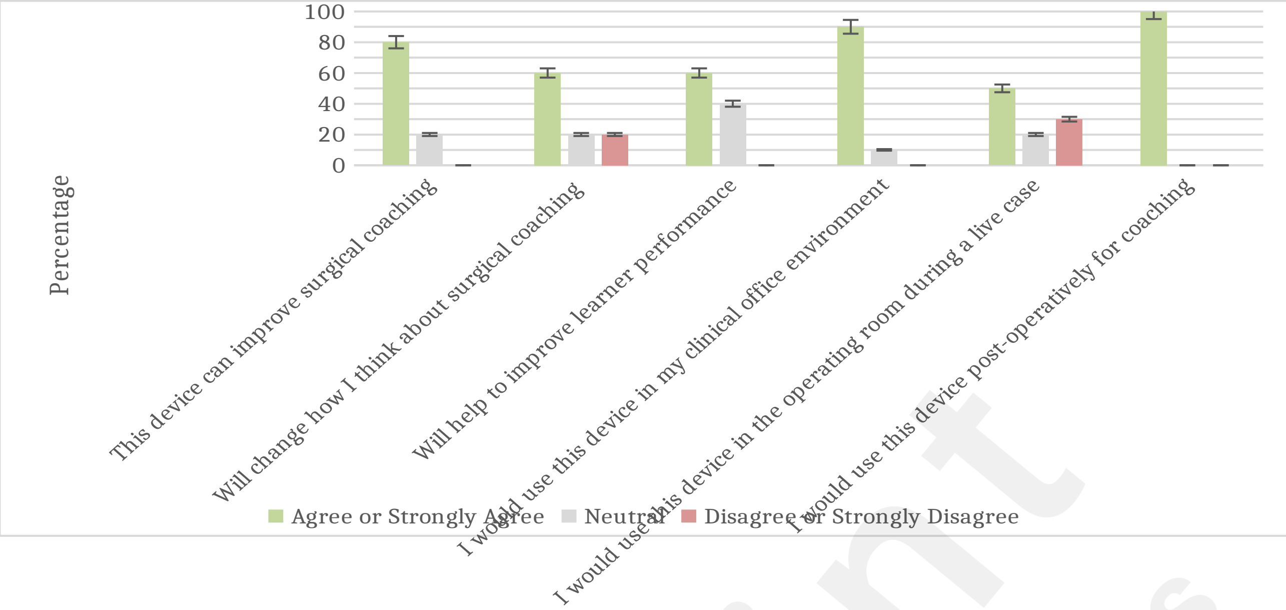

Figure 4. Participant agreement responses on perceived educational value

Technical Difficulties

Lastly, participants were asked to report on technical difficulties experienced while participating in the study. While 40% of participants (4 out of 10) reported experiencing a delay or lag with the device positioning, only 10% of participants (1 out of 10) reported experiencing difficulties loading the study video and 10% (1 out of 10) also noticed instructional text not displaying correctly. When participants were asked about the device's ability to track their hand movements accurately, 60% (6 out of 10) SA/A that it did and 40% of participants (4 out of 10) felt neutral about it.

DISCUSSION

A novel telestration device for surgical coaching was designed to enhance the surgeon coach and learner experience in the context of laparoscopic surgeries. This device enables a dynamic interaction with surgical display monitors with free-hand annotation function and live overlay of three-dimensional virtual laparoscopic tool avatars.

Previously described devices and systems for telementoring had usability challenges that this device aims to mitigate. This study aimed to evaluate the overall satisfaction and usability of the first-generation prototype telestration device for use in surgical coaching activities. In terms of demographics, our study had an equal distribution of women and men, which strengthens the validity of our results.

The use of evaluation tools such as SUS during the development and testing process of user interface applications is commonly recommended in the literature [7,11]. The SUS reported an average score of 70 with a median score of 75 (IQR [63-84]) indicating an above average usability rating in comparison to thousands of other devices and systems [19]**.** Also, 60% of participants (6 out of 10) were either completely or very satisfied with the device overall. This is an encouraging result of our first iteration prototype.

On the other hand, those that rated their overall satisfaction less than this, commented on the device's ergonomics, including the button placement, finger loops, and weight, as well as the device's precision and lagging experience. These comments on ergonomics are likely why participants had lower confidence in the post study to select or change tools compared to the other tasks. Additionally, while most users agreed that the device's weight was comfortable, only 40% (4 out of 10) felt the device's shape was physically comfortable to hold. Furthermore, 40% (4 out of 10) felt that the buttons were hard to reach; a theme that also emerged in the open feedback responses where one user commented "instrument … hard to hold for small hands to reach the top buttons". Comments were also made about the usefulness of the handle piece. While confidence levels of completing study tasks accurately were similar in either position, participants did prefer using the device while sitting. The ergonomic feedback is in line with the SUS scores reported. With ergonomics being a priority for surgeons, future iterations of this device will aim at improving these scores.

With regards to task completion, including video stream controls (play/pause), annotation, and tool avatar manipulation, was generally very positive; the majority of them were considered "easy" to complete. All tasks were completed successfully with the provided training even though participants had never interacted with the device prior to this study. In addition, many of the participants did not experience any technical difficulties performing all the tasks – no major bugs were identified in this study. Only 40% participants reported experiencing a lag during the usability testing period, and the time required to complete a task was comparable to that of the study facilitator (trainer). Therefore, in future iterations of the device and software, addressing the lag experienced by users is of importance.

With regards to task completion, including video stream controls (play/pause), annotation, and tool avatar manipulation, was generally very positive; the majority of them were considered "easy" to complete. All tasks were completed successfully with the provided training even though participants had never interacted with the device prior to this study. In addition, the majority of the participants did not experience any technical difficulties performing all of the tasks listed in Table 1, as only 40%

participants (4 out of 10) reported experiencing a lag during the usability testing period, and the time required to complete a task was comparable to that of the study facilitator (trainer). Therefore, in future iterations of the device and software, addressing the lag experienced by users is of importance.

Furthermore, participants found the majority of tasks easy to complete, most notably video manipulation (pause/play at 80%, 8 out of 10; and fast-forward/rewind at 90%, 9 out of 10) and annotation (draw at 90%, 9 out of 10; and erase at 100%, 10 out of 10). Overall, with regards to task completion, this device demonstrates an acceptable level of usability; all tasks were completed successfully, and the majority of them were considered easy to complete.

In analyzing the open feedback responses, participants used language including “easy to use”, “great response time”, “accurate”, “intuitive”, and “realistic” to describe the device when given the opportunity to provide open and anonymous feedback. This positive feedback is highly encouraging and highlights important themes relevant to usability including an acceptable level of complexity and realistic experience.

Lastly, participants evaluated the perceived educational value of the device with an overwhelming majority (80%, 8 out of 10) of users agreeing that this device can improve surgical coaching especially in the post-operative setting (100%, 10 out of 10). However, only 50% of participants agreed that they would use the device live in an operating room, a main setting in which we intended this device to be used. Thus, participant hesitancy is an important goal of future usability assessments of the telestration device and perhaps would be better understood with testing in an operating room.

Study Limitations

While a sample size of four to five participants in usability studies is usually adequate in detecting 80% of system issues, a limitation of our study was its smaller sample size [20]. Another limitation of our study was that the participants were asked about their thoughts on the usability of the device in different settings, specifically intraoperatively. As the study was conducted within an office setting and not within the operating room, it limits the applicability of the answers to being a preliminary thought rather than an actual observation in the asked about scenario.

Future Considerations

Overall, the results of this first iteration study indicate our novel telestration device has a strong degree of usability, general user satisfaction, and potential with regards to surgical skills coaching. Therefore, we have determined the prototype to have met a satisfactory threshold to merit further development and refinement.

Further improvements will focus on ergonomics with effort dedicated to making the device lighter and relocating the buttons to a more accessible location. Based on participant input, future iterations should also investigate either adding functionality to the device’s handle or potentially removing it altogether. This would address the majority of constructive criticisms from users. From the software perspective, improvements of priority include refinements in the software to allow for a more simplified application launch and calibration as this was the main task of difficulty for our participants.

Future studies should evaluate the educational value of the device in the operating room setting and further evaluate its effectiveness in enhancing surgeon coach and trainee experience.

CONCLUSION

In conclusion, preliminary usability testing of a prototype telestration device for surgical coaching has demonstrated above average usability and positive feedback regarding the perceived educational value and task completion. Future improvements should focus on ergonomics and design, namely weight and button location, as well as application launch and calibration. Next steps following usability testing can include the assessment of the educational value of the telestration device.

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Supplementary Files

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Figures

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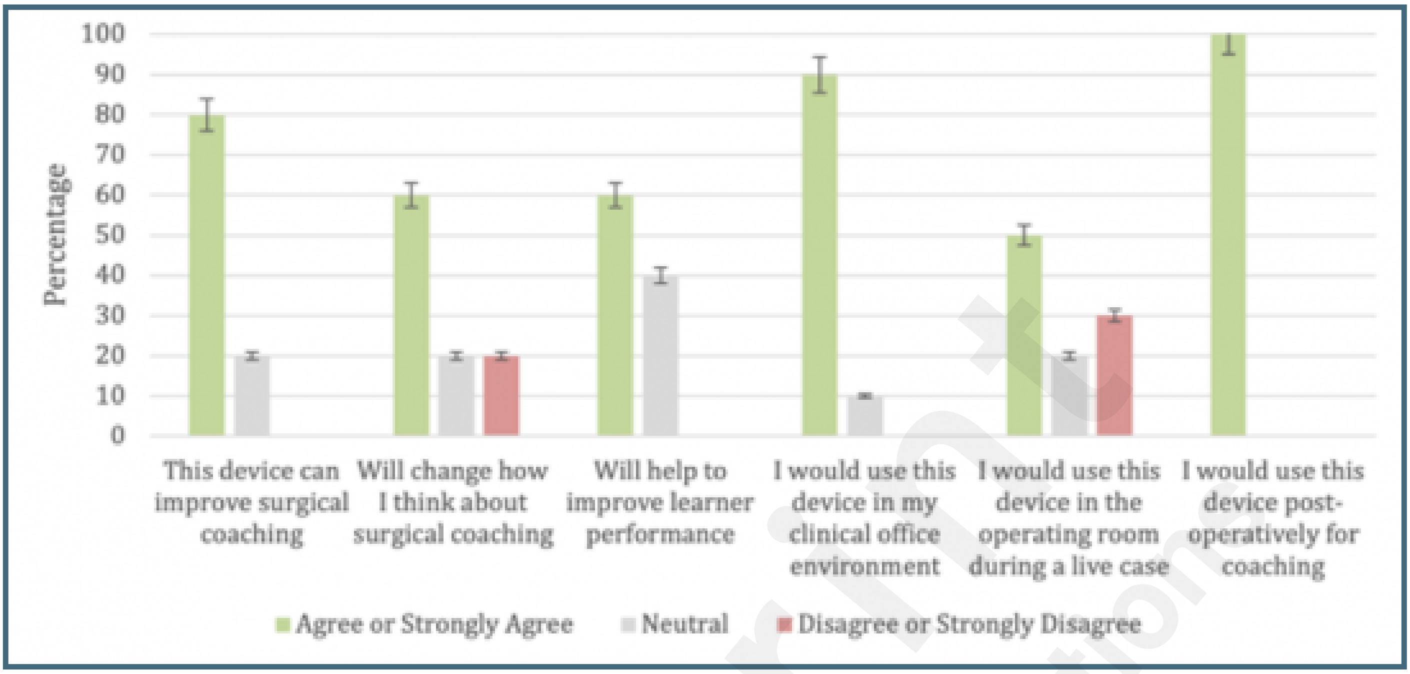
100
90
80
70
60
50
40
30
20
10
0
Percentage
This device can improve surgical coaching
Will change how I think about surgical coaching
Will help to improve learner performance
I would use this device in my clinical office environment
I would use this device in the operating room during a live case
I would use this device post-operatively for coaching
Agree or Strongly Agree
Neutral
Disagree or Strongly Disagree

Multimedia Appendixes

Untitled.
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