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Research article

Assessment of students' satisfaction with virtual robotic surgery training

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ABSTRACT

Objective: Nowadays, in Bulgaria there is a trend of increasing entry into the surgical field of robot-assisted surgery operations, which suggests a need for the establishment of a large number of specialists in this field in a short period. Based on these arguments, the Medical University of Varna was the first university in the country to introduce a robotic surgery training program for medical students. The study aims to investigate the medical students' satisfaction on robotic surgery training provided at Medical University of Varna with da Vinci Skills Simulator.
Design: During the summer semester of the academic 2020/2021 and 2021/2022 years, a pilot training of robotic surgery was conducted with 5th year students in Medicine. Within one month, the students had the opportunity to get acquainted with the simulator of da Vinci Xi robotic system. The training was divided into two modules: a two-week theoretical module and a two-week practical module. After completing the training, students filled out a questionnaire dedicated to assess their satisfaction with the proposed training. Correlation between their responses and the objective parameters assessed on the simulator was calculated.
Results: Thirty participants (16 men and 14 women) shared their opinion on easiness of use and usefulness of the robotic simulator in training of surgery activities. Students' responses highly evaluated both aspects with average five-point Likert scale scores of 4.3 and 4.5, respectively. 93% of the participants would continue their further education and training in robotic surgery field. In addition, there was no correlation between objective evaluation by the simulator and students responses.
Conclusions: Training in robotic surgery proves to be a useful approach for training students to develop skills and profession in the field of surgery. The results suggest that training in this field may be accomplished even at the student level, by exploiting the robotic surgery in realistic scenario and thus, in a timely manner to find out the surgical direction they want to be further evolved.

1. Introduction

The continuous development and improvement of medical surgery simulators during the last two decades and the consequences of Covid-19 crisis have imposed the necessity to use the simulation in the training of medical students, clinicians and the maintenance of

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patient safety [1-4]. On the other hand, the increased number of surgery robots and therefore robotic procedures results in an increased need for training, moreover, there are different skill requirements between open, laparoscopic and robotic surgery [5,6]. Nowadays, surgery trainees have the option to perform training in surgery skills within a short time period due to the above limitations and such related to training time and non-availability of facilities and trainers [7,8]. Thus, medical simulators became important in respect to issues such as risks and patients' safety, operating costs, residents working time regulations, specific and rare cases, long learning curves, and at the same time they also provide useful feedback and objective evaluation [8-13].

The use of virtual reality (VR) education and training against the traditional methods shows that knowledge improvement may be relatively small, while the technical skills are significantly mastered especially in practicing of new surgical technique [3,14]. Tergas *et al* [9] compared the use of two medical simulators – VR simulator and dry laboratory simulator platform for gynaecology surgery training, as both were found to improve the students' robotic technical skills. The VR simulator provided realism in instruments' movement and interaction depth perception with 58% of the participants preferring the VR simulator.

The results of a recent survey showed that although the robotic surgery training is considered important for the medical students [15], the majority of them did not had access to robotic surgery training in their hospital [16]. Trainees and residents still enter clinical robotic surgery practice without the necessary robotic skills and without having previous formal training on robotic surgery platform [6,15]. Often, residents participation is limited to observing role only [15,17]. These studies also reported that majority of the participants considered necessity of formal robotic surgery training and this training to be performed regularly - either monthly or every few months. Other studies showed that robotic simulators are effective training tools for junior trainees [18,19], which suggest possibility for the development of an institutional curriculum [6,20].

Skills acquisition is now related to the possibility to provide as early as possible robotic experience [5,17] within a relevant formal curriculum on robotic surgery training and to deliver appropriate documentation of the training quality and participants achievements [6,15–17]. One of the main conclusion drawn from studies is that training on simulators in isolation from traditional teaching methods contributes to the skills training of the surgeon, however the best time and place to use these skills comes only with experience [1]. Studies that provide conclusions on the attitude and the satisfaction of the participants from the training on da Vinci Skills Simulator are rare, which is our motivation to investigate this issue by studying the students' satisfaction on robotic surgery simulator training provided at Medical University of Varna.

2. Materials and methods

Medical University of Varna is the first university in Bulgaria to include robotic surgery training within the mandatory hospital practice for students in Medicine from 3rd to 6th year as well as to develop a dedicated and more advanced elective course "Introduction to Robotic Surgery". A pilot training programme was launched for the 5th year medical students during the summer semester of 2020/2021. For a period of one month the students were involved in a robotic training, divided in two modules: a fortnight of theoretical study and a fortnight of practice with da Vinci Skill Simulator.

Main training activities were the following: a) camera targeting – camera positioning towards a marker as the camera movement is a very specific task in the robotic surgery; b) sea spikes game – working with robotic arms positioned in a way impossible for human hands; c) thread the rings – sewing under all angles without limitation and d) needle targeting – handling the needle and positioning at the target. Screenshot examples from two exercises: with the camera targeting and the sea spice game are shown in Fig. 1.

For the purposes of evaluating the attitude and the satisfaction of the participants from the training, a questionnaire was developed by the surgery team from the Department of General and Operative Surgery. The questionnaire is composed of four sections as described in Table 1 and was provided to all students at the end of the training course, as their answering was voluntary. Ethical approval for the study was obtained from the Ethical Review Committee at MU-Varna.

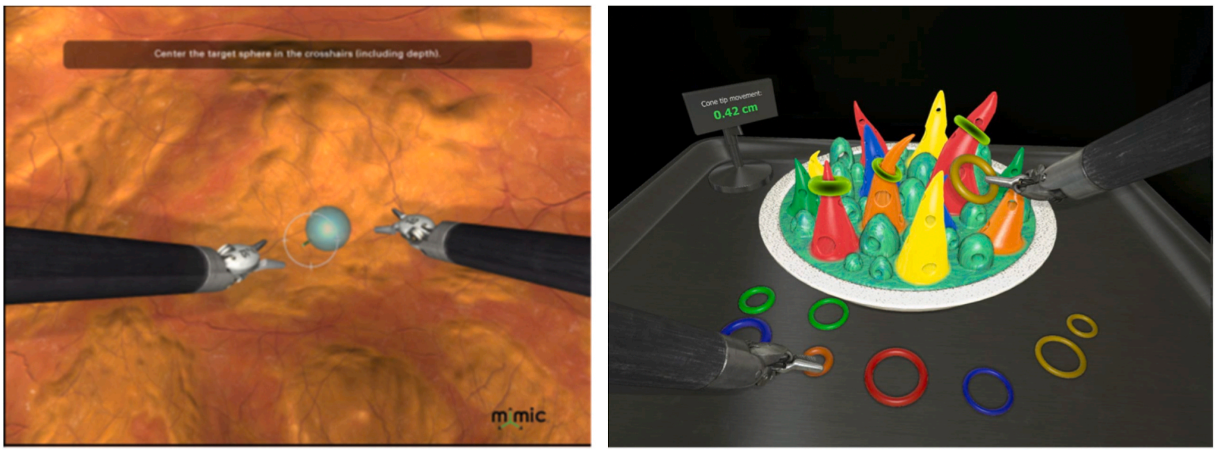


Fig. 1. Exercise related to the camera targeting and sea spice game.

The total number of questions was 13. Specifically, there was a single question whether the participant had previous experience with VR robotic surgery simulators. The next 11 questions were divided into two sections: six questions concerned the *Ease of Use* of the simulator while the rest five concerned the *Usefulness* of the training with answers such as strongly disagree, disagree, neither agree nor disagree, agree and strongly agree. These answers were then converted to numbers from 1 to 5 according to the five-point Likert scale for better numerical representation and comparison. Finally, there was performance self-assessment with a scale from 1 to 10.

Students' performance in terms of procedural time and economy of movement as well as the scores for the training activities was also objectively analyzed by the simulator itself. Further, the correlation between the objective evaluation delivered by the simulator and the questionnaire scores provided by the students was calculated by Pearson correlation coefficient.

3. Results

3.1. Participants

Two training courses were realized, one in the summer semester of 2020/2021 academic year and one in 2021/2022. Each course length was 1 month. The students who participated in the study were 30. The cohort included 14 women (47%) and 16 men (53%). The median age of the students was 23 (range 22–27). Only four students (13%) have reported previous experience with medical simulators, however these were VR laparoscopic simulators.

3.2. Results from questionnaire analysis

Fig. 2a shows the results for the *Ease of Use* group of questions. As seen from this figure most of the students considered da Vinci Skills Simulator easy to use as 14 students (47%) strongly agreed and 15 students (50%) agreed on this statement, while only 1 student replied that neither agree nor disagree. Same results are shown for the perception about easiness of manipulation of the robotic simulator tools with 97% of participants to agree on this issue and the rest (corresponding to one student) to disagree.

Further, twenty-nine students agreed that the provided visualization was comfortable, while there was one student (3%) who neither agreed nor disagreed on this issue. The results obtained on evaluating whether mastering of the robotic surgery technique using the simulator was intuitive and easy to understand indicated 28 (93%) students either strongly agreed or agreed, 1 student neither agreed not disagreed and 1 student disagreed. The Camera use was difficult for five students (17%), while 25 of them found the use of Camera easy. Finally, one student disagreed on easiness of operation field perception, two of them did not have opinion, while 90% of the participants agreed or strongly disagreed on the easiness of this issue. The average score for the six statements in the *Ease of Use* group, based on the five-point Likert scale was 4.3. Fig. 2b reflects the answers of the students with previous experience with VR simulators. The results reveal similarity to these shown in Fig. 2a.

Fig. 3a shows the results for the *Usefulness* group of questions. Most of the students (90%) either strongly agreed or agreed that the simulation platform is a useful tool to evaluate execution of the robotic surgery procedures. More than half of them think that their performance was properly evaluated by the simulator platform. 26 students (87%) strongly agreed and 4 students (13%) agreed on the statement "VR simulators are with practical application in robotic surgery training". All students agreed that the simulation platform is suitable for teaching students, while 93% of them intend to continue their development with robotic surgery.

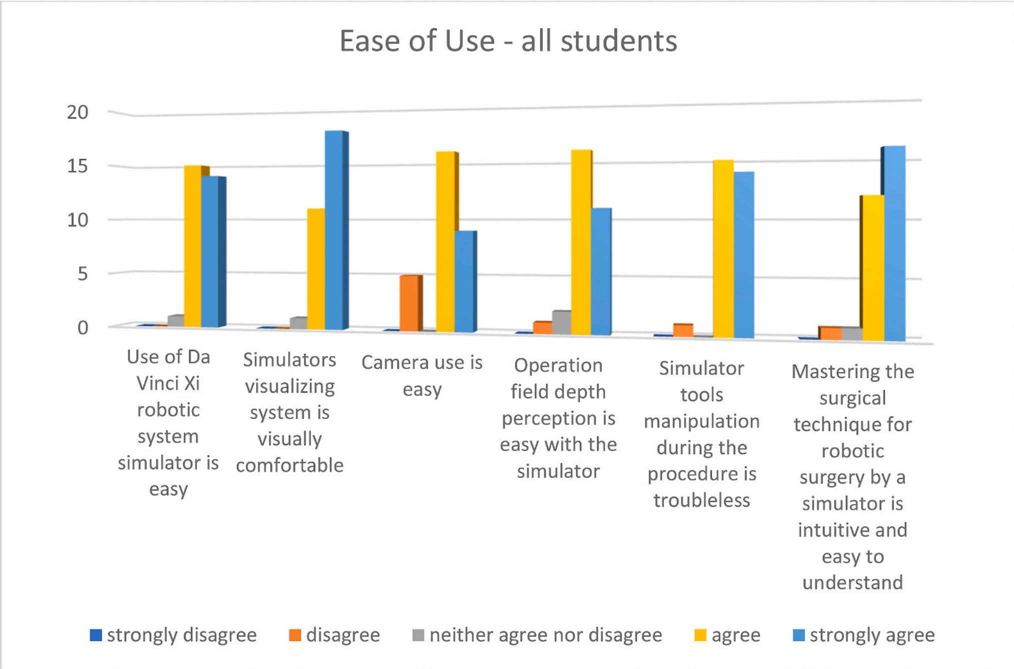
The average score, given in a five-point Likert scale, for the five statements of the *Usefulness* group was 4.5.

Fig. 3b summarises the results for the four students with previous experience with VR simulators. Their experience was limited to laparoscopy surgery simulators. In general, results coincide with these, shown in Fig. 3a, with major deviation for the objective evaluation performed by the medical simulator.

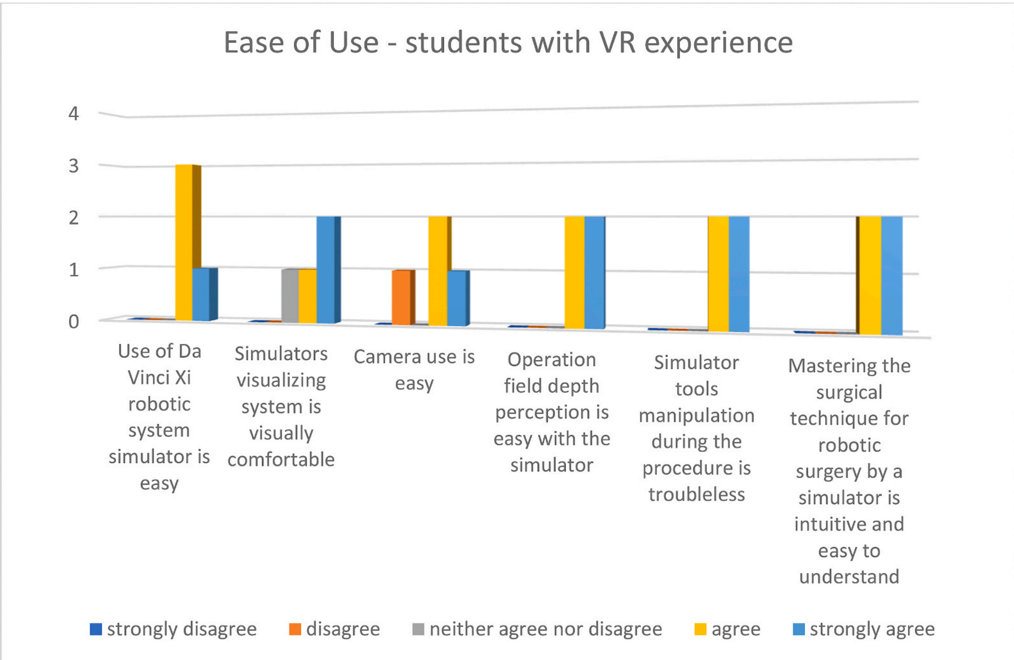
Finally, Fig. 4a shows the self-evaluation of the participants for the completed robotic tasks, based on a scale from 1 to 10. As seen, the majority of the students (83%) evaluated themselves from 7 to 10. The results for the students with VR experience are summarised

Table 1
Questionnaire, developed by the Department of Surgery.

A. Previous VR simulator experience
Do you have previous experience with another type of robotic surgery VR simulator?
B. Ease of Use
Use of da Vinci Xi robotic system simulator is easy.
Simulators visualizing system is visually comfortable.
Camera use is easy.
Operation field depth perception is easy with the simulator.
Simulator tools manipulation during the procedure is troubleless.
Mastering the surgical technique for robotic surgery by a simulator is intuitive and easy to understand.
C. Usefulness
The simulation platform accurately assesses my skills and competence in performing robotic procedures.
The simulation platform is suitable for teaching students.
The simulation platform is a useful tool for evaluating the execution of the robotic surgical procedures.
VR simulators are with practical application in robotic surgery training.
Training through the virtual reality simulator in robotic surgery strengthened and deepened my desire to work in robotic surgery.
D. Self-evaluation
Evaluate your performance on 1-to-10 scale.



(a)



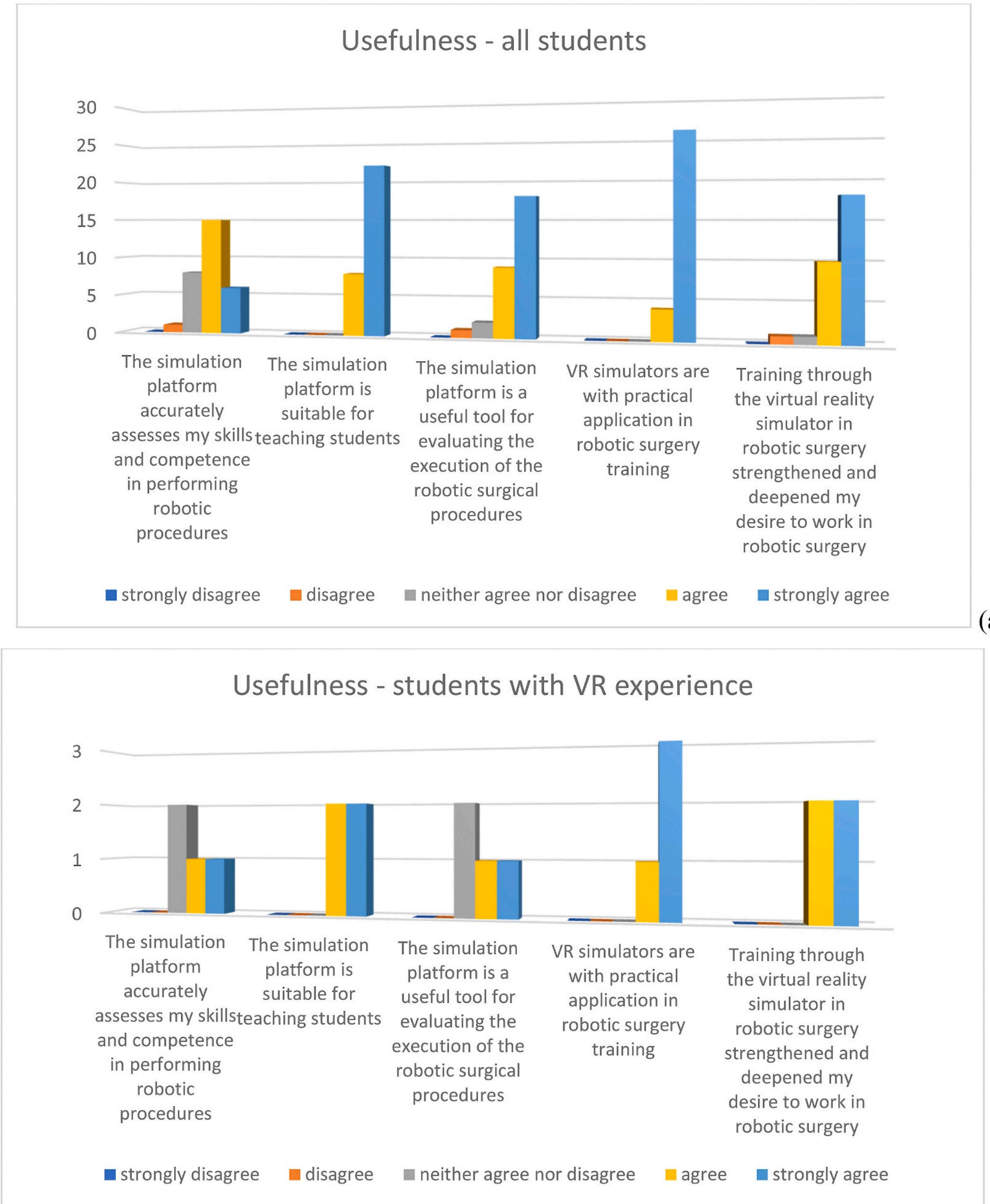
(b)

Fig. 2. Summarised results from the Ease of Use section of the questionarie (a) for all students and (b) for those with previous VR simulator experience (b). The ordinate axis shows the number of students.

in Fig. 4b.

The objective metrics, assessed by the simulator were performance time data (seconds), economy of motion (cm) and additionally evaluation points assigned by the simulator are shown in Table 2. In the same table, the average platform's assessment for the training activities are summarised.

The results in Table 2 reveals continuous improvement in all parameters performance time, economy of motion and hence evaluation points. Further, no correlation was found between the objective evaluation, assigned by the simulator and the score, given by the students on *Ease of Use*, *Usefulness* and the *Self-evaluation*. In particular, the correlation between *Ease of use* and the objective



(a)

(b)

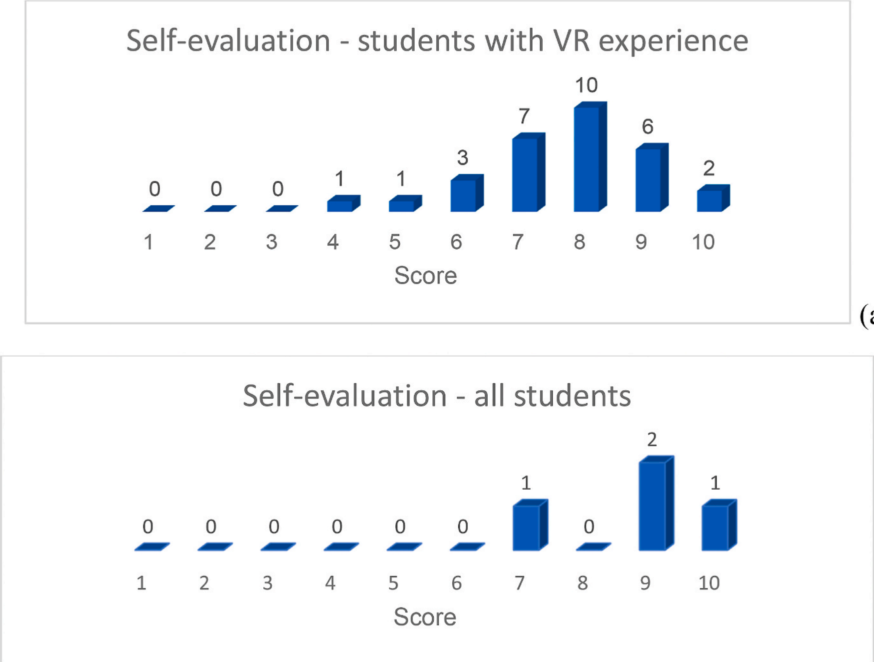
Fig. 3. Summarised results from the Usefulness of the robotic training section of the questionarie for (a) for all students and (b) for those with previous VR simulator experience (b). The ordinate axis shows the number of students.

evaluation was 0.43, while the corresponding correlation for *Usefulness* and *Self-evaluation* was 0.22 and 0.32, respectively. Finally, we calculated the correlation taking in account only the scores from the fifth attempt, however the received values were even smaller than the mentioned above.

Table 3 summarises the results of the two groups: with and without VR experience. Mann-Whitney *U* test showed no significant difference between both groups.

4. Discussion

Medical robotic surgery simulators, such as da Vinci Skills Simulator, are excellent tools and must be effectively exploited in training of medical students and residents, especially in situation, characterised as pandemic. Amongst the advantages of da Vinci Skills Simulator is that this simulator works in synchronisation with the surgical console, used by the clinicians to perform operative



(a)

(b)

Fig. 4. Summarised results from the self-evaluation of the participants (a) for all students and (b) for those with previous VR simulator experience (b).

Table 2
Students performance results.

	attempt 1	attempt 2	attempt 3	attempt 4	attempt 5
camera targeting	28.6 ± 26.7	54.8 ± 21.2	64.6 ± 20.6	67.3 ± 15.6	72.2 ± 15.1
sea spikes	45.4 ± 31.7	65.3 ± 25.2	77.5 ± 15.3	83.1 ± 10.1	88.5 ± 9.5
thread the rings	28.4 ± 27.4	48.6 ± 26.9	59.1 ± 18.6	65.4 ± 16.4	71.2 ± 14.9
needle targeting	36.5 ± 34.0	66.7 ± 23.9	79.7 ± 18.1	85.2 ± 14.0	85.7 ± 11.6
performance time, s	300.0 ± 136.9	202.6 ± 100.3	161.5 ± 73.8	137.7 ± 48.3	124.9 ± 46.6
economy of motion, cm	422.2 ± 175.8	330.7 ± 142.5	283.6 ± 120.5	261.3 ± 81.4	247.8 ± 69.7
points	32.6 ± 20.6	54.7 ± 15.8	68.2 ± 14.1	74.6 ± 11.2	79.1 ± 9.3

Table 3
Students points results.

	attempt 1	attempt 2	attempt 3	attempt 4	attempt 5
without previous VR experience	31.5 ± 21.1	55.3 ± 16.3	67.7 ± 14.8	75.2 ± 10.9	79.1 ± 9.7
with previous VR experience	39.9 ± 17.8	50.7 ± 13.4	71.2 ± 8.4	70.9 ± 13.7	79.5 ± 7.1

interventions.

In overall, this study showed that the VR simulator can be used as a tool to assess robotic surgery skills [21]. The participants have the opportunity not only to build, but also to upgrade their skills in robotic surgery. Each participant within five sessions of the training, managed to almost double the time for the execution of their individual procedures.

This study showed that the use of da Vinci Skills Simulator was easy and comfortable for the majority of the students. Tools and depth perception were highly assessed by the majority of the students, while only a small number of them disagree with this statement. The total number of "strongly agree" and "agree" on these six statements was 167, corresponding to 93% of the possible answers and presents the satisfaction of the students on the *Ease of Use*. This result is also well supported by the calculated average score, showing a result of 4.3. Further, our results well coincide with the results of the survey provided by Hertz et al. [22]. Results on their questionnaire related to easy to use, adequate optics, depth perception, instrument movements, fulcrum effect and realism of da Vinci Skills Simulator has received a score of 4.53 on average using the five-point Likert scale. However, results showed that participants make slower progress in *Camera targeting* and *Thread the Rings*. As some of them share in the survey, the camera of the robotic system was not easy to work with. Camera control is very specific and is different from any other simulator tools, non-robotic surgery practice and virtual reality computer games used by young people. Slower improvement rate in *Thread the Rings* may be due to the fact that the master controllers on the surgical console provide needle manipulation capabilities beyond that of the human hand. For this reason, the participant needs more experience to master all possible sewing and tying trajectories.

The participants in this study found the simulator training useful for training and evaluation of the training performance. The overall score for this group of statements was 4.5, indicating that students consider the robotic simulator da Vinci Skills Simulator useful for robotic surgery training and skills evaluation. These results are also well supported by the findings from the survey of Hertz et al. [22], specifically the evaluation of the questionnaire related to accurate assessment, relevancy, usefulness in practice, usefulness in training, performance assessment and role in training. The authors reported that the average questionnaire score for da Vinci Skills Simulator was 4.62 on average.

The training also showed that 93% of the trainees strengthened their intention for further development in the area of robotic surgery. This correlates with the average participants' result from the simulator, where most of the participants manage to reach an average score of around 80 points, which is within the competence level. The evaluated score for this statement was 4.5, which can also be considered compatible to the score of 4.8 received by Lee et al. [7] obtained by evaluating the question about development of trainees' interest in the skills. It should be noted, however, that the survey of Lee et al. was on training that had begun on simulator but continued on cadaveric models.

Self-evaluation shown in Fig. 4a, indicates that majority of the students evaluated their performance as very good and excellent. The only "disagree" on the statement whether this training strengthen the intention to work further in the field of the robotic surgery originated from the same student whose self-evaluation was 4. It may be suggested that the low self-evaluation on performed tasks that brought certain disappointment and distancing of this student from the robotic surgery. Self-evaluation of students with VR simulator experience shown in Fig. 4b is higher, than self-evaluation of all students, although it is not statistically significant.

This study showed that there is no correlation between the objective evaluation by the simulator and the score, given by the students on *Ease of Use*, *Usefulness* and *Self-evaluation*. Similar conclusions are drawn by the study of Uemura et al. [23], who researched the relation between objective evaluation and cognition analysis and found no significant correlation. Further, the study did not find a statistically significant difference between the students with experience on another type of simulator (laparoscopic) and these without experience. The simulator can be recommended to students and residents with experience from non-robotic simulators. The student with experience in this study had training on laparoscopic simulator, where methods and tools are different from these in the robotic simulator, for instance the use of laparoscopic instrument versus the robotic arms.

This study convincingly showed that majority of the students agree on the use of simulators for robotic surgery training. Other studies, such as Farivar et al. [15] revealed that 52% of participants would definitely like to receive formal training. However, this result is obtained from a web-based survey with no details about the VR simulators used by the participants. Fleming et al. [16] published a survey based on a questionnaire sent using mailing lists and reported that majority of the participants (77.2%) considered necessity of formal robotic surgery training and this training to be done either monthly (25.8%) or every few months (29.9%).

Evidence data to introduce a standardized protocol for robotic surgery training in Bulgaria was published in 2006 by the consensus of the Association of American Gastroenterologists and Endoscopic Surgeons (SAGES) and the Association of Minimally Invasive Robotic Surgery (MIRA) [24]. They published a consensus document that includes a standardized training program for robotic surgery. It represents a combined approach using didactic methods and practical exercises on a simulator. According to both organizations, surgical simulators can play an increasingly important role in minimally invasive surgery training. A rating scale for the competence of the medical decisions taken and a technical assessment of the skills are validated. Validated measures of competence, including medical decision-making and assessment of technical skills, are also encouraged when available.

Surgery operations represent a complex multidisciplinary activity and teamwork. Both, the surgical technique and the stages of preliminary preparation of the team and the patient are important. Therefore, training in robotic surgery should not be solely focused on the surgical technique, but also on the theoretical and practical preparation for the stages before the surgery itself. A study by Guzo and Gonzalgo [25] described three stages in preparation for robot-assisted surgery: the preclinical phase, the first assistant phase, and the console surgeon phase. This represents a relatively long process, within which the novice surgeon has the opportunity to train his skills only on the simulator. Simulation is particularly useful for the preclinical phase and the console surgeon phase. The role of the first assistant of robotic operations consists of comprehensive preparation of robotic tools, their adjustment and commissioning. The simulator gives to the novice knowledge and skills how to coordinate the work with his hands and feet. Thanks to the surgical simulators, this extremely multi-layered training period could perfectly be complemented by a similar type of simulators.

Key limitation of this study was the small number of participants, which is due mainly to the COVID period, since students are organised in smaller groups. In addition, this elective course is organised during the summer semester, and taking into account the small group size, the course was repeated twice. Another limitation is the cohort homogeneity. This course is elective and depends on the background of the students who apply for the course.

5. Conclusions

This study evaluated the satisfaction of the medical students trained at da Vinci Skills Simulator. The study showed that the training at this simulator in advance before the real surgery practice will be useful for medical students. Moreover, the surgery is nowadays expanding in different directions, such as laparoscopy, open and robotic. Students found the VR robotic simulator easy to train on and considered it useful for their education and training. The average scores on a five-point Likert scale were 4.3 on easiness to use and 4.5 on usability and effectiveness. The robotic surgery VR simulator course strengthen students' intention to work with surgery robots. Decision to launch formal robotic surgery training as elective course in the curriculum will be beneficial for students and it was well accepted by them.

Ethical issues

The study “The application of virtual reality simulators in the training of laparoscopic surgery” was accepted by the Ethics Committee of the Medical University of Varna with a protocol № 98/26.11.2020. This study was supplemented by “Application of virtual reality simulators in the training of robotic surgery”, approved by the Ethics Committee of the Medical University of Varna with a protocol № 108/25.11.2021.

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