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Relationship between learning styles and simulation in surgery

Relação entre os estilos de aprendizagem e simulação em cirurgia

Fernando Henrique de Oliveira Mauro[1] fernandohmauro@gmail.com
Rogerio de Fraga[1] rogeriodefraga@gmail.com
Flavio Daniel Saavedra Tomasich[1] flavio@iop.com.br
Carla Simone da Silva[1] carlasimone@erastogaertner.com.br
Jose Henrique Agner Ribeiro[1] jose.agner.ribeiro@gmail.com
João Lucas Aleixes Sampaio Rocha[1] joaolucasasr@gmail.com

ABSTRACT

Introduction: It was found that the good performance in conventional techniques was not transferable to minimally-invasive alternatives, and then simulators were created for improved learning.

Objective: To assess whether robotic virtual reality simulation conditions ability for laparoscopy in medical students, associating the VARK tool and Mind Styles to determine whether there is a correlation between learning styles and the ability to develop these skills.

Methods: Randomization of 3 groups of medical students was performed, where one of the groups performed a simulation of a surgical knot exercise in the laparoscopy box and another, the same exercise on the robot console. The third group did not simulate. All participants took a practical test in the laparoscopy box and their performances were evaluated. Moreover, a pre-test and a post-test were applied, in addition to the VARK and mind styles methods, to assess whether there was a difference in performance between the different learning styles.

Results: The practical test scores were relatively homogeneous between the groups and between the Mind Styles and VARK categories, with no significant difference being found between the groups; therefore, it was not possible to demonstrate that learning styles interfered with the results of this study. There was only a significant difference between the pre-test scores of at least one pair of the groups and between the Laparoscopy and Robotics groups, with a p-value of 0.038.

Conclusion: There was no statistical significance between learning styles and performance regarding the proposed tasks.

Keywords: Virtual reality. Robotic Surgical Procedures. Simulation Training. Teaching.

RESUMO

Introdução: *Constatou-se que o bom desempenho em técnicas convencionais não se transferia para as minimamente invasivas, e, com isso, foram criados os simuladores para melhor aprendizado.*

Objetivo: *Este estudo teve como objetivo avaliar se a simulação em realidade virtual robótica promove habilidade para laparoscopia em acadêmicos de Medicina, associando a ferramenta VARK e o mind styles (GSD) para determinar se há correlação dos estilos de aprendizagem com a capacidade de desenvolver essas habilidades.*

Método: *Realizou-se randomização de três grupos de acadêmicos de Medicina, em que um dos grupos fez simulação de um exercício de nó cirúrgico na caixa de laparoscopia (CL), e outro, o mesmo exercício no console do robô. O terceiro grupo não participou da simulção. Todos os participantes fizeram um teste prático na CL, e as performances deles foram avaliadas. Ademais, foram aplicados um pré-teste e um pós-teste, além do formulário VARK e GSD, para avaliar se havia diferença de performance entre os diferentes estilos de aprendizagem.*

Resultado: *As notas das provas práticas foram relativamente homogêneas entre grupos e entre as categorias de Mind Styles e do VARK. Como não se encontrou diferença significativa entre os grupos, não foi possível demonstrar que os estilos de aprendizagem interferiram nos resultados deste estudo. Houve apenas diferença significativa entre as notas do pré-teste de pelo menos um par de grupos e entre os grupos laparoscopia e robótica com p-valor 0,038.*

Conclusão: *Não houve significância estatística entre os estilos de aprendizagem e o desempenho nas tarefas propostas.*

Palavras-chave: *Realidade Virtual; Procedimentos Cirúrgicos Robóticos; Treinamento com Simulação; Ensino.*

[1] Universidade Federal do Paraná, Curitiba, Paraná, Brazil.

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INTRODUCTION

Virtual reality in surgery

When first introduced, laparoscopic surgery was associated with many complications. The surgeons, experts in their fields, found that when they performed the same procedure through the minimally-invasive route, their performance did not transfer to this new technique[1]. However, the ethical implications of learning using humans and the legal risks during such a process must be considered[2], as training during live surgery exposes the patient to the inherent risks of an inexperienced surgeon[3]. This led to the creation of skills labs, which allowed surgeons to develop basic skills without putting patients at risk[1].

Surgical education plays a very important role in patient care[4]. Virtual reality (VR) simulation was first introduced in surgical education in the late 1980s. After that, many virtual reality simulators emerged, allowing students to experience a more real contact with the practice of medical procedures. As a result, VR surgical education has been largely integrated into minimally-invasive surgery (MIS) training. The MIS revolution has forced the surgical community to rethink how they train residents and adapt to new technologies[5].

As demonstrated in laparoscopy, moving the venue for the acquisition of a reliable basic skill set out in the operating room and into the simulation laboratory has significant advantages for trainees, hospitals and patients alike[6]. It provides the surgeon with the adequate tools to train in a risk-free environment and bridges the gap between the safe acquisition of surgical skills and effective performance during live robot-assisted surgery[3].

Robotic training poses several unique challenges to educators, trainees and training program directors[7]. The da Vinci Skills Simulator® (dVSS) (Intuitive Surgical Inc., Sunnyvale, CA), also referred to as the ´Backpack´, is a customized computer package that attaches to the actual surgical console through a single fiber optic network cable[8]. There are no general recommendation guidelines for the best training modality for surgeons and residents learning to use the da Vinci robot®[9]. However, it is possible to verify that several countries and medical institutions have organized themselves to create their own training guidelines.

Current simulators enable trainees to practice psychomotor skills and basic procedural skills[10]. Taking into consideration the effectiveness of the virtual reality surgical simulators, new uses for this tool have been suggested. Since robotic surgical skills are unique and not derivative from either open or laparoscopic surgery[6], would it be possible to acquire laparoscopic skills using a robotics simulator?

Learning styles (LS)

Learning is an acquired appropriate response to a stimulus, which tends to change the organism's environment. It has been long known that several factors can influence learning in medical education, including teacher-, system-, and student-related factors. Understanding the student-related factors is crucial to facilitate learning, as well as to improve teacher- and system-related factors. The learning style is an individual's natural or habitual pattern of acquiring and processing information in learning situations. it varies from student to student and from time to time. The students' approaches to learning can be influenced by the perception they gain from their learning environment[11]. To overcome the disadvantages of treating all students in the same way, knowledge of their learning styles seems helpful to educators[12]. Teaching strategies associated with interpersonal intelligence should be stimulated, which could increase academic performance and encourage engagement in the learning process[13].

Although a large number of LS and strategies are formulated based upon various psychological constructs, educators are interested in identifying learners based on the visual (V), auditory (A), read/write (R), or kinesthetic (K) preferences of learning[14]. Fleming and Miles defined those four sensory modalities of learning, which are referred together as VARK[12]. Because of the diversity in LS, students often find a mismatch between their learning and the delivery of instruction[12]. One characterization of LS is to define the learners' preferred mode of learning in terms of the sensory modality through which they prefer to take in new information[15]. This knowledge can also be a useful asset in identifying the learning problems of students and making them effective learners. Students with a visual preference prefer to explain concepts by drawing pictures and diagrams[12].

Conceptually defined, style is a general term encompassing all studies related to recognizing individual learning differences[16]. These stylistic differences can be investigated by using the Gregorc Style Delineator (GSD), based on a theory known as Mind Styles. The GSD focuses on the cognitive abilities of perception and ordering. Arranged via a quaternary design, the GSD sums the rank order of 10 sets of 4 words, thereby creating the Concrete Sequential (CS), Abstract Sequential (AS), Abstract Random (AR), and Concrete Random (CR) mind styles[16].

Synchronizing a teaching style with the students' learning preferences may bring additional benefits for them[12]. There is a lack of studies proving that different learning styles make it easy or difficult to develop their skills in a virtual reality environment in surgery. Robotic surgery is a minimally-invasive surgical platform, and its impact on medical student education has not yet been elucidated[17].

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METHODS

A prospective, longitudinal, randomized and controlled study, approved by the Research Ethics Committee was conducted. The VARK (2017) questionnaire and the multiple intelligences questionnaire proposed by Gregorc (Mind Styles) were acquired online. After printing, each participating student received one copy of each quiz.

Intern medical students from the Erasto Gaertner Hospital, aged between 18 and 25 years old, attending between the second and fourth years of medical school in the city of Curitiba, state of Paraná, Brazil, were included. All those with experience in virtual reality or video games, those with degenerative diseases or visual disorders were excluded. Students that did not complete all the planned steps were also excluded.

The students were invited to participate in the project by e-mail. Sixty-three students were selected according to the inclusion criteria and then randomized into control (C), laparoscopy (L) and robotics (R) groups. All of them signed an informed consent form. The sample number was directly related to the number of interns available to participate, as well as the availability of the simulator for the study.

Sixty-one students were included. Randomization was performed right after the students' check-in. Subsequently, they were informed of the study schedule and objectives. A pre-test was then applied, which included ten true-or-false statements regarding the operative technique. At the end, a thirty-minute lecture was given, with surgical-clinical content. A post-test, containing the same questions as the pre-test was then applied, as well as version 7.8 of the VARK questionnaire (2017) and the Mind styles. The pre-test, post-test and questionnaires were common to all groups. At the end of the post-test, the students in the L group were referred to a surgical knot exercise in the Johnson & Johnson® laparoscopic box for sixty minutes. The students in the R group were referred to perform the same exercise for the same period, but on the dVSS® platform. The C group did not train. After the end of the activities, an exercise in the laparoscopy box, called 'practical test', was applied to all students, in which the students' performances were evaluated. The students from the L and R groups, at the end of the sixty-minute training, and those in C group, who did not train, had the objective of performing a surgical knot in the laparoscopy box within a ten-minute period. For this purpose, a specific evaluation form was created, considering time to perform the exercise and occurrence of critical errors (falls, breaking the wire, lacerating the prototype, number of attempts). A scoring system was created to generate a final score for each student.

In the end, two students from the L group did not complete all the steps and were excluded from the study, totaling nineteen students in this group. The C and R groups remained with twenty-one students each.

Statistical Analysis

Considering the asymmetric distribution of most quantitative variables, these were represented by the median and interquartile range, and the qualitative variables by absolute and relative frequencies. The Kruskal-Wallis test was used when comparing values of quantitative variables between the 3 groups, , followed by the Dunn-Bonferroni test for multiple comparisons when necessary. Fisher's exact test was used when comparing qualitative variables between the 3 groups. Wilcoxon's signed rank test for paired data was used when comparing values of quantitative variables within the same group, whereas the Mann-Whitney U test was used when comparing values between two independent groups.

RESULTS

Description and Comparison between Groups

All variables concerning the selected sample and each group are described in Table 1. There was a significant difference between the pretest scores in the L and R groups (Dunn-Bonferroni test p-value = 0.038).

Fisher's exact test found a significant difference between the proportions of students who managed to pass the thread in each group, with the C group showing the lowest proportion.

Comparison of scores within each group

The differences between the pre-test and post-test scores for the L and R groups were statistically significant according to the Wilcoxon signed rank test. Both the L and R groups had significantly higher scores in the post-test, compared with the pretest. The median increase was 5 points for the L group, and 10 points for the R group (Table 2).

Comparison of Scores According to Mind Styles and VARK

For each group, the pre-test and post-test scores and the difference between the two for each Mind Styles (Table 3) and each VARK category (Table 4) were compared. As the same participant could be classified into more than one Mind Styles category or more than one VARK category, comparisons were performed for each category separately. Whenever possible, the p-value associated with the Mann-Whitney U test was calculated, but no statistically significant differences were found.

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Table 1. Distribution between groups.

Variable	Entire sample	C Group	L Group		R Group	p-value
Mind Styles	CS	34	15 (71.4%)	9 (47.4%)	10 (47.6%)	0.229
	CR	6	2 (9.5%)	2 (10.5%)	2 (9.5%)	1
	AS	16	3 (14.3%)	5 (26.3%)	8 (38.1%)	0.22
	AR	17	7 (33.3%)	4 (21.1%)	6 (28.6%)	0.722
VARK	*V*	13	5 (23.8%)	3 (15.8%)	5 (23.8%)	0.793
	A	23	6 (28.6%)	8 (42.1%)	9 (42.9%)	0.637
	R	14	6 (28.6%)	5 (26.3%)	3 (14.3%)	0.553
	K	22	11 (52.4)	5 (26.3%)	6 (28.6%)	0.197
Pre-test	80 (75; 85)	80 (75; 85)	85 (82.5; 90)		75 (70; 85)	0.045
Post-test	85 (80; 95)	85 (80; 90)	90 (85; 85)		85 (85; 95)	0.507
Post-test – Pre-test	5 (0; 10)	5 (-5; 10)	5 (0; 10)		10 (5; 15)	0.07
Emergency room hours training	0 (0; 200)	80 (0; 430)	0 (0; 6)		0 (0; 72)	0.07
College semesterr	6 (5; 7)	6 (5; 7)	6 (4; 6)		6 (5; 7)	0.292
Operating technique discipline	38	13 (61.9%)	11 (57.9%)		14 (66.7%)	0.944
Needle dropping	55	20 (95.2%)	17 (89.5%)		18 (85.7%)	0.673
Prototype laceration	19	5 (23.8%)	6 (31.6%)		8 (38.1%)	0.615
Completed knot	6	2 (9.5%)	4 (21.1%)		0	0.07
Number of attempts	2 (1; 3)	2 (1; 4)	3 (1.5; 4)		2 (1; 2)	0.44
Thread passage	45	11 (52.4%)	17 (89.5%)		17 (81%)	0.025
Practical test score	9 (9; 12)	11 (9; 12)	9 (8; 11.5)		9 (9; 12)	0.314

Source: the authors (2022).

Table 2. Comparison of scores within each group.

Group	Pre-test	Post-test	p-value
C	80 (75; 85)	85 (80; 90)	0.063
L	85 (82,5; 90)	90 (85; 85)	**0.033**
R	75 (70; 85)	85 (85; 95)	**0.004**

Source: the authors (2022).

Table 3. Comparison of scores according to mind styles.

			C Group			
Mind Styles	Pre-test	p-value	Post-test	p-value	Post-test – Post-test	p-value
CS	85 (77.5; 85)	0.383	90 (80; 92.5)	0.383	5 (0; 7.5)	0.525
Others	77.5 (75; 80)		82.5 (76.2; 88.7)		-2.5 (-5; 7.5)	
CR	87.5 (83.7; 91.2)	0.299	85 (82; 87.5)	0.903	-2.5 (-3.7;-1.2)	0.245
Others	80 (75; 85)		85 (80; 92.5)		5 (-2.5; 10)	
AS	80 (77.5; 85)	0.918	75 (72.5; 85)	0.384	-5 (-5; 0)	0.218
Others	80 (75; 85)		87.5 (80; 90)		5 (0; 10)	
AR	80 (72.5; 85)	0.543	80 (75; 90)	0.305	0 (-5; 7.5)	0.469
Others	82.5 (76.2; 85)		90 (81.2; 90)		5 (0; 8.7)	

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Tabela 3. Continuação.

			L Grupo			
Mind Styles	**Pre-test**	**p-value**	**Post-test**	**p-value**	**Post-test – pre-test**	**p-value**
CS	85(85; 85)	0.67	90 (85; 95)	0.737	5 (0; 10)	0.833
Others	85 (76.2; 90)		87.5 (85; 93.7)		5 (0; 10)	
CR	92.5 (91.2; 93.7)	0.128	95 (95; 95)	0.152	2.5 (1.2; 3.7)	0.631
Others	85 (80; 85)		85 (85; 90)		5 (0; 10)	
AS	80 (70; 85)	0.135	85 (85; 90)	0.296	10 (0; 10)	0.391
Others	85 (85; 93.7)		90 (85; 95)		5 (0; 8.7)	
AR	87.5 (82.5; 91.2))	0.639	90 (85; 96.2)	0.505	5 (3.7; 6.2)	0.918
Others	85 (82.5; 87.5)		90 (85; 92.5)		5 (0; 10)	
			R Grupo			
Mind Styles	**Pre-test**	**p-value**	**Post-test**	**p-value**	**Post-test – pre-test**	**p-value**
CS	80 (71.2; 88.7)	0.315	92.5 (81.5; 95)	0.331	10 (1.2; 13.7)	0.542
Others	75 (70; 77.5)		85 (85; 90)		10 (7.5; 17.5)	
CR	70 (67.5; 72.5)	0.222	85 (85; 85)	0.581	15 (12.5; 17.5)	0.428
Others	75 (70; 85)		90 (82.5; 95)		10 (5; 15)	
AS	75 (70; 81.2)	0.684	90 (85; 91.2)	0.317	12.5 (10; 16.2)	0.238
Others	75 (70; 90)		85 (80; 95)		10 (0; 15)	
AR	75 (75; 82.5)	0.721	85 (81.2; 88.7)	0.381	10 (6.2; 13.7)	0.552
Others	75 (70; 82.5)		90 (85; 95)		10 (5; 20)	

Source: the authors (2022).

Table 4. Comparison of scores according to VARK.

			C Group			
VARK	**Pre-test**	**p-value**	**Post-test**	**p-value**	**Post-test – Pre-test**	**p-value**
V	80 (80; 85)	0.801	90 (85; 90)	0.674	0 (-5; 10)	0.933
Others	80 (75; 85)		85 (80; 91.2)		5 (-1.2; 6.2)	
A	80 (75; 85)	0.812	82.5 (72.5; 92.5)	0.525	2.5 (0; 5)	0.781
Others	80 (77.5; 85)		90 (80; 90)		5 (-5; 10)	
R	80 (76.2; 83.7	0.968	87.5 (81.2; 93.7)	0.5	5 (5; 5)	0.404
Others	80 (75; 85)		85 (77.5; 90)		0 (-5; 10)	
K	85 (75; 87.5)	0.566	85 (80; 92.5)	0.943	5 (-5; 7.5)	0.829
Others	80 (76.2; 83.7)		87.5 (81.2; 90)		2.5 (0; 8.7)	
			L Grupo			
VARK	**Pre-test**	**p-value**	**Post-test**	**p-value**	**Post-test – Pre-test**	**p-value**
V	85 (85; 90)	0.521	95 (90; 97.5)	0.251	0 (0; 7.5)	1
Others	85 (78.7; 90)		87.5 (85; 91.2)		5 (0; 10)	
A	85 (70; 87.5)	0.344	90 (83.7; 95)	0.865	7.5 (5; 10)	0.089
Others	85 (85; 90)		85 (85; 92.5)		0 (0; 7.5)	
R	85 (80; 85)	0.247	85 (85; 90)	0.296	5 (0; 10)	0.886
Others	85 (85; 93.7)		90 (85; 95)		5 (0; 10)	
K	90 (85; 95)	0.067	90 (85; 95)	0.635	0 (0; 5)	0.115
Others	85 (76.2; 85)		87.5 (85; 93.7)		7.5 (0; 10)	

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Tabela 4. Continuação.

			R Grupo			
VARK	**Pre-test**	**p-value**	**Post-test**	**p-value**	**Post-test – Post-test**	**p-value**
V	85 (70; 90)	0.584	80 (75; 90)	0.237	10 (0; 10)	0.13
Others	75 (70; 80)		87.5 (85; 95)		12.5 (5; 20)	
A	75 (75; 80)	0.744	85 (85; 90)	0.327	10 (5; 15)	1
Others	77.5 (70; 86.2)		90 (83.7; 95)		10 (5; 16.2)	
R	80 (75; 82.5)	0.837	85 (77.5; 90)	0.644	10 (0; 12.5)	0.609
Others	75 (70; 83.7)		87.5 (85; 93.7)		10 (5; 18.7)	
K	75 (71.2; 78.7)	0.874	92.5 (86.2; 95)	0.095	15 (6.2; 20)	0.267
Others	75 (70; 85)		85 (80; 90)		10 (2.5; 15)	

Source: the authors (2022).

Table 5. Score in the practical test between the different mind styles and VARK.

Mind Styles	Score in the – practical test	p-value	VARK	Score in the – practical test	p-value
CS	10 (9; 12)	0.841	V	9 (9; 10)	0.449
Others	9 (8; 12)		Others	11 (8; 12)	
CR	10 (9; 11.7)	1	A	9 (8; 12)	0.921
Others	9 (9; 12)		Others	9.5 (9; 12)	
AS	12 (9; 12)	0.189	R	11.5 (9.2; 12)	0.334
Others	9 (8; 12)		Others	9 (9; 12)	
AR	9 (8; 12)	0.315	K	9 (8.2; 12)	0.896
Others	10.5 (9; 12)		Others	10 (9; 12)	

Source: the authors (2022).

Scores in the practical test

Considering the three groups together, the practical test scores between the different Mind Styles and the different VARK learning styles were compared in the same way as the other test scores. No significant differences were found, indicating that the practical test scores were relatively homogeneous between groups and between the Mind Styles and VARK categories (Table 5).

The same procedure was performed within each group, comparing each Mind Styles with the others, and each VARK category with the others.

No significant difference was found, indicating that the practical test scores were relatively homogeneous between the groups and between the Mind Styles and VARK categories.

DISCUSSION

When the idea of this research with medical students came up, the first question that was raised was the adherence. Higgins et al. found that the robotic operating room experience is demotivating for medical students. There is little opportunity for mastery, autonomy, and relationship development[17]. However, in our study, the vast majority showed interest and motivation to participate. Another challenge was related to the availability of the dVSS® for training, as our robotic training center was the first in the state of Paraná and, therefore, an essential part of the implementation of other robotic services and training of surgeons in the technology.

All aspects of medical education have been severely impacted by the pandemic. There is an increased interest in simulation programs at home, which could ensure the continuity of technical skills training during the COVID-19 pandemic, particularly in highly technical and demanding surgical specialties[18].

During the COVID-19 pandemic, online medical training including simulated clinical scenarios prevented training interruption and the majority of the participating students had a positive attitude regarding the perceived quality of this training modality[19]. In addition, the COVID pandemic limited the viability of face-to-face meetings in the previously approved model, which enabled the first adaptation – increase of preventive measures and social distancing.

The dVSS® can be integrated with the existing da Vinci Xi or Si surgeon consoles, thus providing a practice platform to be used inside or outside the operating room, without requiring additional system components[20]. Although there are other available platforms, this was the only one used in this study.

Each platform has the capacity to train and assess a variety of different robotic skills fundamental to the technique[7]. It can be used to assess basic robotic skills, as well as the first step in training, before moving on to more advanced tasks[21].

A final opportunity to optimize medical student learning in robotic surgery is simulation. An additional component of robotic surgery that impacts the medical student learning environment is the influence of other students, who are also navigating through the technology's learning curve[17].

Unfortunately, most of the currently available exercises in VR simulators are generic tasks testing hand – eye coordination, tissue manipulation, dissection, suturing and knot tying. There is no evidence to suggest which exercises lead to improved real-setting performance[7].

From the evidence available, it seems that simulation-based training does result in skills transfer to the operative setting. Simulation-based training therefore provides a safe, effective, and ethical way for trainees to acquire surgical skills before entering the operating room[22].

Despite a lack of evidence for a direct relationship between VR simulation and performance on actual human cases, it has been well described that the skills gained from VR training are similar to those attained via traditional robotic dry laboratory simulation training[6].

Laparoscopic surgery requires working in a three-dimensional environment with a two-dimensional view. Skills such as depth perception, hand-to-eye coordination and bimanual manipulation are crucial to its efficacy[1].

This makes the development of skills in standard simulators very challenging, raising the question of how much virtual reality simulators can help in the learning curve. Nonetheless, training in virtual reality simulators versus 'standard' laparoscopic training (the traditional apprenticeship model) did not reveal any difference in the overall operating time and complication rates (measured by number of cases converted to open surgery). Performance was assessed by parameters such as tissue handling, path length of instruments and keeping the instruments within the field of vision[1].

Training in laparoscopy, notably the Fundamentals of Laparoscopy Surgery (FLS) curriculum, is more accessible to surgery residents, but evidence is lacking as to whether these skills transfer to robot-assisted surgery[23].

Few studies have compared medical students' exposure to virtual reality training in robotic and laparoscopy surgeons. And according to Vurgun, medical students' initial experience with robot-assisted surgery did not differ significantly after limited laparoscopy exposure[23].

Our study did not demonstrate any statistical significance when comparing skill gains between the studied groups.

Most of the studies assess surgeons' skills. Pimentel et al. supported the concept that the fundamental techniques of robot-assisted surgery are not influenced by the surgeon's experience in laparoscopic surgery. This may be explained by the fact that the skills required for robotic surgery are different from those acquired in laparoscopic surgery training. There are no significant differences in the performance of simulated robotic surgical tasks between surgeons with laparoscopic training and surgical residents[24].

Altogether, Vurgun et al., suggested that exposure to laparoscopic training, in the form of limited psychomotor skills training, does not affect initial robot-assisted surgical performance among students and supports the idea that training in robotic surgery ought to take place in a robot-assisted simulation environment[23].

In medical studies, both theoretical and practical expertise have a vital role, while repetition of hands-on practice can improve the young doctors' professional competency. Virtual reality was found to be the best for medical students regarding both learning motivation and learning competency. Medical students and teachers may select virtual reality as a new learning methodology for curriculum learning[25].

Learning styles based on four sensory modalities of VARK were described by Fleming. A visual student prefers the visual mode, i.e., through seeing, whereas an aural student prefers listening techniques. Read/write students prefer reading and writing for assimilating and accommodating the information. A kinesthetic student experiences learning by performing tasks . According to Valerdi et al., multimodal-type students may be in a situation that they can shift from mode to mode, depending on the context or are satisfied only when they have had their input in all their preferred modes[11].

Students with an aural preference prefer to receive or give information by listening and talking. Students with a read–write preference can easily understand concepts using lists, booklets, and textbooks. Students with a kinesthetic preference favor a hands-on approach, trial and error, and real-life examples[12].

Parashar et al. compared learning styles among students using Friedman's test. The pattern of learning styles was different, and some learning styles were more often preferred than others; this difference was statistically significant ($P<0.001$). In this study, aural and kinesthetic styles were preferred over other styles by the students[11]. The same results were found in our study.

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The learning style varies from one group to another based on culture, the nature of the studies and the students' characteristics. A study carried out in Malaysia showed that the mean VARK scores of kinesthetic and read/write students were higher than those of auditory and visual students[14].

Knowledge of the students' learning styles and the characteristics that affect them is important for teachers to improve lesson plans and develop teaching methodologies to adapt them to their students' needs. Khanal et al. showed that the majority of the medical students (53.52%) were multimodal students, with more than one VARK component. Among unimodal students, most of them were kinesthetic learners (29.6%), followed by aural, visual and read/write students[12].

Learning styles may change over a shorter time frame than over the course of a medical degree. Learning styles may indeed change based on the context, environment and topic being learned and it is likely a flexible changing trait, rather than a fixed innate trait exhibited by a student[26].

Another way to assess learning styles is using the GSD. The GSD focuses on the cognitive abilities of perception and ordering. Arranged via a quaternary design, the GSD sums the rank order of 10 sets of 4 words, thereby creating the Concrete Sequential (CS), Abstract Sequential (AS), Abstract Random (AR), and Concrete Random (CR) mind styles. The CS individual prefers physical, hands-on tasks that are structured (e.g., repair technician). The AS individual prefers reflective thinking tasks that provide an expression of intellect and rationality (e.g., academician). The AR individual prefers nonphysical tasks that allow emotional and interpretive expression (e.g., poetic writer). The CR individual prefers investigative tasks that incorporate risk taking or multiple options (e.g., cinematographer)[16].

The undergraduate students assessed in this study showed the following distribution of styles: 89 (44.5%) were CS, 21 (10.5%) were AS, 54 (27%) were AR, and 36 (18%) were CR. These results support the findings of Gregorc, who reported the CS mind style to be the most commonly preferred, followed by the AS, AR, and CR styles, respectively[16]. In our study, we found similar distribution of styles.

Several studies have previously reported faster learning curves and improved retention of skills with robotic assistance as compared to laparoscopy regarding basic manipulation tasks, and improved task speeds with robotic assistance have been measured as compared to laparoscopy, but with minimal transfer effects. Other studies have stated that skills transfer effects from laparoscopy to robotic surgery may be more pronounced with difficult tasks, such as suturing. In our viewpoint, laparoscopy and robotic surgery are different domains, perhaps requiring different skills[23].

STUDY LIMITATIONS

The first limitation of this study was the number of included students. A larger number of participants would improve the results. One reason is that the medical students were from a single institution. Furthermore, with the COVID pandemic and the low availability of the robotics simulator, participation was limited, as was the possibility of extending the training time. The use of a standard assessment method could facilitate data analysis or standardize them using assessments previously described in the literature.

CONCLUSION

There was no statistically significant difference between learning styles and performance of the proposed tasks. More studies are needed to determine whether learning styles influence skill development in robotic surgery and laparoscopy.

AUTHORS' CONTRIBUTION

Fernando Henrique de Oliveira Mauro: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original drafting and writing – review & editing. Rogerio de Fraga: conceptualization, data curation, formal analysis, methodology, supervision, validation and writing – review & editing. Flavio Daniel Saavedra Tomasich: conceptualization, formal analysis, investigation, methodology, supervision, visualization and writing – review & editing. Carla Simone da Silva and Jose Henrique Agner Ribeiro: data curation, formal analysis, funding acquisition, investigation, project administration, resources and writing – original drafting. João Lucas Aleixes Sampaio Rocha: formal analysis, investigation, validation and writing – review & editing.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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