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**Teaching**

# Taxonomy of educational objectives and learning theories in the training of laparoscopic surgical techniques in a simulation environment.

## Taxonomia dos objetivos educacionais e as teorias de aprendizagem no treinamento das técnicas cirúrgicas laparoscópicas em ambiente de simulação.

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## ABSTRACT

The acquisition of psychomotor skills in surgery is the central component of medical residency programs in General Surgery and Specialties. Making learning more effective is a cornerstone of educational processes. This article portrays aspects of educational taxonomies and learning theories that may be involved in the training of surgery. Among the many taxonomies and educational theories applicable to learning in surgery, the following stand out: 1) Dave's taxonomy- Hierarchy to actions that facilitate the acquisition of psychomotor skills; 2) Miller's theory- Step-by-step definition that facilitates acquisition; 3) Ericsson's theory- Competence after repetition of the practice followed by systematic reinforcement; 4) Vigotsky's theory- Definition of the role of the specialist in learning; and 5) Theory of Boud, Schon and Ende- Importance of feedback for students and teachers. Knowledge of these tools by teachers and preceptors can facilitate learning in surgery, especially in more complex activities.

**Keywords:** Education, Medical. Simulation Training. Teaching. Laparoscopy.

## INTRODUCTION

The current surgeons training model in the Western world was proposed and implemented by William Halsted at the Johns Hopkins Hospital, in 1889, in the United States. The initial model introduced the concept of medical residency based on the German experience of training for surgeons. Over time, this training model was adopted in the United States and throughout America[1,2].

Classically, this training is performed in the operating room under the supervision of a graduate surgeon. This form of teaching, although efficient, is time-consuming, costly and can increase patients' morbidity[3]. With the advent of minimally invasive surgery in the 1980s, surgeons were encouraged to acquire a number of new skills to overcome technical challenges that had not existed in conventional surgical practice, such as loss of depth perception and spatial orientation due to two-dimensional view, inverted perception of the hand movements with the surgical instruments (abdominal wall effect), limited degree of movement due to the use of rigid instruments introduced through fixed trocars in the abdominal wall, decrease of the haptic sensitivity due to the resistance inside of trocars and the use of long instruments, and the need to perform the skills with both hands (ambidexterity)[4-6].

The traditional training model for learning in open surgical procedures has proved over time to be inadequate and of low efficiency when applied to the training of skills in laparoscopic procedures. In addition, surgical skills already acquired by surgeons in open surgical procedures to perform surgical knots did not facilitate the learning of laparoscopic intracorporeal knots, requiring specific training in minimally invasive surgical procedures[7]. Over the years, it became clear that the training model proposed by Halsted (see one, do one, teach one) would not apply to learning the skills of minimally invasive surgery and would have to be replaced by a model that prioritized the simulation with many repetitions and always under qualified supervision[8].

The learning of surgical techniques includes the acquisition of several psychomotor skills, defined as mental and motor activities required to perform a given manual task[9]. To facilitate the training of the new psychomotor skills, simulators and simulation environments were developed, thus eliminating the risks of iatrogenies and offering the learners a safe, comfortable place without the pressure of the operating room[6,10].

With the natural evolution of video-surgery, abdominal procedures became more and more complex, and intra-corporeal knots, stitches and sutures were gradually necessary. In the initial experiments, it was evident that these maneuvers were difficult to perform, being considered as maneuvers of high complexity[9,11]. To overcome this difficulty,

some training models for performing knots, stitches and intracorporeal sutures in laparoscopic operations were proposed and applied[10,12].

A training program in basic and advanced laparoscopy for residents, preceptors, and guidelines for training for those who had already completed their Surgical residency was proposed in 1998, by the American Society of Gastrointestinal Surgery and Endoscopy (SAGES). The objective of the proposal was to incorporate advanced laparoscopy training into the training programs of medical residences in Surgery[13].

The American Society of Gastrointestinal Surgery and Endoscopy, endorsed by the American College of Surgeons (ACS), proposed in 2004 an educational training program called Fundamental of Laparoscopic Surgery (FLS) to teach and evaluate the basic psychomotor skills required in the performance of laparoscopic surgery for residents and surgeons. The program is based on an initial cognitive assessment and a practical training in a five-task simulator: transferring objects, cutting tissue, applying ligature with a loop, performing extracorporeal and intracorporeal sutures. The training is based on the repetition of the tasks proposed. The time of each exercise is set individually, with a previously established limit. At the end of the training, certification is granted to those approved[14].

In Europe, the European Society of Endoscopic Surgery has implemented a training program for surgeons and residents called Laparoscopic Surgical Skills (LSS). The structure of this program is composed of three phases: pre-course, course and post-course, and all include theoretical and practical activities[15].

Due to the difficulty of ensuring effective learning for surgeons, Sadideen *et al*.[9] carried out a review of the aspects of the educational theories that could be applicable to the teaching of Surgery. Among them the considered most important were: 1) acquisition and retention of motor skills (Miller's pyramid, Fitts and Posner's theory); 2) development of expertise with repeated practice and reinforcement (Ericsson's theory); 3) availability of expert supervision (Vygotsky's theory); 4) learning in the practice environment (Lave and Wenger's theories); 5) feedback in learning practical skills (Boud, Schon and Ende theories); and 6) learning affectiveness[9].

As in the training of surgeons, that of resident physicians in laparoscopic techniques is based on most programs, in scientifically untested training models, and without the guarantee of obtaining the competence in the process of knowing how to do at the end of the process[16]. In Brazil, significant efforts have been made to improve the learning of psychomotor skills in surgical procedures, with the development of innovative training models, such as those proposed by Artifon *et al*., an ex-vivo model for advanced education

in endoscopic retrograde cholangiopancreatography[17], Oti *et al*., a model of laparoscopic surgery training using a smartphone[18], Spencer *et al*., a low-cost porcine model for venous dissection[19], and Cunha *et al*., who developed a low-cost simulator for training in laparoscopy in three dimensions[20]. Moura Júnior *et al*. tested a model of performance evaluation in endosutures in the simulation laboratory and concluded that the model was safe and revealed the student's profile as well as his/her performance at the end of training[21].

Nacúl *et al*. performed a critical analysis of the current training of laparoscopy residents in Brazil and suggested that the training for the acquisition of skills in laparoscopy in the medical residencies needs a more appropriate pedagogical process of teaching to give a more solid educational base than the current one[22]. Rasslan *et al*. evaluated the profile of the resident of General Surgery of the Hospital das Clínicas of the São Paulo Medical School and concluded that there is a reduction in demand and an earlier definition of the specialty. Considering the duration of two years of medical residency in General Surgery, it is probable that the training in laparoscopy will be restricted[23].

The accomplishment of this review was motivated by the observation of the enormous difficulty encountered by resident physicians during the learning of laparoscopic skills and especially in the accomplishment of knots, stitches and sutures. The central objectives of this article are the need to understand in which aspects the taxonomy of the educational objectives are based and the educational learning theories applicable to the training models in surgical procedures.

## TAXONOMY OF EDUCATIONAL OBJECTIVES

Teaching practical skills is the central component of undergraduate and postgraduate surgical education. In general, the learning models of the operative techniques are not previously tested and there is no guarantee of efficiency at the end of training. Effective learning of psychomotor skills requires an approach that includes several components, including the environment (practice scenario), practice structuring, teacher/student dialogue, and pedagogical strategies[24].

In this context, the concept of learning is defined as becoming able or capable, through study, observation or experience, after receiving knowledge, understanding and memory retention. Skill is a behavioral response to the practice established by frequent and continuous repetition of movements that increase agility, dexterity, accuracy in handling, and sensory-motor perception. Aptitude, on its turn, is the peak of sensory-motor

perception obtained after training, while proficiency is when skill, competence, and retention of skill achieve stability, a plateau[25]. Although widely cited in several studies, the criteria for proficiency in performing laparoscopic stitches and sutures were not defined by any of them[26,27].

To facilitate the planning, organization and control of the learning objectives, Benjamim Bloom *et al*. proposed a structured and oriented classification[28]. This classification, known as Bloom's Taxonomy, served as the basis for researchers, who adapted and refined it. Bloom's taxonomy offers advantages such as: establishing a common language about learning objectives, serving as a basis for the development of assessment tools, stimulating student performance, encouraging educators to help their students in a structured and conscious way to acquire skills and to determine consistency between educational objectives, activities and syllabus assessments[29,30].

Dave, in 1967, proposed a taxonomy of educational goals to facilitate the acquisition of psychomotor skills and staged it in: imitation, manipulation, practical precision, articulation and naturalization[24]. This classification has been widely used as an educational guideline by the ATLS (Advanced Trauma Life Suport) program of the American College of Surgeons over the past 30 years. Simpson defined that the psychomotor domain consists of the somatic movement, the motor coordination and the use of the psychomotor areas. Developing these skills requires hands-on training that is usually measured in speed, accuracy, or technical performance in execution. The principles of learning the psychomotor skills were defined in conceptualization, visualization, verbalization, practice, correction and reinforcement, mastery of ability and autonomy. These principles should be clear and arranged sequentially and hierarchically in training models for the acquisition of psychomotor skills[24].

## EDUCATIONAL THEORIES OF LEARNING

The understanding of learning educational theories by preceptors of surgical programs and undergraduate teachers can facilitate the structuring and application of training models in procedures and operative techniques. Theories of learning for the acquisition of psychomotor skills in surgical procedures include the theories of Miller, Fitts and Posner, Ericsson, Vygotsky, Lave and Wenger, Boud, Schon and Ende.

Miller proposed a hierarchical sequence of competence on four levels, based on "knowing," followed by "knowing how," "demonstrating how," and finally "doing." In this way, he established the step-by-step approach to competence in which the learner advances through the necessary cognitive and behavioral steps that underlie the next

step, building the knowledge that eventually assists and supports the execution of a specific skill. There is, apparently, a disadvantage in this process that assumes that competence previously includes knowledge[31].

Fitts and Posner have established a theory for the acquisition of motor skills in three phases: cognitive (when skill is learned), associative (when performance approximates skill) and autonomy (when the skill has become fully automatic and can be performed without thinking much about the task). At the cognitive stage, the learner intellectualizes the task. With continuous practice and relevant feedback, one reaches the associative or integrative stage, during which knowledge is translated into appropriate motor behavior. Finally, continuous practice results in a more qualified performance in the autonomy phase, in which the trainee does not think about how he/she is performing and begins to focus on the other aspects related to the proposed ability[32].

Vygotsky, a Russian psychologist in the beginning of the 20th Century, accurately defined the role of specialists in assistance. He suggested the notion of a "proximal development zone", within which the student could progress in solving problems “in collaboration with more able peers”, even though unable to do so independently[33]. Each student has his/her own "proximal development zone". Some learners start at a more advanced level, while others do not. Each student's "proximal developmental zone" may vary, requiring different levels of peer support and guidance from the counselor until eventually the skill can be mastered[34].

Lave and Wenger defined learning as an inseparable and integrated aspect of social practice, rather than a process of internalizing an individual experience. Thus, the essential component of learning, when viewed as an activity, is the process of participation. This means that students who integrate communities of practice, with the goal of mastering skills, should move towards full participation in the sociocultural practices of that community. This social process may include learning practical skills. It is clear that learner participation is crucial in this theory, since there is involvement with peers in the common stage. This theory is not directly related to health care. However, it may be noted that successful acquisition of skills requires sustained social interaction, which is usually time-consuming. Obviously, it is best to start learning the simple, low-risk practical skills during which learners can reach plausible goals[35].

Boud and Schon described processes whereby learners learn from practice the knowledge, the experiential learning, and the reflection on practice (feedback). Feedback can be applied after the teaching session, while performing the skill, or before the action. The combination of all feedback processes can maximize the reflection process[36,37]. For

Ende, feedback from trainers (teachers, preceptors) is as important as the feedback from the learners themselves[38]. Feedback is considered one of the most powerful learning tools and is useful in developing and targeting subsequent steps. Thus, feedback is a crucial component of learning practical skills, whether defined by the Vygotskian approach, in Lave and Wenger's theory, or in deliberate practice, helping the student to gain expertise.

The affective component in learning cannot be forgotten in this process. It is powerful and exerts both positive and negative effects on learners' experiences and, in some respects, is critical to the acquisition of psychomotor skills. It is common for older people to report experiences that have been enriching or disastrous and have significantly affected their professional development[39]. The hierarchical model in which the physical, emotional and psychological aspects of the learners need to be solved before the beginning of the learning was described by Maslow, establishing as essential condition for the learning the creation of a sustainable and pleasant environment, with the objective of motivating and encouraging participation in the learning process[40].

## CONCLUSION

In the face of the challenges of promoting effective learning for the acquisition of psychomotor skills, it seems sensible to base the training models of the operative techniques, especially laparoscopic knots and sutures, on the taxonomy of educational objectives and learning theories.


## RESUMO

A aquisição de habilidades psicomotoras em cirurgia é o componente central dos programas de residência médica em Cirurgia Geral e Especialidades. Tornar o aprendizado mais efetivo é ponto basilar dos processos educacionais. Esse artigo retrata os aspectos das taxonomias educacionais e teorias de aprendizagem que podem ser envolvidas no treinamento da cirurgia. Entre as inúmeras taxonomias e teorias educacionais aplicáveis no aprendizado em cirurgia destacam-se: 1) Taxonomia de Dave- Hierarquização a ações que facilitam a aquisição de habilidades psicomotoras; 2) Teoria de Miller- Definição do passo a passo que facilita a aquisição das habilidades; 3) Teoria de Ericsson- Competência após a repetição da prática seguida de reforço sistemático; 4) Teoria de Vigotsky- Definição do papel do especialista no aprendizado; 5) Teoria de Boud, Schon e Ende- Importância da devolutiva (feedback) para alunos e professores. O conhecimento dessas ferramentas por professores e preceptores pode facilitar o aprendizado na cirurgia, em especial nas atividades mais complexas.

**Descritores:** Educação Médica. Treinamento por Simulação. Ensino. Laparoscopia.

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