The Influence of the Instructional Approach on Acquiring Clinical Skills in Surgery: A Comparative Effectiveness Study

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OBJECTIVE: The instructional approach used to teach skills and competencies seems to have a critical impact on retaining and performing the learned skills/competencies. However, for most of them, the effect of different instructional approaches as well as evidence for appropriate approaches is unknown. The aim of the present study was to analyze and compare the impact of different instructional approaches in the acquisition of basic skills during undergraduate surgical training.

DESIGN: Randomized controlled cohort study. For the intervention, four instructional approaches ('See one - Do one', 'Video 4-Step Approach', 'Mental Group Mapping', and 'Control') were compared in six basic skills. Students completed a six-station OSCE (one for each skill) during their skills lab training week after the intervention.

SETTING: This study was conducted at the medical faculty of the Goethe University, Frankfurt, Germany.

PARTICIPANTS: Medical students in their fourth year completing their four week of obligatory surgical training.

RESULTS: A total of 151 students were included. The group 'Mental Group Mapping' scored significantly higher in comparison to 'See one – Do one' in four of the six skills and 'Control' in five skills. The group 'Video 4-Step Approach' scored significantly higher in comparison to 'See one – Do one' (three skills) in comparison to 'Control' (two skills). There were no significant differences between the approaches 'Mental Group Mapping' and 'Video 4-Step Approach' as well as between the approaches 'See one – Do one' and 'Control'.

CONCLUSION: Activating instructional approaches such as the '4-Step Approach' and 'Mental Group Mapping' have a significant impact on performing the learned skills and competencies. (J Surg Ed 76:140–149. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: teaching methods, practical skills, instructional approach, undergraduate medical education, competencies, surgical training

INTRODUCTION

Despite the increasing mechanization in medicine, clinical skills are an essential part of the medical occupation and consequently must have a main focus in medical training. The adequate attainment of the required knowledge and of sufficient competencies in clinical skills and attitudes is necessary for entering every speciality training.

The instructional approach used to teach skills and competencies seems to have a critical impact on retaining and performing the learned skills/competencies.[1-4] However, for most of the required skills and competencies, the effect of different instructional approaches as well as evidence for appropriate approaches is missing. Basic skills were especially thought to be 'naturally' acquired, and yet thoughtful attention was not given to their training.

The acquisition of clinical competence, especially of procedural (motor) skills, is affected by a multitude of cognitive aspects, such as focused attention, visuospatial

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competencies, and declarative and procedural memory capacities.[5-9] Several authors postulate that instructional approaches who stimulate and facilitate the activity of declarative memory (e.g. mental imagery or verbalization), a precedent condition for the performance of complex skills.[10,11] Thus, leading to a deeper memory processing in declarative capacities.[12]

Several studies analyze instructional approaches, e.g. for suturing.[13,14] However, a multitude of these studies compare training with no intervention or are single-group pretest-posttest studies, thus only have a small explanatory power.

Therefore, the aim of the present study was to analyze and compare the impact of different instructional approaches in the acquisition of defined basic skills during undergraduate surgical training.

MATERIAL AND METHODS

Study Design

This study is a comparative effectiveness research study aiming to detect the influence of different instructional approaches on the acquired practical skills during undergraduate surgical training.

Study Participants

Study participants were undergraduate medical students at Johann Wolfgang Goethe University in Frankfurt/Main, Germany in the fourth year of a six-year program completing their obligatory surgical training. The training was preceded by the lecture series "Introduction to surgery" in the first half of their third year and the "Main lectures in surgery" in the second half of the third year. Students' attendance of the lectures is optional. However, both lecture series end with obligatory multiple choice examinations.

In the study, participation was voluntary and took place after written informed consent, which was revocable at any time. Students were blinded towards the used instructional approaches as well as affiliation to any study group. Basic data regarding student age, sex, and duration of study were collected using a questionnaire.

The study was conducted according to ethical principles of the Helsinki Declaration (Ethical Principles for Medical Research Involving Human Subjects) and was approved by a local ethics committee.

Study Protocol

The first week of their four week obligatory surgical training takes place in the skills lab as 'training week of practical clinical skills in surgery'.[15]

This week consists of 12 teaching units for basic general and surgical skills. The training concept is based on a learning spiral in order to repeat and enlarge the skills in the subsequent unit and gives all students the possibility to acquire and master basic surgical competencies. It is designed based upon the learning objectives for practical skills defined in the national competency-based catalogue of learning objectives in surgery from the German Society of Surgery.[16] Practice, feedback, and correction in a supportive environment were the operational rules of the training. The training has a capacity of 48 students per week with a maximum of 6 students per group and tutor.

On day one, students rotate through four 90-minute training units of basic clinical and surgical principles (Fig. 1**a**). These training units are taught by peer tutors.

From the second to fifth day, students rotate through eight 210-minute training units (Fig. 1**b**), which are partly taught by surgical specialists.

Following the first week, students pass through three weeks of surgical rotation in the associated hospitals with participation on the ward, the ambulance, and in the operation theatre in order to integrate and apply the acquired surgical knowledge and skills under supervision in daily clinical practice.

Intervention

For the intervention, six skills were analyzed, including three general basic skills (insertion of an intravenous line, performance and analysis of a bedside test, and removal of a central line) and three basic surgical skills (replacement of a complex wound dressing, sterile covering, and performance of a simple-interrupted suture). These skills were chosen based on the definition in the national competency-based catalogue of learning objectives that suggests that students should be able to perform these skills in an experienced and independent manner at the end of their training.[16]

The existing tutoring manuals for each unit were reworked and adopted for the study purpose for each skills and for each instructional approach. Each manual consists of a detailed schedule and workflow as well as a step-by-step checklist to ensure a standardized sequence of each training. For further quality assurance and standardization, a PowerPoint presentation was designed for each skills and instructional method including pictures or videos dependent on the instructional approach. All tutors received a detailed training, where each skill was demonstrated and trained in each of the instructional approaches, and the correct performance of each instructional approach was trained. As part of the study, there were two tutors in each unit in order to supervise each other on adherence to the defined quality standards

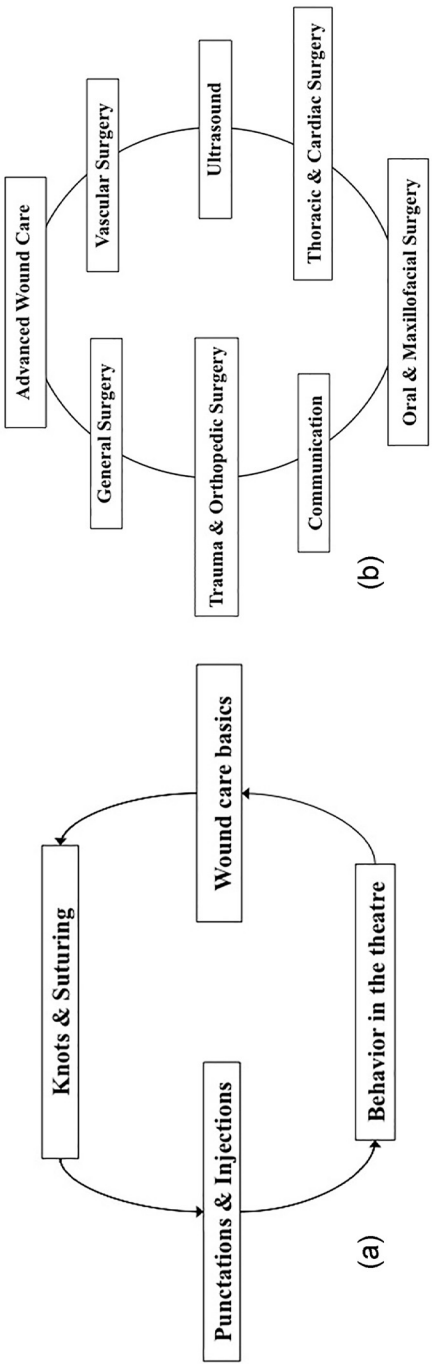

FIGURE 1. (a) and (b) Teaching units of the surgical skills training week. (a) Day 1: Students rotate through four 90 minutes training units. (b) Day 2 to 5: Students rotate through eight 210 minutes training units.

corresponding to the manual, checklists and schedule, and, furthermore, to assure a close supervision of the students.

Three instructional approaches ('See one - Do one', 'Video 4-Step Approach', 'Mental Group Mapping') as well as the existing approach for the teaching units ('control') were compared.

See One – Do One Approach

This approach is labeled as the main component of clinical-bedside teaching. Students learn by watching an expert explaining and demonstrating a skill. This is followed by the first independent performance of the skill, which is mostly with a patient.[17] As quality assurance and standardization for the demonstration of each skill from the trainers, each skill was videotaped based on the existing manual and checklist. The trainer demonstrated the video and explained the skill step-by step in detail using the PowerPoint presentation. The explanations were predetermined in the manual and trained in the tutor training. Subsequently, students could practice the skill under supervision and, if needed, correction of the tutor. Each student should train each skill at least once.

Video 4-Step Approach

The 4-step approach was initially described by R. Peyton and has since been implemented in many parts of medical education and advanced training.[18-20] It consists of 4 fixed instructional steps. First, the trainer demonstrates the skill without any comments at a real-time pace. Second, the trainer demonstrates the skill slowly and describes the skill in detail step-by-step. Third, the trainer performs the skill under the detailed step-by-step instruction of the trainee, whereupon the trainer only performs what is instructed. Fourth, the trainee performs the skills by himself. The efficiency of the 4-step approach could be demonstrated for individual skills 'in-vitro' with mostly only small numbers of study participants.[2,19,20] It is postulated that the verbalization of skills and the instruction of others leads to a deeper and more elaborate memory processing in declarative capatities.[1,12] The effects of using the 4-step approach within curricular training ('in-vivo') is rarely analyzed.

The utilization of video for steps 1 and 2 enables a higher standardization of the demonstration of the skills, especially within the curricular training with many students, many trainings, and many trainers, who tend to present the skill with their own individual stamp.[21]

As described above, each skill was videotaped. For step 1, the video was demonstrated without any comments. For step 2, the trainer demonstrated the video and explained the skill step-by-step in detail using the PowerPoint presentation. The explanations were

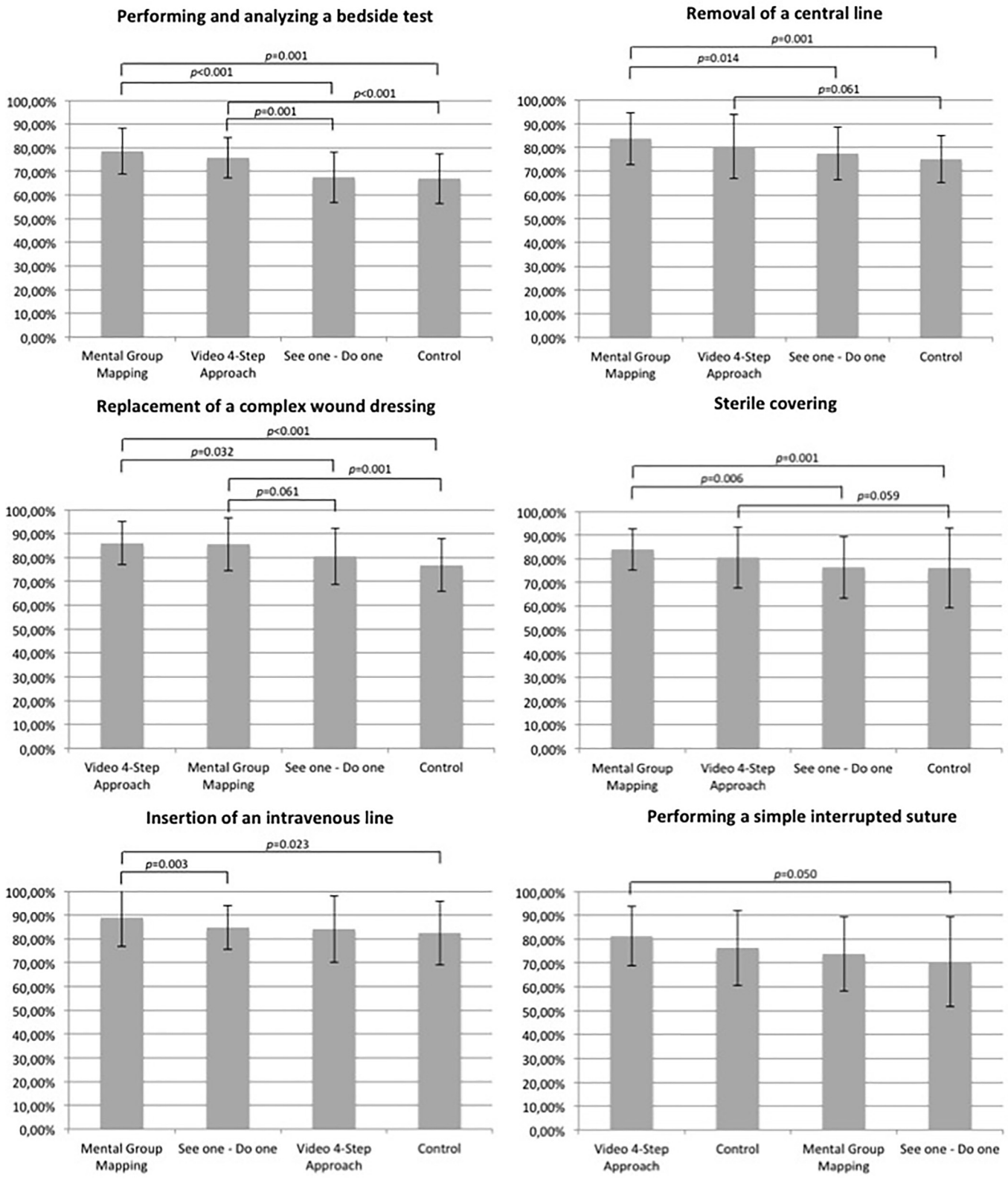

FIGURE 2. Results of the instructional approaches for each skill.
Each score presented as mean percentage (± standard deviation) of the maximum possible score for each skill.

predetermined in the manual and trained in the tutor training. Steps 3 and 4 were performed as described by R. Peyton. Subsequently, students could practice the skills under the supervision and, if needed, correction of the tutor. Each student was advised to train each skill at least once.

Mental Group Mapping

The instructional approach 'Mental Group Mapping' was developed by MR for the present study. It is based on mental training as well as algorithm-based learning. The approach of mental training is widely used in high performance sports. The correspondent activity is consciously imagined step-by-step without the real performance. Several authors describe the positive learning effects of this method in medicine, e.g., for advanced surgical training of laparoscopy.[22-25] An algorithm is defined as a path of action toward the solution of a problem or a certain type of problems. This corresponds to the mode a learner is mentally subdividing a competence in several steps (mapping) in order to memorize it in declarative memory.[12]

For the approach of 'Mental Group Mapping', the students actively developed a detailed, step-wise sequence of the particular skill under the supervision of the tutor on index cards. Thus, they could furthermore visualize the sequence of the skill. Students were enabled to set their points of intersection individually. Based on the manual and the checklist, the tutor had a detailed, stepwise description of the skill and the desired algorithm. Thus, the tutor's role was to guide the group and integrate missing steps or correct the sequence, if required.

Students were asked to imagine the skill step-by-step. One student performed the skills based on the prepared algorithm under the supervision of the other students. Subsequently, students could practice the skills under the supervision and, if needed, correction of the tutor. Each student was advised to train each skill at least once.

Control

Students in the group 'control' received their training in the existing 'traditional' approach for the teaching units. Here, for each unit, the particular skills are described in the manual and defined in the checklist. However, there is no standardization like a schedule or a video/presentation. The final performance is dependent on the individual tutor. Usually, a short interactive lecture is followed by a demonstration of the skill by the tutor or a volunteer trainee with subsequent individual training under supervision and correction of the tutor. Each student was advised to train each skill at least once.

Assignment of the Students to Instructional Approaches of the Skills

The assignment of students to one of the 8 learning groups per training week with a maximum of 6 students per group who pass through the teaching units together occurred prior to the training week independent of the authors and independent of study participation by the deanery. The allocation of the learning group in the study to the 3 instructional approaches and the traditional approach took place as described in **Table 1**.

Outcome Measures

In order to assess the acquired competence in the skills of the study, the OSCE-format was used.

For the present study, during their training week, students completed a six stations-OSCE (one for each skill). A trinary scoring scale was used (0 points for *not done*, 1 point for *done, but incorrect*, 2 points for *done and correct*) for the checklist, which was based on the checklist used in the tutor manual. A time-frame of 5 minutes to complete each OSCE station was given. Subsequently, students received a short feedback regarding their performance inclusive suggestions for improvement. The examiners were blinded toward the students' instructional approach and affiliation of learning group. The examiners received a training before the OSCE in order to gain experience in the use of the checklist.

Data Analysis

Statistical analysis was performed using SPSS 19.0 (SPSS Inc., Chicago, IL). The distribution of the data was verified as Gaussian using the Kolmogorov–Smirnov test. Data are presented as means ± standard deviation; if not, they are indicated differently. Data were then analyzed using a mixed model ANOVA followed by posthoc comparison on the total scores. Significance levels were set to $p < 0.05$. The educational effect size was calculated using Cohen's d. By convention, if the effect size is 0.5 or less, it is considered to be 'small'; if it is greater than 0.5, it is considered to be 'medium'; and if it is greater than 0.8, it is considered to be 'large.'

RESULTS

Of the 173 students who completed their surgical training during the study period, 157 students consented to participate in the study. Six students were excluded, as they did not participate in all 6 OSCE stations. Therefore, a total of 151 students were included in the data analysis. The characteristics of the four groups are shown in **Table 2**.

TABLE 1. Allocation of Instructional Approach and Skill to Learning Groups

Learning group	1/5	2/6	3/7	4/8
Skill				
– , **insertion of an intravenous line'**	See one – Do One	Mental group mapping	Video 4-step approach	Control
– , **performing and analyzing a bedside test'**				
– , **removal of a central line'**				
(Unit: punctations and injections)				
– , **replacement of a complex wound dressing'**	Mental group mapping	Video 4-step approach	See one – Do One	Control
(Unit: wound care basics)				
– , **sterile covering'**	Video 4-step approach	See one – Do One	Mental group mapping	Control
(Unit: advanced wound care)				
– , **performing a simple-interrupted suture'**	Video 4-step approach	See one – Do One	Mental group mapping	Control
(Unit: knots and sutures)				

All instructional approaches were feasible as envisaged within the given time frame in the curriculum. Though, both instructional approaches 'Video 4-Step Approach' and 'Mental Group Mapping' are more time-consuming until the students practice themselves under supervision. This aspect was already presumed within the study design, and thus, the timeframe for students' self-practice was a planned variable in order to fit into the given time frame of the curriculum. That way, the students of the groups 'See one - Do one' and 'Control' had more self-practice-time (approx. 10-15 min per skill).

The results of the OSCE (Fig. 2 and Table 3) demonstrate that the students achieved significantly higher scores if taught using the 'Mental Group Mapping' in comparison to 'See one – Do one' and in comparisson to 'Control'.

Students taught with the instructional approach 'Video 4-Step Approach' achieved significantly higher scores in comparison to 'See one – Do one' and in comparisson to 'Control'.

There were no significant differences between the approaches 'Mental Group Mapping' and 'Video 4-Step Approach' for all of the investigated skills as well as between the approaches 'See one – Do one' and 'Control'.

There were no significant differences between sex, number, of previous OSCE and number of previous clinical electives regarding the investigated skills or the investigated instructional approaches.

DISCUSSION

The proper performance of a skill is highly relevant in daily clinical practice, and if performed inaccurately can harm the patient. The aim of the present study was to analyze the effect of different instructional approaches for teaching the performance of basic general and surgical skills.

We were able to demonstrate that students performed better in 4 of 6 skills if taught via 'Mental Group Mapping' and in 3 of 6 skills if taught via 'Video 4-Step Approach' in comparison to 'See one - Do one'. In the existing literature, we were able to identify only few studies with a comparable study design. Krautter et al. compared the '4-Step Approach' with 'See one – Do one' for the skill 'insertion of a nasogastric tube'.[2] The study did not demonstrate any differences in the stepwise performance between both approaches; however, students with the '4-Step Approach' demonstrated better patient–doctor communication and were able to perform the learned skill faster for the first time. Rossettini et al. demonstrated that the '4-Step Approach' is

TABLE 2. Study Group Characteristics
For the Items 'Age', 'Years of Study', 'Number of Previous OSCE' and 'Number of Previous Clinical Electives', Data are Presented as Mean ± Standard Deviation

Learning group	1/5	2/6	3/7	4/8	Total
Number of participants	41	38	35	37	151
Male	13 (31.7%)	14 (36.8%)	11 (31.4%)	12 (32.4%)	50 (33.1%)
Age (years)	24.3 + 2.6	24.1 + 2.8	23.3 + 2.6	24.1 + 2.7	24.0 + 2.6
Duration of study (years)	3.7 + 0.4	3. + 50.2	3.7 + 0.5	3.6 + 0.4	3.6 + 0.4
Number of previous OSCE	1.1 + 0.6	1.0 + 0.0	0.94 + .2	1.0 + 0.0	1.0 + 0.3
Number of previous clinical elective	1.2 + 0.7	1.0 + 0.7	1.1 + 0.7	1.0 + 0.7	1.1 + 0.7

more effective than 'See one – Do one' regarding the teaching of manual skills to physiotherapy students.[26] However, based on their study design, the group 'See one – Do one' had a demonstration of each skill as 'See one' followed directly by the assessment without any student self-practice ('Do one'). The intervention group '4-Step Approach' received the complete 4-Step Approach including self-practice and consecutive detailed structured feedback. Afterwards, students had their assessment. Students of the '4-Step Approach' performed significantly better. Romero et al. demonstrated that medical students who were taught laparoscopic suturing and knot tying using the '4-Step Approach' outperformed students taught by 'See one – Do one', but this study is restricted in its explanatory power because of the small number of participants.[27] Compared with the studies outlined above, all our study groups in the present study had the possibility to self-practice each skill under supervision at least once before the assessment and we could include a large number of participants.

The instructional approach 'Mental Group Mapping' was implemented in curricular training for the first time. It combines the mental imagination and the verbalization of a skill similar to the '4-Step Approach'. It is postulated that compared to the pure observation, the mental imaging and the verbalization of a procedure leads to a deeper and more thorough memory processing in declarative capacities, which is a precedent condition for the performance of complex skills;[10-12] thus, leading to a more accurate acquisition of motoric skill.[28-30] Tying new learning objectives in with existing previous knowledge promotes the learning process. In the presented instructional approach, the determination of existing previous knowledge does not occur using any kind of testing, but the learners must apply it directly to the actual problem-solving process.[31,32] The learners are actively involved in the learning process by the self-dependent development of the algorithm. Furthermore, the discussion of the development of the algorithm with weighting each contribution as well as the accurate wording of each step and the definition of the sequence of the steps increases the active involvement of the learners. Besides, the group process stimulates the individual reflection upon the skill.[33-35]

With the present study, we were able to demonstrate that the instructional approach 'Mental Group Mapping' is a feasible (within the given time frame and with the same number of tutors) and effective method to learn general and basic surgical skills comparable in the acquired competencies to the '4-Step Approach' and significantly superior to the competencies acquired if using the 'See on – Do one'. However, there were considerable advantages and disadvantages of both instructional approaches in the practical implementation.

Using the '4-Step Approach' in its original form, the skills are performed 4 times. Especially for surgical skills, the hygienic and often sterile aspects of a performance including the correct opening of the wrapping under sterile conditions are of high importance. This implies a high consumption of material and equivalent high costs for training via the '4-Step Approach'. Using the 'Video 4-Step Approach', the costs for material could be reduced half, as materials are needed only for steps 3 and 4. In addition, the video increases the standardization of the skill by reducing the individual style of the trainer.

In our study, in comparison to 'Mental Group Mapping', the 'Video 4-Step Approach' was more feasible for skills, where the students had none to little previous knowledge. For skills, where the students have previous knowledge and for complex, time-consuming skills, learning a skill demonstrated by the teacher three times—even though the third time was under the instruction of a student—becomes quickly boring and students are no longer attentive.

TABLE 3. Differences and Educational Effect Sizes of Each Instructional Approach for Each Skill

		Mental group mapping vs. See one – Do One	Mental group mapping vs. control	Video 4-step approach vs. See one – Do One	Video 4-step approach vs. control	Video 4-step approach vs. mental group mapping	See One – Do One vs. Control
Performing and analyzing a bedside test	*p*	**<.001**	**<.001**	**0.001**	**<.001**	0.209	0.821
	d	1.060	1.122	0.834	0.897	0.298	0.051
Insertion of an intravenous line	*p*	**0.003**	**0.023**	0.357	0.704	0.509	0.821
	d	0.377	0.499	0.056	0.118	0.363	0.198
Removal of a central line	*p*	**0.014**	**0.001**	0.294	0.061	0.263	0.333
	d	0.564	0.815	0.241	0.446	0.264	0.221
Replacement of a complex wound dressing	*p*	0.061	**0.001**	**0.032**	**0.001**	0.867	0.172
	d	0.437	0.794	0.509	0.905	0.036	0.325
Sterile covering	*p*	**0.006**	**0.001**	0.164	0.059	0.284	0.687
	d	0.662	0.572	0.315	0.594	0.297	0.211
Performing a simple interrupted suture	*p*	1.000	1.000	**0.050**	1.000	0.372	1.000
	d	0.191	0.159	0.669	0.341	0.518	0.335

On the contrary, the instructional approach 'Mental Group Mapping' depends on the learners' previous knowledge. Learners should possess at least a rough perception for parts of the skill. The conjunction of the varying previous knowledge from the individual students in the learning group develops the detailed algorithm of the skill.

This study had some limitations. Based on our study design, we were not able to analyze the long-term retention of the acquired competencies and the effect of the instructional approaches on students' behavior and performance of the skills on the wards and patients. Here, further studies are required. The study was, however, conducted within a single cohort of medical students at a single medical school. This might restrict its explanatory power and its transferability to other medical schools; however, it does not diminish the large sample size and the significant results. Regarding feasibility, all analyzed instructional approaches should be applicable at other medical schools with adequate tutor training.

CONCLUSION

The instructional approach has a significant impact on preforming the learned skill/competency. Activating instructional approaches such as the '4-Step Approach' and 'Mental Group Mapping' are superior to the traditional 'See One Do One' approach.

COMPETENCIES

Practice-Based Learning and Improvement, Professionalism

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