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INVITED PAPERS

Deconstructing forearm casting task by videos with step-by-step simulation teaching improved performance of medical students: is making working student's memory work better similar to a process of artificial intelligence or just an improvement of the prefrontal cortex homunculus?

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Abstract

Purpose To compare two teaching methods of a forearm cast in medical students through simulation, the traditional method (Trad) based on a continuous demonstration of the procedure and the task deconstruction method (Decon) with the procedure fragmenting into its constituent parts using videos.

Methods During simulation training of the below elbow casting technique, 64 medical students were randomized in two groups. Trad group demonstrated the entire procedure without pausing. Decon group received step-wise teaching with educational videos emphasizing key components of the procedure. Direct and video evaluations were performed immediately after training (day 0) and at six months. Performance in casting was assessed using a 25-item checklist, a seven item global rating scale (GRS Performance), and a one item GRS (GRS Final Product).

Results Fifty-two students (Trad $n = 24$; Decon $n = 28$) underwent both day zero and six month assessments. At day zero, the Decon group showed higher performance via video evaluation for OSATS ($p = 0.035$); GRS performance ($p < 0.001$); GRS final product ($p < 0.001$), and for GRS performance ($p < 0.001$) and GRS final product ($p = 0.011$) via direct evaluation. After six months, performance was decreased in both groups with ultimately no difference in performance between groups via both direct and video evaluation. Having done a rotation in orthopaedic surgery was the only independent factor associated to higher performance.

Conclusions The modified video-based version simulation led to a higher performance than the traditional method immediately after the course and could be the preferred method for teaching complex skills.

Keywords Simulation · Undergraduate medical students · Peyton's 4-step approach · Surgical education · Halsted's see one do one approach · Forearm cast

Introduction

Over the last decades, many studies [1] have demonstrated that training clinical skills in surgical education are probably insufficient. Traditionally, the phrase "see one, do one, teach one" has been used to describe practical training in surgery [2]. This means that trainees, after observing a procedure, are expected to perform that procedure and can teach another person how to perform that procedure. This tradition is attributed to Halsted [3] who transformed surgical education at Johns Hopkins Hospital by creating a residency program based on acquiring increasing responsibility. But due to the lack of time, the last step "teach one" often takes part without supervision in clinical practice.

Therefore, many think this method belongs to the past [4] because students cannot perform a surgical procedure after observing it only once. For some tasks, there are evident difficulties in the learning process of students, especially due to lack of attention or to the high number of information

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to remember, or to the difficulty of some technical skills such as doing a plaster [5–7] for orthopaedic residents. Early in their clerkship, medical students have to manage injured patients under supervision. Students are expected to learn casting technics in medical school, and acquiring plaster forearm skills is one of the challenges for residents in orthopaedics. Trainees must master various difficulties arising from new material perception as plaster, altered tissue (fracture, oedema), and the difficulty of manual intervention with plaster changing of consistency during the process.

Therefore, medical education has incorporated new tools [8] to favour the learning processes, facilitate knowledge acquisition and improve the transmission of information. As one of these tools, "deconstruction" applied to education was one of the innovations. The "4-step Approach" was proposed by Rodney Peyton in 1998 [9] to teach clinical competence and procedural skills. Peyton adopted deconstruction in four steps for teaching clinical skills: (1) Demonstration with the teacher performing the skill without any comments. (2) Deconstruction where the teacher repeats the technique with explanation describing the subsections. (3) Comprehension when the student describes each step. (4) Execution: The student executes the procedure step by step. This approach optimizes the process in which the student retains knowledge.

The "4-step Approach," which was first created as a teaching tool for operating rooms, is also employed in resuscitation and trauma management [10]. It is also effective in the instruction of surgical suturing [11]. However, if the method could be relatively simple for learning how to perform cast, it could be material, time-consuming, and personnel-intensive. A possible strategy to reduce personal and material investment is to move from the "4-step Approach" to educational video stimulation [10]. According to several studies, using films in place of "steps 1 and 2" have no negative effects on the teaching strategies [12]. In order to compare a modified video-based "4-step Approach" to the standard "see one, do one" method, we replaced steps 1 through 3 with instructional videos.

Our study was based on the hypothesis that in teaching a forearm plaster cast the execution of all training steps (according to Peyton) is superior to the traditional "see one, do one, teach one" model. This hypothesis was tested on 2 groups of trainees (one group with continuous video according to the traditional "see one and do one" and one group with the Peyton technique and sequential videos) to do plasters. Then, an instructional video was made to be shown during the course. In this video, the cast application technique was broken down into the predefined sequential tasks accompanied by small descriptive texts and audio clips.

Learning to do a cast with a deconstruction process on a video is a process [13] of working memory (how to remember) associated to an executive function (how to do); this process is located in the prefrontal cortex [14] that has long been thought to subserve both working memory and "executive" function. Therefore, we also discussed in this article whether making working student's memory work better is just an improvement of the prefrontal cortex homunculus, or can be considered similar to a process of artificial intelligence [15].

Material and methods

The study was reviewed and approved in 2019 by the Research and Ethics Committee of Paris Saclay University (CER-Paris-Saclay-2019–046).

Study participants

The population of the 144 participants in this study was undergraduate medical students (fourth-year medical school) at Paris-Saclay University in September 2020. Prior to engagement in clinical duties, they were given a one week practical course on the basic skills required for the incoming year such as lumbar puncture, peripheral venous catheter placement, skin suturing, and cast application. Participants were voluntary and had no knowledge of the didactic principles. All participants did not know the casting technique principles.

For logistical reasons, the promotion of students was separated evenly into two groups (flowchart in Fig. 1) by the medical school staff and listed in alphabetical order. Thus, one group was trained by traditional teaching (Trad–control group) and the other by task deconstruction (Decon–experimental group). Thirty-two students from each group were selected randomly to participate in the study. Students were informed that evaluation would not be summative and used only for research purposes. Written informed consent was obtained from each participant for study participation and video recording.

Cast application course

Courses were delivered in the simulation center and started with a basic knowledge session on indications and cast application techniques followed by a practical session. Duration of the course was approximately one hour and 30 min, with 30 min allocated to basic knowledge and 60 min to practical training. Duration of these sessions was identical between groups. Although the formats of the basic knowledge session were different between groups, they contained identical information on each step of casting. During the practical session, instructors (senior orthopaedic surgeons), setting, material, and equipment required for the cast were the same for each group, with one instructor for six students.

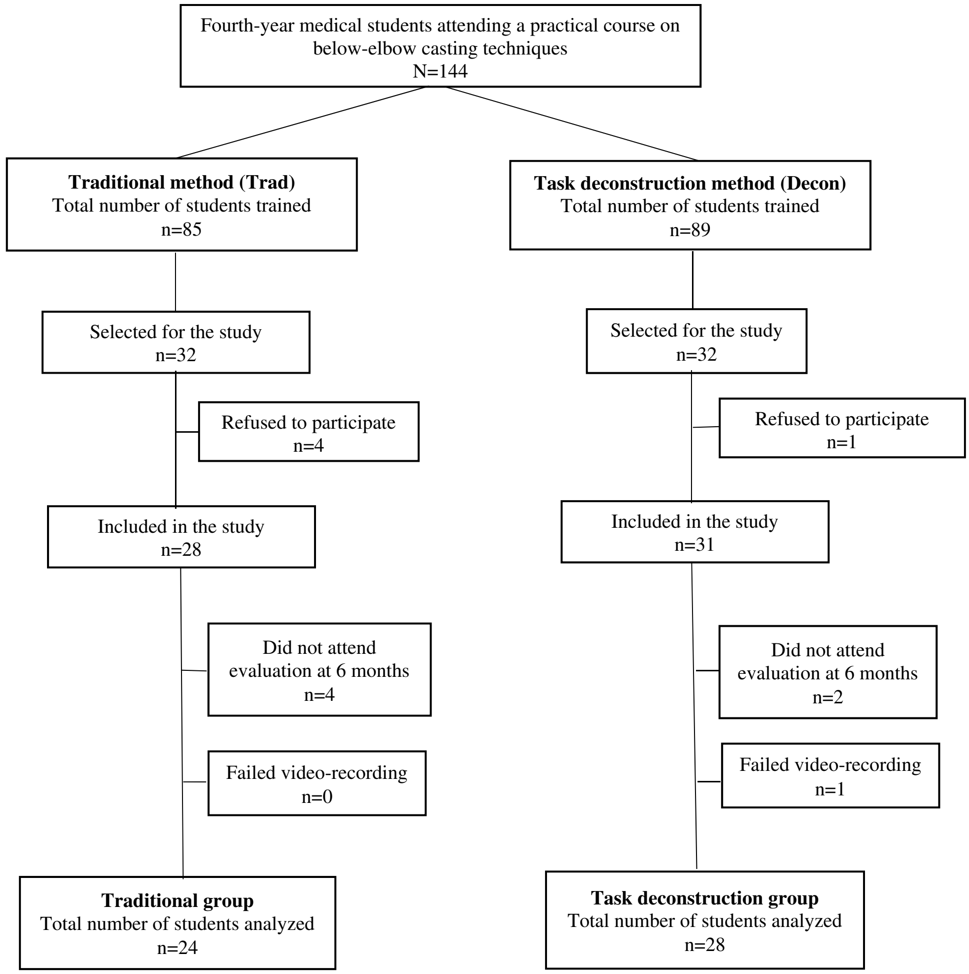

Fig. 1 Flowchart of the study

Traditional method: "see one, do one approach"

During this approach, students first watch a senior orthopaedic surgeon demonstrating and explaining the entire cast application with a PowerPoint presentation and directly on a simulated patient. The instructor first demonstrated the entire cast application technique continuously with explanations but without pausing at each step. Then each student performed a cast under supervision with feedback on their performance and, if needed, receive correction from the tutor. Each student practiced a plaster once.

Task deconstruction method (experimental group)

The technique of casting was deconstructed in a video containing ten short video clips:

1. Video 1 Introduction: introduce oneself, check identity, notify the patient, and obtain consent
2. Video 2 Equipment description: stockinette, roll padding, plaster casting material (7.5 to 10 cm;3- to 4-inch width), strong scissors, lukewarm water and a bucket, and nonsterile gloves.
3. Video 3 Patient positioning: The patient is positioned allowing an appropriate access to the upper extremity. The patient is seated and the elbow is supported on a flat surface (table). During casting the elbow should be positioned in 90° flexion, and the wrist immobilized in the neutral position.
4. Video 4: Stockinette placement: extend about 5 to 10 cm proximal and distal to the surface where the plaster will be applied. But the cast should cover only the area starting from a line proximal to the metacarpophalangeal joints and the distal palmar crease to the two proximal thirds of the forearm.
5. Video 5: Soft roll wrapping (2 layers) circumferentially from distal to proximal; covering the area before applying plaster.
6. Video 6: Plaster immersion: hold the extremity in one hand while immersing plaster roll in water, wait until bubbles stop, and squeeze excess water.
7. Video 7: Plaster application: apply the plater circumferentially from the metacarpophalangeal line to the

distal third of the forearm; place circumferentially two layers of plaster, each layer overlapping the underlying roll layer by half the width of the plaster material. Leave about 3 cm of the padding and stockinette at the end of the casting material.

8. Video 8: Molding: Apply pressure with palmar thenar eminences and smooth out casting material to conform to the forearm's contour.
9. Video 9: Fold back the stockinette before applying the last layer of plaster material to cover the edges of the cast and create a smooth edge.
10. Video 10: Final check and information: check patient's pain, finger aspect, and range of motion. Deliver information on risks and precautions associated to cast.

For this method, the "4-step Approach" was modified. For step 1, the instructor just displayed the video without offering any comments. For step 2, the 10 video clips were explained individually in detail. For step 3, the video clips were halted sequentially with the students having to describe the subsequent step video before it was then played. Then, students practiced the cast step-wise under close supervision and, as necessary, obtained guidance from the trainer.

Outcomes

Cast application performance (day 0 and 6 months)

Evaluation of students' competency took place immediately after the practical session (day 0) and was used as the main outcome measure. In order to assess skill retention, evaluation was repeated six months later with no additional session in the meantime. Each time, participants were asked to complete a below-elbow cast on a simulated patient while being video-recorded. The scenario stipulated that the patient was in the emergency department for a non-displaced distal radius fracture. Both groups were provided with the same equipment and material required to perform the cast (i.e., tubular stockinette, soft bands, plaster bands, scissors, gloves, basin, and water). Communication with the patient and casting technique was thoroughly assessed by one of four senior orthopaedic surgeons, regardless of the teaching group. Also, a video assessment of de-identified videos was also carried out several weeks after each course to ensure evaluators could not recall the student's group. Therefore, on day zero and at six months, participants underwent two types of evaluation, namely (1) a direct and unblinded evaluation and (2) a video and blinded evaluation based on the de-identified video.

Evaluation was performed using three previously validated scales [16] that were modified to include items on communication with the patient (identity check, explanation of the need for casting, information on potential complications, …): (1) the Objective Structured Assessment of Technical Skills (OSATS) checklist of 25 items scored 0 or 1 point with a maximum score of 25 (Table 1); (2) a Global Rating Scale for the performance (GRS Performance) expressed as a mean of 7 items rated on a 5-point Likert scale (Table 2); (3) a Global Rating Scale for the quality of the final product (GRS Final Product) on a 5-point Likert scale (Table 2). Duration (in minutes) of cast application, from handling of the stockinette to the end of molding, was recorded in a standardized fashion.

Course satisfaction (day 0)

Students' satisfaction with the course was collected using a standardized end-of-session evaluation form. The 6-item form consisted of specific questions assessing the overall quality of the workshop on a 10-point Likert scale (from 0 strongly disagree to 10 strongly agree).

Potential factors affecting performance (at 6 months)

At the six month evaluation, additional information was collected to look for factors that may influence student performance. Students were asked whether they would consider a career in surgery; whether they had applicated a cast on a real patient and/or had done an orthopedic surgery rotation after the course. They were also asked to self-report their level of knowledge of the casting procedure and mastering of the technique.

Statistical analysis

The sample size was calculated based on measurements using the modified 25-item OSATS checklist obtained at the evaluation at six months. We hypothesized that the group with traditional learning would have an average score value of 15/25 and the contribution of innovative learning would improve the score result by at least one standard deviation (±4/25) (preliminary local data). Using a two-sided analysis (alpha 0.05; 1-beta 0.9), the number of subjects necessary to include was 22 students per group. Thus, 32 students were included in each group to take into account a 30% potential attrition rate at 6 months (refusal, loss of follow-up). In order to determine normalcy, the Shapiro-Wilks' test was employed. The data are displayed as mean percent standard deviation. End-of-session satisfaction auto-questionnaire responses as well as casting competency, measured by each evaluation scale, were compared between groups, using two-sided Student's *t*-tests. Univariate analyses were performed on each scale to assess whether student-related factors were associated with higher competency. Based on the available literature [10], the 5-point Likert GRS Performance and GRS Final Product outcome scales were dichotomized

Table 1 OSATS checklist scoring for below elbow circular cast

Checklist	Not done, incorrect	Done, correct
Introduction		
Introduce her/himself and check patient ID	0	1
Notify about the procedure and get consent	0	1
Setup and patient position		
Collect materials and equipment required for the cast	0	1
Patient is exposed from above the elbow to the hand	0	1
Patient is sitting or lying down with the elbow in mid-flexion resting on table or bed	0	1
The wrist and fingers are in "functional position"	0	1
Stockinette		
Stockinette is measured to span from proximal to elbow to past the MCPJs	0	1
A small snip is made in the stockinette for the thumb	0	1
Stockinette is gently unrolled over the hand and forearm	0	1
The stockinette is smoothed out, leaving no wrinkles or creases	0	1
Soft roll		
Soft roll is applied using moderate tension	0	1
Soft roll is wrapped such that each layer overlaps the previous layer by 50%	0	1
Thicker soft roll layers are applied over the palm and proximal base of cast	0	1
Soft roll coverage extends from the antecubital fossa to past MCPJs	0	1
Plaster application		
The plaster is soaked in tepid water with the free end slightly enrolled	0	1
Once out of water bath gentle pressure is used to squeeze out extra water	0	1
Plaster is applied to leave a distal and proximal border or "cuff" of soft roll and stockinette	0	1
Distal end of the first plaster layer is the distal palmar crease on palmar side and MCPJs dorsally. Proximal end of the first plaster is 2–3 cm distal to the antecubital fossa	0	1
Thumb should remain exposed at metacarpophalangeal joint	0	1
The stockinette and soft roll cuff are folded over the first layer of plaster	0	1
A second plaster layer is applied to cover the folded cuffs to leave a smooth border	0	1
Molding		
Thenar eminences of palms are used to apply pressure until mold is firm	0	1
Mold is applied firmly but retains natural contour of the arm (ovular shape)	0	1
Final check/information		
Check patient's pain, aspect and range of motion of fingers	0	1
Deliver information to patients regarding risks associated to cast	0	1
Total /25		

into binaries, where students are deemed either "competent" (≥ 3) or not (< 3), and the associated odds-ratios (OR) were estimated using logistic regressions. The modified OSATS checklist was maintained as a quantitative outcome scale, and the associated regression coefficient was estimated using linear regression.

Finally, a multivariate regression analysis was conducted on each scale to assess whether the learning method was associated with higher competency after controlling for potential student-related confounding factors. The three outcome scales (OSATS Checklist, GRS Performance, and GRS Final Product) were specified similarly as in the univariate analysis. In the models, factors which were associated with higher competency in the univariate analyses were retained. To conduct statistical analysis, we used R Foundation, version 1.3.10703.

Results

Trad group consisted of 24 students (7 males, 17 females; mean age 21.6 ± 1.6 [range 20–28]). There were 28 students (9 males, 19 females; mean age 21.2 ± 1.1 [range, 19–24]) in the Decon group. None of the students had performed a cast prior to the course.

Table 2 Global Rating Scale (GRS) of the below-elbow cast: 7-item GRS performance and 1-item GRS final product

Communication/information to patient	**1** Forget to deliver information	**2**	**3** Satisfactory	**4**	**5** Outstanding
Respect for arm/patient	**1**Inappropriate handling	**2**	3 Caused inadvertent damage	**4**	**5** Appropriate with minimal damage
Time and motion	**1** Many unnecessary moves	**2**	**3** Efficient time/motion	**4**	**5** Economy of movement
Materials handling	**1** Inappropriate use	**2**	**3** Knew materials and used appropriately	**4**	**5** No stiffness or awkwardness
Flow of casting	**1** Unsure of the next move	**2**	**3** Reasonable progression	**4**	**5** Effortless flow from one move to the next
Positioning of the patient/arm	**1** Placed arm poorly	**2**	**3** Appropriate positioning	**4**	**5** Strategically positioned arm
Knowledge of specific procedure	**1** Deficient knowledge,	**2**	**3** Knew all steps	**4**	**5** Familiarity with steps
Quality of final product	**1** **Very poor**	**2**	**3** **Competent**	**4**	**5** **Clearly superior**

Table 3 Groups comparisons of the students' performance on below elbow cast immediately after simulation training

Performance at day 0			Traditional	Task deconstruction	*p*
Checklist					
	Direct	mean ± SD	19.8 ± 2.6	21.1 ± 2.2	0.053
		min–max	15–25	17–24	-
	Video	mean ± SD	19.7 ± 2.3	21.0 ± 2.1	0.035
		min–max	14–24	16–24	-
GRS performance					
	Direct	mean ± SD	2.9 ± 0.3	3.5 ± 0.5	< 0.001
		min–max	2.4–3.7	2.4–4.1	-
	Video	mean ± SD	2.7 ± 0.2	3.3 ± 0.3	< 0.001
		min–max	2.1–3.3	2.4–4	-
GRS final product					
	Direct	mean ± SD	2.8 ± 0.7	3.3 ± 0.7	0.011
		min–max	1–4	2–4	-
	Video	mean ± SD	2.6 ± 0.7	3.3 ± 0.5	< 0.001
		min–max	1–3	2–4	-

GRS modified Global Rating Scale

p-values were calculated using Student's *t* tests

Table 4 Groups comparisons of the students' performance on below elbow 6 months after simulation training

Performance at 6 months			Traditional	Task deconstruction	*p*
Checklist					
	Direct	mean ± SD	16.5 ± 3.8	18.1 ± 3.2	0.118
		min–max	5–22	14–25	-
	Video	mean ± SD	16.2 ± 3.4	17.7 ± 3.9	0.139
		min–max	8–22	11–24	-
GRS performance					
	Direct	mean ± SD	2.7 ± 0.5	2.9 ± 0.6	0.105
		min–max	1.9–3.9	2–4.1	-
	Video	mean ± SD	2.5 ± 0.4	2.6 ± 0.6	0.745
		min–max	1.7–3.4	1.3–3.9	-
GRS final product					
	Direct	mean ± SD	2.4 ± 0.8	2.6 ± 0.7	0.28
		min–max	1–4	1–4	-
	Video	mean ± SD	2.3 ± 0.8	2.6 ± 1.0	0.272
		min–max	1–4	1–5	-

GRS Global Rating Scale

p-values were calculated using Student's *t* tests

Cast application performance (day 0 and 6 months)

As regards to students' performance on day 0 (Table 3), the Decon group showed statistically significant higher performance on scores at the OSATS checklist via video evaluation ($p = 0.035$) but no statistical difference via direct evaluation ($p = 0.053$). GRS Performance and GRS Final Product scores, respectively, were higher in the Decon group via video evaluation ($p < 0.001$, $p < 0.001$) and direct evaluation ($p < 0.001$, $p < 0.011$).

After six months, a moderate overall decrease in students' performance was seen in both groups with no difference in competency between groups according to the three scales (Table 4).

Cast application duration on day 0 was shorter in the Decon group, namely 7.9 ± 1.5 min (range, 6–12 min) versus 9.2 ± 1.6 min (range, 6.5–12.5 min) ($p = 0.016$). Groups (at 6 months) showed no significant difference: Decon = 8.8 ± 1.7 min (range, 5.5–12.5 min) and Trad = 8.9 ± 2.1 min (range, 5–13 min) ($p = 0.939$).

Factors influencing performance (6 months)

The multivariate analysis (Table 5) revealed that having done a rotation in orthopedic surgery was an independent factor associated with a higher performance on scores at the OSATS checklist and GRS performance.

End-of-session questionnaire (day 0)

Irrespective of the training method, students appeared satisfied with the course (Table 6). There was no difference between the two methods for each item except for the comprehension of the technique which was slightly higher in the deconstruction group (9.3 ± 0.7 vs 8.7 ± 0.9, $p = 0.034$).

Discussion

Teaching practical skills to medical students should be done in a simulation centre [18]. The "see one–do one" method has long been the traditional method. More recently, task deconstruction in several small steps (as referred to Peyton's approach) has shown benefits in learning various complex procedures [19]. This randomized study compared these two methods to teach casting to medical students through simulation and demonstrated as follows: (1) The deconstruction method provided better immediate skill acquisition.; (2) skills moderately decreased at the six month evaluation and became similar in both groups; (3) having worked in an orthopaedic environment during the six months following the course was the only factor affecting skill retention; (4) students' course satisfaction was high in both groups.

Results of the end-of-session questionnaire showed a high level of satisfaction irrespective of the method used. In fact, it was shown in other studies that procedural training with simulation stimulates interest in surgery [17, 18] and pleasure to learn [19]. Additionally, when requested to conduct procedures on live patients, medical students just beginning their clinical years frequently experience anxiety [20, 21]. By offering them to improve their knowledge and skills in a safe environment, these sessions of simulation tend to help students gain confidence on practical skills they might fear starting their surgical clerkship.

The Peyton's deconstructive approach [22, 23] is a promising method for learning to perform upper limb plaster. This method with video simulation [24–27] helps comprehension in a time-saving manner since trainees are able to achieve better scores with this approach. This is the initial study with residents for a plaster training model. In order to evaluate the effectiveness of this method for residents in trauma surgery, it should be assessed in with other plasters.

This study has limitation as the tiny number of participants. Although there are few participants in a single

Table 5 Factors associated with student's competency at 6 months: results from multivariate analyses

Scale	Type of évaluation	Variable: Trained by task deconstruction			Did a rotation in orthopedic surgery			Self-reported knowledge of casting procedure		
		Coeff/OR	IC95 interval	p	Coeff/OR	IC95 interval	p	Coeff/OR	IC95 interval	p
Checklist	Direct	0.63	−1.33–2.58	0.522	3.41	0.75–6.06	**0.013**	0.45	−0.18–1.09	0.160
	Video	0.40	−1.53–2.34	0.672	4.98	2.21–7.75	**<0.001**	0.48	−0.15–1.12	0.132
GRS Performance	Direct	1.52	0.41–5.78	0.528	8.21	1.46–71.26	**0.027**	1.29	0.87–1.97	0.219
	Video	1.45	1.01–51.97	0.057	6.36	1.01–51.97	**0.050**	1.60	1.03–2.69	0.052
GRS final product	Direct	1.44	0.46–4.62	0.532	1.76	0.35–10.03	0.495	1.03	0.73–1.47	0.852
	Video	1.77	0.55–5.84	0.342	3.05	0.53–24.86	0.235	1.17	0.82–1.71	0.383

For the Checklist, we used linear regressions to estimate the regression coefficients: for instance, students who did a rotation in orthopedic surgery had, on average, a checklist score 3.41 higher than other students with the "Direct" evaluation, all other included variables considered

For the GRS Performance and Final Product, we used logistic regressions to estimate the odds-ratios: for instance, students who did a rotation in orthopedic surgery were, on average, 8.21 times more likely to obtain a GRS score ≥ 3 than other students with the "Direct" evaluation, all other included variables considered

GRS Global Rating Scale

Table 6 Group comparisons of the students' responses to the end-of-session questionnaire related to the practical course on cast application (10-point Likert scale. From 0, strongly disagree to 10, strongly agree)

Question	Traditional group	Task deconstruction group	*p*
I have enjoyed the course on cast application	9.4 ± 0.9	9.4 ± 0.7	0.957
I think the session in simulation was realistic	8.4 ± 0.9	8.9 ± 1.2	0.098
I think the course was valuable for my medical training	9.8 ± 0.7	9.8 ± 0.5	0.832
I have understood the technique of cast application	8.7 ± 0.9	9.3 ± 0.7	**0.034**
I have preferred learning the technique through simulation	9.7 ± 0.9	9.6 ± 0.9	0.793
I am confident to apply a cast in a real situation	8.3 ± 1.1	8.4 ± 0.9	0.551

Values are expressed in means ± standard deviations

p-values were calculated using Student's *t* tests

research centre, it provides the advantage of having everyone get training from the same tutor under the same circumstances. However, given that the protocol is simple to put into practice, our study could serve as a pilot study for a multicenter collaboration if tutors with comparable backgrounds decide on a common demonstration strategy. In our investigation, the deconstructive strategy was found to be superior, at least in the first months. There are probably several explanations for this superiority.

System of memory of the traditional "see one and do one"

The fact that each situation calls for a different memory system is likely one of the causes. The classic "see one and do one" ordinary observation when looking at the instructor doing a plaster (or looking at a continuous video) provides the brain with a broad orientation of the task, similar to the first glance at a picture before doing the puzzle. Semantic memory is used in the conventional way of seeing a surgeon apply a plaster or watching a continuous movie. Semantic Memory [28] organizes words, thoughts, and symbols nearly like a kind of mental dictionary, it allows us to comprehend the world in which we live. Video is useful in developing this cognitive ability because semantic memory simply records broad facts and knowledge (rather than personal experiences). This process begins at a young age and involves the accumulation of general knowledge. Semantic Memory [29] could be viewed as a form of "unintentional learning" in which our brains "accidentally" store generic knowledge that we can then access as needed. We can instinctively understand that dogs are different from cats thanks to semantic memory, without having to rummage through our memories for a particular instance where we noticed the difference. Video content is stored in semantic memory when people cannot experience a scenario personally. We "automatically" retain facts when we employ semantic memory, such as the fact that plaster requires water and plaster rolls or that plaster changes color when it dries; we "just know it." We frequently retrieve information from this type of memory without even realizing it. It seems to be automatically saved and retrieved. Individuals, however, do not associate the video with their own circumstances.

System of memory of the Peyton deconstruction system

According to Peyton, the trainee benefits from the deconstruction step. In fact, even skilled teachers who accomplish tasks precisely sometimes forget to break them down into the individual steps an unskilled student would need. When the teacher is asked to explain the steps, he becomes aware of them and the demonstration gets more organized as a result. The deconstruction step is crucial for the trainees because they can identify the crucial parts of a complicated technique (according to Peyton's "nodal points"), and each step is recorded to his personal experience and the brain "consciously" stores exact information. The memory system differs just as there is a difference between solving a puzzle and just looking at it. An executive function and working memory [30] are both involved in the process of learning to perform a cast with a deconstruction process on a video. Working memory and "executive" function have long been considered to be functions of the prefrontal cortex, but the molecular underpinnings of their combined function are still poorly understood, frequently called homunculus function [31].

Working memory is supposed to facilitate a variety of tasks, including preparation, and problem-solving [32]. In monkeys executing a delayed matching task, Joaquin Fuster [33] captured the persistent electrical activity of PFC neurons in 1973. In primates, single-cell recordings of neurons show persistent firing, a biological feature, to be a mechanism for knowledge retention. The prefrontal cortex (PFC), parietal cortex, and other association cortices include glutamatergic pyramidal neurons that are optimized for prolonged activity, enabling the cells to produce action potentials at a high rate for several minutes. It is believed that sustained firing preserves the informational signal that the neuron encodes. When using sustained firing to briefly store mnemonic information, a PFC neuron with a background firing rate of 10 Hz (normal for cortical cells) may elevate that rate to 20 Hz. A macaque monkey participates in the experiment by watching the researcher place food under one of two similar cups. The cups are then hidden by a shutter that is lowered for a variable delay time. After a brief pause, the shutter is opened, giving the monkey one chance to grab the food. Through training, the animal learns to select the right cup on the first try. The animal must maintain the meal's location in working memory during the delay to complete the task. As the learner must remember the many videos of the plaster technique, it is conceivable that the monkey must maintain both a memory of where the food is and a motor memory of the strategy needed to collect it.

The length of sustained fire predicts whether objects will be recalled and when this delay-period activity is weak. Furthermore, performance on these kinds of tasks is noticeably worsened by lesions to the prefrontal and association cortices, which contain the neurons with the highest capacity for sustained firing. Functional magnetic resonance imaging (fMRI) studies in humans [34] demonstrate that activity in prefrontal and association areas remains during the delay phase of analogous working memory tasks, which is consistent with our animal work. In fact, the degree of neural activation relates favorably to the quantity of items people are instructed to store in their memories.

Making working student's memory work better can be considered as an improvement of the prefrontal cortex homunculus [35]. The homunculus picture represents how the brain controls different parts of the body. In the homunculus, the size of a body part is devoted to the amount of the brain related to it. In attempting to improve the student's working memory for casting, the Peyton technique deconstructs the information to encode the homunculus function better.

Similarity between artificial intelligence and working memory

For many activities to be completed intelligently, memory is a necessary component. Working memory acts as a workspace in the brain to encode information for a brief amount of time so that it can be used to direct behaviour for cognitive activities. This is similar to artificial intelligence [36] that learn from sequences of inputs employing artificial neural networks as memory for all sorts of learning systems (supervised, unsupervised, and reinforcement).

Neurons are yet another area where artificial intelligence and the human brain is similar [36]. In deep neural networks, the equivalent parts are referred to as "units." These units are interconnected, much like neurons, allowing information to pass between layers. The connections between artificial network units can also fluctuate, exactly like neurons. The strength of the path increases as more linked neurons are used. The ability of the brain to adapt or react to repeated stimulation—a phenomenon known as plasticity—underlies learning and is responsible for changes in strength in the brain. Deep networks also gain knowledge by modifying the degree of connections between their components. The output of the artificial network is reviewed after processing an input image (such as a cat), and if any mistake, it is corrected.

There will always be new developments that test and enhance our established models, both as orthopaedic surgeons and as educators. Clear expectation setting, teaching through patient interactions, providing feedback based on direct observation with an opportunity to repeat performance, and incorporating simulation [37–39] are all strategies to enhance teaching skills for the modern learning. In order to meet these challenges, orthopaedic surgeons [40, 41] must embrace a growth mentality and artificial intelligence [42–44] to adjust to the evolving demands and expectations of our patients and our trainees.

Conclusion

A pre-surgical clerkship simulation training course allowed medical students to achieve competency in the below elbow casting technique. Although competency was high in both groups immediately after training, task deconstruction was superior to the traditional method. Video material focusing on task deconstruction seems to be a useful adjunct during the didactic lecture to teach technical skills. The six month retention was moderate in both groups probably because very few students had to opportunity to apply in the clinical setting what they learned in simulation. Multimodal teaching including bed-side teaching, simulation, artificial intelligence, and so forth has become a key component in learning practical tasks.

Author contribution All the authors participated in the study. Pr Benhamou and Pr Court supervized the study.

Data Availability The set of data can be obtained on request from Dr. Bouthors Charlie.

Code availability None.

Declarations

Ethics approval The study protocol was reviewed and approved in 2019 by the Research and Ethics Committee of Paris Saclay University (CER-Paris-Saclay-2019–046). The study took place at the simulation laboratory "LabForSIMS" located at the medical school of the Paris-Saclay University. 78 Rue du Général Leclerc, 94270 Le Kremlin-Bicêtre cedex, France.

Competing interests Dr Bouthors declared travel expenses and congress registration fees covered by Medtronic outside of the present study. Pr Court received royalties from NeuroFrance spine outside of the present study. The other authors do not disclose any conflict of interest in relation with the present study.

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