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Recruiting expertise: how surgical trainees engage supervisors for learning in the operating room

Patrick Nieboer,^{1*} Mike Huiskes,^{2*} Fokie Cnossen,³ Martin Stevens,¹ Sjoerd K Bulstra¹ & Debbie A D C Jaarsma⁴

CONTEXT For centuries now, the operating room (OR) has been the environment in which surgical trainees come to master procedures. Restricted working hours and insufficient levels of autonomy at the end of their training necessitate a shift towards alternative effective learning strategies. Self-regulated learning is a promising strategy by which surgical trainees can learn more with fewer exposures. However, the challenge is to understand how surgical trainees regulate their learning in the clinical context of the OR.

OBJECTIVES The purpose of this study is to identify and understand the strategies of surgical trainees in engaging their supervisors for learning purposes and how these strategies contribute to effective learning.

METHODS Total hip replacement procedures performed by four surgical trainees and their supervisors were videotaped. Using the iterative inductive process of conversation analysis, each verbal initiative to engage the supervisor was identified, analysed ('why that now') and categorised.

RESULTS Surgical trainees used a range of practices to engage supervisors and recruit expertise, ranging from explicit recruitment to implicit hints. We identified four major categories. Surgical trainees: (i) invite the supervisor to provide an evaluation of the ongoing task; (ii) express an evaluation of the ongoing task and then explicitly invite the supervisor to provide an evaluation; (iii) express an evaluation of the ongoing task and then invite the supervisor to provide confirmation, and (iv) express an evaluation of the ongoing task without engaging the supervisor.

CONCLUSIONS Surgical trainees recruit expertise from supervisors using practices of four different categories. Trainees' actions are provoked by the moment at which they experience insufficient expertise and are focused on the task at hand in the immediate present. Supervisors can and do elaborate on these requests to provide explicit teaching. Insight into these practices provides tools for reflection on OR learning, proficiency assessment and deliberation to adapt guidance in the real time of the procedure.

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INTRODUCTION

In addition to being a complex workplace in which teams are under time and outcome pressures, the operating room (OR) in a teaching hospital is also the most important learning environment in which surgical trainees are able to master surgical skills.¹ Surgical trainees commonly start by observing and assisting expert surgeons before they execute a procedure under strict guidance. Next, in line with the Halstedian tradition of surgical training, the supervisor decreases the level of guidance until the trainee can execute the procedure alone.² Although learning in workplaces is powerful, relevant and directly applicable, it presents challenges: conditions for learning in the OR are unpredictable and hard to control, and supervisors' behaviours may have adverse effects on the learning environment.^{3,4} Moreover, in the OR patient outcome remains the overriding priority and learning is usually interwoven with the ongoing activities of the surgical procedure itself.^{5–10}

In recent decades, competency-based programmes, formative feedback and structural assessments have reshaped the traditional strategy of 'learning by doing' in the OR.^{11–15} Nowadays restrictions on working hours and gaps in autonomous task performance force surgical trainees to learn more in less time.^{16–18} One strategy that allows surgical trainees to master clinical skills and improve individual learning strategies may involve self-regulated learning (SRL).^{19,20} According to the theories of SRL, learners can deliberately develop and adapt their cognitive strategies, behaviour and interactions with the learning environment to maximise the benefits of the learning moment.^{19,20} They continuously engage in a cyclical self-regulatory process of forethought (select which strategy might be effective), performance (test the strategy) and self-reflection (assess the effect of the strategy).^{20,21} Learners' strategies may be either goal-directed (execute a specific task) or process-directed (apply a specific learning strategy).²⁰

Although SRL is appealing and effective in the academic context, its benefits in the clinical context have yet to be determined.¹⁹ Moreover, a recent systematic review of SRL in the clinical context highlighted the barriers SRL must overcome. Time and patient outcome factors affect SRL in workplaces; furthermore, SRL appears to be highly context-specific and is constructed by individual interactions between trainees and their

workplaces.^{19,22} The authors emphasised that as long as processes of learning in clinical workplaces are not clarified, SRL will struggle to be effective.¹⁹ Unfortunately, despite increasing attention in the literature towards interaction between surgical trainees and supervisors, regulation of learning in the OR remains poorly understood.^{9,10,23–26}

This study focused specifically on interactions of surgical trainees with their supervisors as procedures unfold. We applied the principles of conversation analysis and systematically isolated and analysed how trainees engaged their supervisors and recruited expertise. We were specifically interested in whether patterns of learning could be identified and reproduced amongst surgical trainees with varying levels of training.

METHODS

For this study, we focused on one specific procedure: uncemented total hip replacement. This procedure was chosen because it is highly standardised and shows relatively little variation between occasions. In the Netherlands, surgical trainees in orthopaedics follow a 6-year programme, the first 18 months of which take place in general surgery. At the end of their training, trainees' skills must include proficiency in total hip replacement surgery. In our programme, trainees are guided initially by experienced orthopaedic surgeons until they show sufficient progress, at which point scrub nurses specifically trained in total hip replacement surgery (physician assistants) take over the supervision. In this study, four surgical teams performed uncemented total hip replacement procedures at the Department of Orthopaedic Surgery at University Medical Centre Groningen. Each team consisted of a surgical trainee, a supervisor (either an orthopaedic surgeon or a specialised scrub nurse) and a scrub nurse who handled the instruments. Two surgical trainees were supervised by orthopaedic surgeons and two by the specialised scrub nurses. All activities were captured by a set of three wide-angled cameras, of which one was mounted in a fixed position and two were worn as head cameras by the surgeon and the assistant, respectively. All verbal interactions were transcribed using the Jeffersonian Transcription System.²⁷ However, in the text we present these transcripts in simplified form to facilitate understanding by readers unfamiliar with the conventions of that transcription system.

Patients, surgical trainees, supervisors and OR personnel were all informed about the study and asked to participate voluntarily before the procedure commenced. Written consent was obtained before the start of each procedure. The study was discussed by the ethics Institutional Review Board at the University Medical Centre Groningen, which confirmed that the Medical Research Involving Human Subjects Act (*Wet Medisch-Wetenschappelijk Onderzoek met Mensen* [WMO])²⁸ did not apply and thus, waived requirements for ethical approval. The Declaration of Helsinki guidelines on human research ethics were followed for all study participants.²⁹ Procedures were recorded only after the consent of each participant in the OR had been obtained. The cameras were unable to capture the faces of patients and were restricted to the field of operation. All videotaping of patients in a working environment was conducted in line with the rules of our institution.

We used conversation analysis, a ‘distinctive approach within the social sciences that aims to describe, analyse and understand talk as a basic feature of human social life’, and conducted a collection study.³⁰ Conversation analysis starts with observation; in this case the observation concerned the fact that at certain points in the surgical procedure, the surgical trainee produces verbal initiatives directed at the supervisor, which do not have a procedural function (such as a request to the supervisor to open the wound). The second step in the analysis consists of identifying and collecting a phenomenon. In this case, we were interested in the function of these initiatives (*why that now*³¹): how do surgical trainees recruit their supervisors and how do supervisors in turn respond to these initiatives (what second action of the supervisors is made relevant by these initiatives)? In order to identify these functions, we sampled all verbal

initiatives made by the four trainees. A total of 261 instances were identified. In the third step, we identified specific categories (practices) based on the form of the trainee’s utterance and the response of the supervisor, using an iterative, inductive process until no new practices were encountered (data saturation was achieved).³⁰ Analyses were conducted by the two first authors (PN and MH). Finally, we identified four distinct categories of practice.

RESULTS

In our data, all identified verbal initiatives were used to engage supervisors in task performance in the immediate present. They concerned either an evaluation of the current task or the selection of the next task. Table 1 shows the distribution over the procedures of the initiatives used by trainees to engage supervisors.

The four practices can be placed on a scale based on the recruitment and subsequent involvement of supervisors, which encompasses utterances that range from those in which the supervisor is asked for his or her opinion (request for an initial evaluation = maximum recruitment and involvement: ‘What do you think?’) to those in which the trainee him- or herself provides an evaluation of the ongoing task (minimal recruitment and involvement: ‘This is what I think’). Between these extremes lie utterances in which the surgical trainee may either provide an evaluation and ask the supervisor for an evaluation (‘This is what I think. What do you think?’) or provide an evaluation and ask for confirmation (‘This is what I think. Do you agree?’).

We will illustrate these four categories using prototypical examples of each practice. We selected

Table 1 Practices of surgical trainees to engage supervisors and recruit expertise

	Trainee (years of experience)				Total
	Trainee A (2)*	Trainee B (4)	Trainee C (5)	Trainee D (5.5)	
Length of recording, minutes:seconds	35:57*	82:52	63:42	59:25	241:56
Initial utterances to engage the supervisor or assistant, <i>n</i>	63*	90	57	51	261

* Trainee A performed only three of the total of 10 steps in the procedure.

all our examples from one step in the procedure that is particularly important to the realising of an optimal outcome: reaming the acetabulum. The acetabulum is the cavity of the hip joint in the pelvis in which the prosthesis is inserted. The surgeon adjusts the cavity by mechanically removing the bone and uses drill heads of increasing size to ensure an optimal fit.

The trainee asks the supervisor for an evaluation or instruction: ‘What do you think?’

In this category (Category 1), the surgical trainee reaches the limits of his or her experience and the procedure comes to a halt. In order to continue, the trainee needs expert information from the supervisor. The trainee then invites the supervisor to provide an initial evaluation of the situation at hand and a solution (Box 1). Only when the supervisor has supplied the requested expertise can the procedure continue. Although the trainee still physically handles the scalpel, in this instance the

supervisor decides which next action the trainee will execute.

The trainee evaluates the ongoing activity and explicitly invites the supervisor to offer a second evaluation: ‘This is what I think. What do you think?’

Instances in this category (Category 2) occur in situations similar to the first category (Category 1): the trainee encounters a problem and halts the motor action. However, rather than inviting the supervisor to provide expertise, the trainee produces an initial evaluation of the ongoing task. Only after providing an initial evaluation does the trainee invite the supervisor to provide a second evaluation (Box 2).

The trainee evaluates the ongoing activity and requests the supervisor for confirmation: ‘This is what I think. Do you agree?’

In this category (Category 3), the surgical trainee again encounters a problem in the ongoing activity

Box 1 Trainee B, 44 minutes, 49 seconds into the procedure

Line 1	Supervisor	Dit is ook goed <i>This is alright</i>
Line 2	Trainee	Oke, eh eruit <i>Okay, eh out</i>
Line 3		1.6 seconds of silence
Line 4	Trainee	Heb je daar nog een trucje voor? <i>Do you have a trick for this?</i>
Line 5		3.5 seconds of silence
Line 6	Supervisor	Hier zit ie vast erin he. Eruit slaan <i>Looks like it's stuck here, he. Hammer it out</i>
Line 7		0.7 second of silence
Line 8	Trainee	Heb je daar een uitslag voor? <i>Do you have something to remove it with?</i>

The trainee has just inserted the test prosthesis, and the supervisor provides a positive evaluation of the fit (line 1). The trainee then moves on to the next phase: removing the test prosthesis. When the trainee tries to remove the prosthesis (line 2 and 3), he feels it is tightly stuck in the pre-drilled hole. He subsequently stops the motor action. Failing to come up with a solution for this problem by himself, he makes a request to the supervisor for any hints (line 4). Before the supervisor provides a solution (line 5), she physically probes the prosthesis and gives her evaluation of the situation, providing a solution (line 6). The trainee accepts this solution and then turns to the scrub nurse with a request for a tool to extract the trial prosthesis, as suggested by the supervisor.

Instances in this category (Category 1) always follow this pattern: the trainee encounters a problem and stops the motor action. The trainee then requests expertise from the supervisor. Although the specific realisation of these requests varies, the requests always involve an explicit invitation to provide expertise and show a similarity in linguistic form. In our samples, without exception, these requests were granted. After the expertise had been supplied, the trainee continued with the procedure according to the advice of the supervisor.

Hence, the performance of the task was dependent on the supervisor's explicit advice.

Box 2 Trainee C, 28 minutes, 25 seconds into the procedure

Line 1		12.5 seconds of silence
Line 2	Trainee	Misschien wel iets meer de diepte in. Wat denk jij? <i>Maybe a little deeper. What do you think?</i>
Line 3		0.5 second of silence
Line 4	Supervisor	Nou, lijkt of op de bodem te zijn, he? <i>Well, it looks like we reached the bottom, he?</i>
Line 5	Trainee	Ja, eh, spongieus, he? <i>Yes, eh, cancellous bone, right?</i>
Line 6	Supervisor	Ja Yes
Line 7		2.0 seconds of silence
Line 8	Trainee	Ja, mooi <i>Yes, nice</i>
Line 9		0.3 second of silence

The trainee palpates the hole he just deepened with the drill head. He must now decide whether he can proceed to the next diameter of drill head. He takes an aspirator to clean the hole and remove the debris in order to be able to assess the situation (line 1). Rather than making that decision unilaterally and continuing the procedure, the trainee stops and produces an evaluation suggesting that he is not finished yet with this particular drill head (line 1). He then invites the supervisor to provide a second evaluation (line 2). The supervisor provides this second evaluation (line 4), disagreeing with the trainee's evaluation. In line 5 the trainee accepts the expert evaluation provided by the supervisor. The procedure continues as the trainee moves on to the next drill head, as suggested by the supervisor. Similarly to Category 1, in this category (Category 2) trainees encounter a problem that forces them to recruit expertise from the supervisor in order to continue. Yet rather than just requesting expertise, in these cases trainees also provide an evaluation themselves thus, clearly placing the supervisor's evaluation in second position: the supervisor provides an evaluation in response to an earlier evaluation given by the surgical trainee. In our data, supervisors always responded to the initial evaluation given by the trainee. When supervisors agreed with the evaluation given by the trainee they provided a simple confirmation. When they disagreed they provided an alternative expert opinion rather than just disagreeing (as in this example, in which the supervisor explicitly provides an alternative). In most cases in our corpus, the trainee continued the procedure according to the expert opinion, but in some sequences a dialogue or discussion followed.

In this category (Category 2), trainees evaluate the situation themselves. Yet, by explicitly inviting the supervisor to provide a second assessment, they also show that they need an independent, explicit expert evaluation to move forward with the procedure.

that forces the trainee to stop the procedure and engage the supervisor. Yet, unlike the previous practices, the trainee requests the supervisor only to confirm the trainee's evaluation (Box 3). As a result, only the trainee explicitly produces an evaluation and the supervisor 'merely' produces a confirmation.

The trainee evaluates the ongoing activity without mobilising a response from the supervisor: 'This is what I think'

In all the prior categories (1 to 3), the trainee explicitly recruits expertise from the supervisor. In this final practice (Category 4), the surgical trainee

evaluates an ongoing activity without recruiting supervisor expertise (Box 4). We will argue that the trainee still engages the expertise of the supervisor, albeit implicitly. This practice makes the private thinking of the surgical trainee public and therefore, controllable by the supervisor.³² The lack of a response from the supervisor after such an evaluation serves as a sign of approval that allows the surgical trainee to continue.

In these examples, we discussed the various practices trainees use to recruit expertise from their supervisors. They constitute a scale ranging from an explicit request for a first assessment (maximal recruitment) to online commentary

Box 3 Trainee C, 31 minutes, 49 seconds into the procedure

Line 1	Trainee	Ja Yes
Line 2		1.0 second of silence
Line 3	Trainee	Je past dan eh... je proef past dan een 53, he? <i>In these cases you try eh... you try a 53, right?</i>
Line 4		0.2 second of silence
Line 5	Supervisor	Ja Yes
Line 6		7.0 seconds of silence

In this example, the trainee states that the next task is inserting a trial prosthesis size 53 (line 3). This statement is considered as a final evaluation stating that the remaining is finished and the procedure can move to the next task: fitting a trial prosthesis. The trainee does not request a second evaluation, but does request confirmation from the supervisor by adding the tag 'he?' ('right?' line 3). This tag explicitly mobilises a response from the supervisor, but also – in its form – restricts the type of response that is relevant: the supervisor only has to provide a confirmation. This is confirmed by the supervisor in line 5, and the next task can begin.

Similarly to the prior categories (1 and 2), in this category (Category 3), the trainee displays a need to recruit expertise from the supervisor after encountering a problem. However, rather than asking for an evaluation from the supervisor, the trainee requests a mere confirmation of his or her initial assessment. In our data, these requests for confirmation were always produced as tag questions ('right'). Supervisors, without exception, provided a response, showing that a response was indeed called for. The vast majority of these cases get a simple, minimal confirmation. This is in line with recent conversation analytic research that shows that, in using a tag question a speaker claims more certainty than by using another type of question.⁴⁴ Although all they ask for is a simple confirmation, trainees still show the need for expert opinion. In a few cases, the supervisor does disagree with the evaluation given by the trainee. In such cases, the supervisor not only produces a minimal disconfirmation, but also provides an explicit second evaluation.

(minimal recruitment, only creating a possible control structure). Table 2 shows the frequency of these practices and their distribution over the procedures.

The more implicit strategies are the most frequent: trainees' evaluations of ongoing activities without mobilisation of a response seem to be the main method by which all surgical trainees evaluate motor actions. Requests for an initial evaluation or instruction from the supervisor are very infrequent. There also seems to be a correlation between the use of these practices and experience. In particular, the least experienced trainee (A) recruited more expertise in the first three steps of the procedure than did trainees C and D during the entire procedure. Finally, the most experienced surgical trainee (D) used only the most implicit practices (Table 2).

All these practices naturally play important roles in the regulation of learning: they explicate the learnable and manage the involvement of the supervisor. However, all the instances discussed here

involve the recruitment of the supervisor for the concrete task at hand. They all involve the immediate present, and all activities can be viewed and are framed by the trainees as involving patient outcome.

Interestingly, not once did the surgical trainees take the initiative to discuss their learning strategies, goals or objectives with their supervisors in our data. Supervisors, by contrast, do seem to treat the practices discussed above – at least in some cases – as indications of a need to learn or an opportunity to teach. They will build on these practices to create a learning environment in which they provide expertise that is conveyed and framed to have implications beyond the current situation and the immediate present. Box 5 (which shows an extended version of the extract in Box 2) is a case in point.

DISCUSSION

In this study, we used conversation analysis to examine all the initiatives used by surgical trainees

Box 4 Trainee C, 27 minutes, 54 seconds into the procedure

Line 1 5.0 seconds of silence

Line 2 Trainee Nog een beetje dieper
Just a little deeper

Line 3 7.0 seconds of silence

The task is the stepwise preparation of the acetabulum with a drill. The trainee drills for 5 seconds (line 1), removes the drill from the acetabulum, palpates the hole with his finger and simultaneously produces an evaluation of the ongoing activities, making this evaluation accessible to the supervisor but without explicitly mobilising his response (line 2). No uptake by the supervisor follows, and the trainee reinserts the same drill and continues reaming for another 7 seconds (line 3), in line with his initial assessment. The lack of mobilisation and uptake by the supervisor is the characteristic feature of instances in this category (Category 4). Although supervisors do not explicitly share expertise in these cases, their expertise is still implicitly evoked: in making their own evaluations explicit, trainees make their evaluations of the situation at hand shared and therefore controllable. By not responding to these publicly available evaluations, supervisors ratify the evaluations.

This was the most frequent practice in the present study. In conversation analytic literature, this phenomenon has been described as 'online commentary'. Online commentary 'facilitates effective teamwork by forecasting next actions, allowing members to anticipate probable next steps'.^{32,45} These stand-alone evaluations do not mobilise a response: the supervisor does not need to offer any acknowledgement or second assessment, and none are pursued by the trainee if none are volunteered by the supervisor.⁴⁶ However, supervisors can and – in our corpus – do intervene when these evaluations are not in line with their own evaluation of the situation. As such, these online commentaries create 'a control structure through which the supervisors can intervene'.^{32,45} By withholding an explicit response, supervisors still implicitly ratify the evaluation given by the trainee.

Table 2 Distribution of the four categories by which surgical trainees engaged supervisors and recruited expertise

	Trainee (years of experience)				Total
	Trainee A (2)*	Trainee B (4)	Trainee C (5)	Trainee D (5.5)	
Total practices, <i>n</i>	63	90	57	51	261
Category 1: Request for an evaluation or instruction from the supervisor	0	5	0	0	5
Category 2: Evaluation of ongoing activity with an explicit invitation to the supervisor to offer a second evaluation	7	1	3	0	11
Category 3: Evaluation of ongoing activity with a request for confirmation by the supervisor	20	5	1	10	36
Category 4: Evaluation of ongoing activity	36	79	53	41	209

* Trainee A performed only three of the total of 10 steps in the procedure.

to engage their supervisors. We identified a scale of four practices that range from explicit engagement (requests for evaluation or instruction from the supervisor) to implicit engagement (evaluations of

ongoing activities). Each practice recruits specific information from the supervisor; in the most explicit types, the surgical trainee needs an evaluation by the supervisor. In the most implicit

Box 5 (Extract 2 expanded) Trainee C, 28 minutes, 25 seconds into the procedure

Line 1		12.5 seconds of silence
Line 2	Trainee	Misschien wel iets meer de diepte in. Wat denk jij? <i>Maybe a little deeper. What do you think?</i>
Line 3		0.5 second of silence
Line 4	Supervisor	Nou, lijkt of op de bodem te zijn, he? <i>Well, it looks like we reached the bottom, he?</i>
Line 5	Trainee	Ja, eh, spongieus, he? <i>Yes, eh, cancellous bone, right?</i>
Line 6	Supervisor	Ja Yes
Line 7		2.0 seconds of silence
Line 8	Trainee	Ja, mooi <i>Yes, nice</i>
Line 9		0.3 second of silence
Line 10	Supervisor	Ja, echt mooi dat rondje op de bodem, vaak wel een teken dat je diep genoeg zit <i>Yes, really nice that little circle at the bottom, usually a sign that you are deep enough</i>
Line 11		1.0 second of silence
Line 12	Trainee	En dan <i>And now</i>

In line 8, a decision has been made and the trainee continues with the task, in line with the evaluation of the supervisor in line 4 (as discussed above). However, after a short silence in line 9 the supervisor continues in line 10 by explicating an account or the reason for the evaluation stated in line 4 ('the little circle at the bottom is usually a sign that you are deep enough'). This account not only gives the trainee insight into the reasoning process of the supervisor, but it also provides the trainee with a heuristic that will allow him to reach a similar conclusion by himself in the future. The supervisor has added to the decision-making toolkit of the trainee in an explicit learning situation. This teaching situation is also made relevant in the wording of the heuristic: the supervisor explicitly frames the advice as a result of his own experience ('usually a sign').

Of course not every instance of the practices discussed above is treated in this way: explicit learning (reaching beyond the immediate present) is infrequent in our corpus. Nevertheless, the instances of explicit learning we do find are often triggered by the occurrence of one of the discussed practices. This indicates that supervisors – at least sometimes – gravitate towards these practices as behaviour that makes explicit learning relevant.

This example is a nice illustration of how learning in the OR is acted out on a daily basis. For the most part, trainee and supervisor are working as colleagues on the task at hand. Although learning takes place, there is no orientation towards learning above and beyond the immediate present. Regardless, trainees and supervisors can make the explicit learning environments relevant through specific behaviours. In these circumstances, both trainee and supervisor show an explicit orientation towards learning and transform the context into a learning situation.

categories, the surgical trainee seeks confirmation of his or her evaluation. Even the most implicit practices (evaluations of ongoing activities to which supervisors are not invited to respond) serve as instruments for the recruitment of supervisor approval. Although each of the four categories recruits different types of expert information, all categories have one aspect in common: the surgical trainee is recruiting expertise about what to do or

how to complete an ongoing task in the surgical procedure.

Learning in the OR

Interestingly, in our study we did not find any initiatives whereby surgical trainees explicitly engage supervisors for learning. However, supervisors occasionally elaborate after supplying the recruited

expertise and then provide heuristics for future use. In line with the findings of other studies that have analysed communication in the OR, surgical trainees and supervisors were found to exchange information primarily about how to continue an ongoing task.^{23,25,26} Most of the learning in the OR seems to hide somewhere in the interactions about ongoing tasks: the expert information mobilised from supervisors allows for instantaneous task completion and serves patient outcome, and, in addition, such information can be used by surgical trainees in the future when they merge and store that specific expertise with their previous encounters.

Our findings raise the interesting question of whether surgical trainees use the four different practices in this study as deliberate learning strategies to master surgical procedures in a process of SRL. We think this is unlikely: during surgical procedures trainees will have difficulties in foreseeing gaps in their expertise and then in deliberately selecting a strategy to recruit expertise beforehand. Firstly, our analyses show that, in line with the findings of previous authors,^{6,7,9,25,33} surgical trainees engage their supervisors with questions about how to continue with the procedure in the immediate present. As a result, these questions always seem to be calibrated at the task level, the most elementary component of a surgical procedure. A task consists of three stages that must be performed by the surgical trainee: the motor action that transforms the patient's anatomy; an evaluation of its effect, and the selection of the next motor action.^{34–36} Collections of such tasks define a particular part or step in the surgical procedure. In total hip replacement surgery, the procedure of choice in this study, surgical trainees carry out 44 different steps between the incision of the skin and the final suture, each varying in complexity. We wonder if surgical trainees are able to identify and foresee gaps in their expertise on specific tasks in those clusters.

Secondly, no patients or procedures are entirely identical; differences in anatomy and technical and equipment problems frequently surface during the procedure and influence task complexity in the immediate present.³⁷ Hence, difficulties in task execution arise during procedures and challenge surgical trainees to perceive gaps in their expertise. Overall, surgical trainees seem likely to use the practices to integrate their thinking and doing at the moment task complexity increases, a concept

that Schön recognises as 'reflection in action'.³⁸ They regulate learning as the procedure unfolds, rather than deliberately selecting learning strategies beforehand. Nonetheless, these reflections in action given by surgical trainees (or, more specifically, the practices used by surgical trainees to engage their supervisors and to recruit expertise) do provide a window into the learner's mind.

Turning the implicit practices of surgical trainees to engage supervisors into an asset for deliberate learning in the OR

In SRL, evaluation by self-reflection is one of the cornerstones of learning.^{20,21} However, SRL in clinical workplaces struggles with context-specific learning; learners can only self-reflect effectively when they understand how they create learning in concrete situations.¹⁹ In this study, we demonstrate how the four practices function as conduits or instruments for learning by recruiting expertise, and how learning then ensues when supervisors supply and surgical trainees adopt the expertise. As such, learning seems to be constituted and regulated in moment-to-moment interactions between surgical trainees and supervisors.

Insight into the roles of the four practices in the construction of learning can nonetheless contribute to the optimisation of SRL in clinical workplaces. Once surgical trainees understand how they engage supervisors and appreciate the differences between the learning environments they evoke by the use of the respective practices, they can review footage of their procedures and evaluate their personal learning strategies. For instance, they may reflect on whether they really need a confirmation or an alternative evaluation. Evaluating the number, type and timing of the practice gives surgical trainees insight into how they regulate learning in the workplace. Furthermore, learning is constructed in interactions with supervisors. To improve self-reflection, a surgical trainee can review the procedure together with his or her supervisor and explore whether the trainee recruited expertise effectively and in a timely manner. This might result in metacognitive strategies for future learning in identical or different procedures as these practices constitute a trainee's toolkit for the recruiting of expertise and the instigation of learning.

Supervisors can also benefit from insight into this toolkit. Interestingly, these practices not only function as a window into the mind of the surgical trainee that can be engaged for purposes of

self-reflection, but also provide clues with which supervisors can assess proficiency. In our study, trainee A (the least experienced) undoubtedly used more explicit practices than trainee D (the most experienced); it might be claimed that trainee A demonstrated a much lower level of proficiency than trainee D. Hence, identifying the personal toolkits of individual trainees can be used to assess proficiency. This becomes ever more relevant as recent years show a trend for the replacement of informal assessments with more formal modes. The use of entrustable professional activities, whereby the supervisor entrusts the trainee with a level of autonomy in patient care according to the trainee's level of proficiency, was recently incorporated into surgical curricula in the Netherlands.^{39,40} Now supervisors periodically assess surgical trainees for their levels of proficiency and determine the level of autonomy in patient care that can formally be entrusted to a surgical trainee. A qualitative and quantitative analysis of the practices used by surgical trainees during procedures offers supervisors an indication of their proficiency and therefore an instrument to validate levels of autonomy.

So far we have highlighted the relevance of reflection on metacognitive strategies by reviewing performances of surgical trainees. We will now demonstrate how the four practices might contribute to learning in the OR in real time. Surveys amongst supervisors and surgical trainees emphasise the significance of the proper guidance and motivation of trainees in the OR.^{41,42} Descriptive studies from a grounded theory perspective have identified several categories of guiding behaviour in supervisors.^{23,43} The present study builds and expands on this by providing a practical tool with which supervisors can pedagogically calibrate guidance in the real time of the surgical procedure. Supervisors usually upgrade control over surgical trainees when they sense that trainees overestimate their expertise. Conversely, when supervisors notice that surgical trainees underestimate their expertise and skills, they want to encourage trainees to take more control over the task of the procedure. Using their insight into the trainees' toolkit to recruit expertise, supervisors now have an option to adapt control. They might deliberately downgrade control as long as patient safety and time schedules allow it. For instance, when a trainee gives an evaluation with a request for confirmation, this confirmation is expected and necessary by the trainee before he or she can continue to operate. In recognition of this situation, a supervisor could deliberately ignore such a

request for confirmation (thus, treat it as an evaluation of an ongoing activity for which no response is necessary). This challenges the trainee to make a decision without the requested expertise. If the trainee's decisions then lead to the successful performance of the task, the trainee comes to realise that he or she underestimated his or her proficiency and may change future strategies for recruiting expertise.

Limitations of this study

Some limitations need to be addressed. Although this study elucidates the perspective of surgical trainees and their learning, it does not present a complete overview. As Roberts et al.²³ demonstrated, supervisors do not only await the recruitment of their expertise, but they also supply expertise on their own initiative. In their analysis of verbal teaching interactions in the OR, Roberts et al. identified 188 supervisor–trainee interactions during a 30-minute, low-complexity procedure.²³ Such a large volume of interactions initiated by supervisors with the intent of supplying expertise is likely to override trainees' initiatives to engage their supervisors. Furthermore, this study is limited to surgical trainees engaged in total hip replacement surgery. Until we analyse interactions in other procedures, we cannot claim that surgical trainees in other procedures employ the same practices to engage their supervisors and recruit expertise. Although we sketched ideas about how our findings can contribute to improve learning, teaching and assessing in the OR, the efficacy of the daily practice of supervisors and trainees has not yet been determined.

CONCLUSIONS

This study revealed how surgical trainees recruit expertise and regulate learning during surgical procedures. We identified four different practices used by trainees to engage their supervisors in order to recruit expertise. These practices function primarily for the purposes of task completion as the procedures unfold in real time, and learning ensues when trainees subsequently integrate the information supplied by their supervisors. These findings illuminate the processes of learning in the OR and contribute to our understanding of the processes of self-directed learning in clinical contexts. Moreover, the practices we identified provide a tool with which to reflect on learning and to assess the proficiency of surgical trainees after a

procedure, and an instrument with which supervisors can adapt guidance to the needs of trainees during surgical procedures.

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