

# Beliefs and values about intra-operative teaching and learning: a case study of surgical teachers and trainees

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Received: 2 July 2015 / Accepted: 16 November 2015 / Published online: 21 November 2015  
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**Abstract** Surgeons require advanced psychomotor skills, critical decision-making and teamwork skills. Much of surgical skills training involve progressive trainee participation in supervised operations where case variability, operating team interaction and environment affect learning, while surgical teachers face the key challenge of ensuring patient safety. Using a theoretical framework of *situated learning* including *cognitive apprenticeship*, we explored teachers' and trainees' beliefs and values about intra-operative training and reasons for any differences. A qualitative case study method was used where five teacher-trainee pairs participating in an observed teaching operation were separately interviewed about the same operation. Thematic analysis of transcribed interviews and observations was performed with iterative refinement and a reflexive approach was adopted throughout the study. We found that in all cases, teachers and trainees had shared recognition of learning about technical skills whereas they differed in three cases regarding non-technical skills such as surgical reasoning and team management. Factors contributing to teacher and trainee satisfaction with the process were successful trainee completion of operation without need for surgeon take-over, a positive learning environment and learning new things. Teaching–learning behaviours observed and discussed were modeling, coaching and scaffolding, while exploration, reflection and articulation were less common. Our study reveals differing teacher and trainee perspectives of some aspects of intra-operative training and surfaces new reasons other than amount of feedback and autonomy given. Factors contributing to different perspectives include teacher and trainee abilities,

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values and situational influences. Targeted teaching–learning strategies could enhance intra-operative learning.

**Keywords** Cognitive apprenticeship · Postgraduate medical education · Situated learning · Surgical skills teaching

## Introduction

A surgeon’s ability to operate safely requires advanced psychomotor skills, critical decision-making and effective teamwork skills. Surgical skills training relies on apprenticeship-style learning in the operating theatre with progressive trainee participation in supervised operations. In the operating theatre, real-world factors of case variability, operating team interaction, environment and scheduling impact learning and performance. The aim of this paper is to explore the beliefs and values about intra-operative teaching and learning that are held by surgical *teachers* and *trainees*.<sup>1</sup>

### Teachers’ perspectives

A key concern of surgical teachers is balancing trainees’ learning needs with patients’ safety. When trainees operate, teachers face increased complication rates (Wilkiemeyer et al. 2005) and opportunity costs from slower operating lists (Babineau et al. 2004). The term ‘clinical oversight’ describes how supervisors in general medicine and emergency medicine allow trainee participation in clinical activities while ensuring quality patient care (Kennedy et al. 2007). This framework is inadequate for intra-operative supervision where the clinical situation is harder to predict and rapidly changes without warning. For example, a straightforward teaching operation becomes dangerous due to atypical patient anatomy or faulty equipment. Experienced surgeons, unlike trainees, are able to recognise clinical uncertainty via cues like unusual patient characteristics, external factors and incomplete information and are able to respond appropriately (Cristancho et al. 2013). For teachers, calibrating the right amount of trainee operative independence is difficult and mistakes result in “control dilemmas” that compromise patient safety or teaching efficacy (Moulton et al. 2010).

### Trainees’ perspectives

Surgical trainees want to operate and trainee satisfaction with the quality of education increases with operative opportunity (Ko et al. 2005). Teachers can motivate trainees by facilitating trainee autonomy (Dath et al. 2013). However, trainees are not consistently allowed operative opportunity (Ko et al. 2005) which they may ascribe to their own inadequacies, relationship with the teacher (Blackburn and Nestel 2014) or other systemic and personal factors that influence surgeon’s intra-operative decision-making (Leung et al. 2012). An observational study on intra-operative teaching interactions proposed that when teachers facilitated operations through “instrumental interactions” without explanation, “the learner is left to infer the lesson to be learned” (Roberts et al. 2012).

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<sup>1</sup> We use the term *teacher* to refer to the surgeon trainer and *trainee* to refer to the learner on a surgical training programme.

## Different perspectives of teachers and trainees

Studies using recall surveys and global rating scores of teaching suggest that the quality of intra-operative teaching is perceived differently by trainees and teachers (Claridge et al. 2003; Jensen et al. 2012; Levinson et al. 2010). Trainees report being given less feedback and autonomy than teachers believe they have given. Possible explanations of this phenomenon include recall bias, aggregated data, poor feedback skills, non-recognition of feedback or different ideas of what constitutes feedback and control. Different conceptions of feedback held by teachers and trainees are supported by evidence that teachers and trainees who view the same video-recorded operation interpret guidance levels differently (Chen et al. 2014). Teachers underestimate the amount of physical guidance they give in addition to verbal feedback (Sutkin et al. 2015). Trainees also have different ideas of learning needs compared to teachers (Pugh et al. 2007). Reported dissatisfaction could stem from mismatched expectations about intra-operative learning objectives, rather than suboptimal feedback or guidance. It is difficult to effect educational change when the causes of different perspectives remain uncertain.

## Learning in the workplace and theoretical framework

The operating theatre is a challenging learning environment that subjects trainees to significant stress which affects their technical performance and surgical decision-making (Wetzel et al. 2006). Additionally, the hidden curriculum of surgical culture socialises trainees “to display confidence and certainty” (Jin et al. 2012) which might deter admission of uncertainty and seeking guidance. Situated learning (Brown et al. 1989) and related theories of cognitive apprenticeship (Collins et al. 1991) and legitimate peripheral participation (Lave and Wenger 1991) examine learning occurring through social co-participation in the workplace. Legitimate peripheral participation discusses “the relations between newcomers and old-timers” and “the activities, identities, artifacts and communities of knowledge and practice” (Lave and Wenger 1991, p29) Situated learning used as an “analytical perspective” (Lave and Wenger 1991) on intra-operative training shifts the focus away from the individual learner to permit exploration of separate teacher and trainee perspectives and encourages consideration of sociocultural factors affecting the teaching–learning process. The cognitive apprenticeship model (Collins et al. 1991) translates situated learning theory into practice with teaching strategies that embrace the physical and social context by embedding learning in activity.

In this study we used situated learning (Brown et al. 1989) as the theoretical framework to explore the intra-operative experiences of pairs of surgical teachers and trainees. We sought to understand the beliefs and values of teachers and trainees about intra-operative training.

## Methods

A paired case-study design (Yin 2013) was adopted to locate participants’ reactions to a single shared experience to confirm similarities and/or differences in perspectives. This method allowed naturalistic, real-time observation of behaviours including the relational elements. It enabled capture of participants’ reflections on an actual encounter rather than their thoughts about teaching–learning in general.

Ethical approval was obtained from both the University of Melbourne and the institution where the study was carried out, a large public healthcare institution in Singapore comprising several hospitals nationally accredited to provide all surgical speciality training programmes. Surgeons employed by this institution have variable teaching, administrative and research responsibilities in addition to clinical service provision. Local surgical training programmes last between 5 and 8 years. All training programmes require trainees to undergo multiple rotations in different departments to experience relevant sub-specialities. In each rotation, a trainee will work closely with one or more surgeons for a few months.

In a typical operating theatre, teams of doctors and nurses work together as the anaesthetic team and the scrub team. The scrub team comprises the operating surgeon with one or more assistants, a scrub nurse and a circulating nurse. A trainee who is present at the operation may observe, assist or be supervised in performing the operation, depending on the decision of the surgeon in-charge of the case. In this study, we focused on the experiences of both the teacher and learner when a surgeon supervises the trainee performing an operation.

Purposive and convenience sampling enabled recruitment of well-regarded teachers and their trainees. In the institution, not all surgeons are willing to teach trainees during operations and some have not had formal pedagogical training. We approached surgeons reputed to regularly teach well, that is, surgeons, about whom trainees consistently report satisfaction. These surgeons are likely to be better informants about teaching–learning behaviours than others who teach poorly or rarely. We sampled different surgical specialties to investigate generic rather than speciality-specific training. This also reduced the risk of participant identification within a small surgical community. From eligible surgeons, we invited those who were better acquainted with the principal investigator (CO, a surgeon employed in the same institution) to increase likelihood of recruitment. Consenting teachers provided email contacts of their trainees. Separately, trainees were invited to participate. After identifying consenting teacher–trainee pairs, appointment was made for direct observation of an operation followed by separate interviews.

We asked teachers to choose routine teaching operations appropriate for the trainee's level and to use their regular scheduled lists and operating theatre staff. Routine rather than complex operations were chosen as we aimed to investigate typical intra-operative training interactions without additional stress. Ethical considerations of patient safety also directed choice of simpler routine cases as there was less chance of patient harm should unanticipated study conditions cause poorer operative performance or supervision. One researcher (CO) observed all operations documenting observed teaching–learning behaviours. CO sought to remain unobtrusive during observations by keeping silent and positioning herself out of direct line-of-sight of the teacher and trainee. Notes taken during observation were used during interviews for triangulation and clarification. Immediately after the operation, CO used a topic guide to conduct semi-structured interviews with the teacher and trainee separately. CO is an experienced interviewer and was known to teachers and trainees. Audio-recordings were transcribed verbatim. Transcripts were not returned to participants for verification because of within-pair confidentiality and the potential to disrupt relationships. The topic guide concentrated on the observed operation and included general questions on prior experience as a non-threatening way to elicit additional information (Table 1).

Theoretically-driven inductive thematic analysis (Braun and Clarke 2006) was used. The data set included notes taken during 5 observations of average duration 80 min (range 70–120 min) and verbatim transcripts of 11 interviews of average duration 27 min (range

**Table 1** Topic guide for semi-structured interviews

Prompt questions for surgeon	Prompt questions for trainee
What is your general approach to teaching during an operation?	Generally, what do you expect or wish to learn during a teaching operation?
How do you think this operation went?	How do you think this operation went?
What did you think the trainee learnt?	What did you learn?
Did you guide the trainee in any way? If yes, when, how and why? If no, why not?	What do you feel about the operation as a learning experience? Why?
Did you have to “take-over” at any point in the surgery? If yes, why did you do so? If no, why not?	Were you guided by the Surgeon in any way? If yes, when, how and why? If no, why not?
Have there been any occasions during teaching operations where things did not go as one would wish? Either in your experience or those that you have observed or heard about? Tell me what happened. Why do you think that was so?	Did the faculty “take-over” at any point in the surgery? If yes, why do you think this happened? If no, why not?
*How do you know or decide, what and how much to teach during an operation?	Have there been occasions during teaching operations where things did not go as one would wish? Either in your experience or those that you have observed or heard about? Tell me what happened. Why do you think that was so?  *What do you think are the factors that affect how much you get to do during an operation?

\* Question 7 (under Surgeon) and Question 8 (under Trainee) were added to the template after the first interview, because of the emerging theme of entrustment of professional activities

24–34 min The interview transcripts were open coded by CO and counterchecked by AD using a coding template informed by theories of situated learning and cognitive apprenticeship supplemented with data-derived codes.

Iterative coding and analysis was carried out with discussions (CO & AD) after analysis of the first case, the next two cases, then again after analysis of all the cases. Cases were analysed concurrently with new case accrual, allowing for review of findings before the next case. Discussion using a case-ordered descriptive matrix (Miles et al. 2014) identified key variables and evolving themes were elaborated and refined after discussion leading to the final framework.

Our unit of analysis was each teacher-trainee pair. During within-case analysis, we identified each case within the context of the operation where each case is organised by the key themes derived from the data. Within-case and cross-case analysis focused on concordance or variance of teacher-learner perceptions of their shared experience triangulated with observation data and role-related behaviour characteristics. DN undertook a final checking of concordance and variance of each case against the transcribed data. Discussions and analytic decisions were documented. The research team comprised a surgeon employed within the institution and two educationalists external to the institution. This enabled analysis from outsider perspectives and aided researcher reflexivity.

## Results

We designated participants using S to denote surgeon teachers and T to denote trainees. Each participant was identified by an alphabet that corresponded to the case study, i.e. teacher SA supervised trainee TA in case study A.

### Description of participants and operations

Five surgeons were matched with six trainees (Table 2). In case study B, the same surgeon supervised two trainees in turn on a single patient requiring two operations. The trainees were representative of local surgical trainees in terms of experience and demographics, while the teachers had more teaching responsibilities than others at this institution.

**Table 2** Description of case studies

Participant/operations	Number/gender	Details	
Surgeons	5 (3 Male, 2 female)	Experience in supervising trainees during operations	Range 6–18 years
		Extra teaching responsibilities (appointment as core faculty of residency programmes)	4 out of 5
Trainees <sup>a</sup>	6 (2 Male, 4 female)	Completed formal surgical training	Range 1–3 years
		Present level of formal surgical training	Junior to middle
		Total prior surgical exposure (informal <sup>b</sup> and formal training)	Range 2–5 years
Relationship	3/5 cases short-term	After the end of the rotation, teacher and trainee would not expect to work so closely again for the rest of training unless the graduating trainee chooses to join the same department as a specialist	Working relationship before observation: range 2 weeks to 2 months Rotation duration: range 2–6 months
	2/5 cases longer-term	2 teachers held higher supervisory positions hence would continue to oversee the trainee's progress within the training programme	Teachers' posts: Program Director and Associate Programme Director
Operations	5 cases	All were routine training cases, chosen by the surgeon and done under general anaesthesia: infant hernia, tonsillectomy and adenoidectomy, chest closure, excision biopsy of breast lump and open haemorrhoidectomy (removal of piles)	

<sup>a</sup> The context of surgical training in Singapore recently changed. From 2010/2011, most of the speciality training programmes have moved from traditional UK-style system with 6-monthly rotations to a US residency system with shorter rotations lasting typically between 2 and 3 months in length. Five of the six trainees in this study are enrolled in the new system

<sup>b</sup> Informal surgical training: All trainees had prior experience working as non-trainee medical officers for between 1 and 3 years. Non-trainee medical officers are employed for service reasons without expectation of receiving training. However, most surgeons try to teach non-trainee medical officers, especially those who are considering joining surgical training programmes

## Case studies on teacher-trainee perspectives

Details of each case study are given in Table 3. Cross-case synthesis reveals that teachers and trainees had shared recognition of learning in relation to technical elements of

**Table 3** Surgeon teacher\* and trainee\* perspectives on teaching and learning in the operating theatre

Case A: Surgeon (SA) supervised Trainee (TA) on an infant hernia operation (both sides). This operation is done through a small incision and trainees often mistake the tissue planes. When that happens, there is risk of injury to nearby structures like spermatic cord, bladder and leg vessels. The supervising teacher usually stands opposite the trainee for a better view in order to prevent this error. For the left side hernia, SA supervised by standing opposite TA in the 1st assistant position while another doctor was present in the 2nd assistant position. SA changed to the 2nd assistant position during the right side hernia

A1	Teaching-learning content	Evidence	
		Surgeon teacher (SA)	Trainee (TA)
A1.1	Both agreed that SA emphasised landmarks. SA wanted to teach a stepwise method to avoid problems, but TA thought what learning what to do if things go wrong was more valuable	...every single step to be planned with objective and how you should expose the inguinal canal, and also telling her the exact landmark I'm looking for, before you even enter the canal	... finding the sac, what to look out for, the landmarks... [what to do] if things fail, yes. Exactly. Because things what to do, I know already, I think, But I need to know what happens if I cannot proceed
A1.2	SA tried to give subtle message of independence to TA by moving from 1st to 2nd assistant position midway during the case. TA missed this movement because she was concentrating on performing the operation. When pointed out during the interview, TA recognised what it meant	By me just... retreating to the 2nd assistant position, I know TA ...will get the message. She knows that I'm telling her, you have to be more independent] ...you are doing a good job, I'm promoting you to the next level. I'm not going to be the one retracting for you. You have to learn to command the team and command the assistant as well. So I know she knows that	Now that you say it, it's true... It was [other assistant] that...no, I was not aware of it during surgery. I was just focusing on what I have to do. But now that you mention it, yeah. (laugh) ... like I said I wasn't aware of it, but in fact, it is good! Because in fact if you think about it, and then it would tell me that he trusts me, that I can do it by myself, but that he's still there if I need him
A2	Teaching-learning behaviours	Evidence	
		Surgeon teacher (SA)	Trainee (TA)
A2.1	Both agreed that SA was constantly guiding verbally in a systematic manner highlighting each step	I went through with her at least twice, how I want every single step to be planned with objective	Guided? Yes he tried to actually teach me which are the steps that he goes through, when performing the surgery, and I followed them, and found them quite helpful
A2.2	SA emphasized building trainee confidence by scaffolding and progressive trainee autonomy. TA recognised his efforts and valued the learning environment	My objective for this operation by then, becomes more, I want to build up her confidence, that she can do this kind of thing with minimal supervision	The way he teaches is the way of making me learn, but not of feeling stupid at the same time. He does correct me if I do things wrong, but he does not completely take over it, so I still feel in control of the whole situation

**Table 3** continued

A2.3	SA did not takeover but provided physical guidance for the Scarpa (a specific tissue layer) dissection by moving TA's hand. This was mentioned by SA but not TA	...then she tell me "but then I still can't see the window I create". Yah, so why don't you... then I.. then I think I grabbed her hand and tell her pull it higher, so you can see the window now. Then she's like "Umm, ok"	Because I think everything went smoothly, everything went the way it should go, so that's why he didn't take over
<p>Case B: Surgeon (SB) supervised two trainees (TB1 and TB2) in turn on a paediatric tonsillectomy and adenoidectomy operation. Typically these operations are performed by a single surgeon who operates while seated at the patient's head, looking into the mouth from above, assisted only by the scrub nurse. SB remained unscrubbed and stood behind the seated trainee who was assisted by the other trainee. SB could occasionally view the operative field via images on a TV monitor when the trainee introduced a scope but otherwise it was up to the trainee to judge when to stop and move aside to allow her to look directly into the mouth. TB1 operated on the left tonsil and adenoid, while TB2 operated on the right tonsil. Both TB1 and TB2 were very familiar with tonsil removal, but less so with adenoid removal. Interviews with SB, TB1 and TB2 were all done individually</p>			
B1	Teaching-learning content	Evidence	
		Surgeon teacher (SB)	Trainees (TB1 & TB2)
B1.1	All agreed that the new retraction technique that SB had taught had been learnt	<p>...improved his technique. I think he learnt a new way of holding the instrument</p> <p>Same thing (laugh). Technique! Definitely technique</p>	<p>One of the things that I learnt is how SB handles the retraction, uh the retractor. And it actually did help to expose the planes between the tonsil and the muscle bed more clearly</p> <p>In fact, I mean I've never held the forceps that way before she demonstrated to me how to hold it. I guess I have seen it, but, you know, if people don't point out to you and make you try, right, you just don't do it. I usually fall back to the way that I'm comfortable doing</p>
B1.2	SB discussed teaching about [rare important complication] that neither TB1/TB2 mentioned as a learning point they remembered	He learnt about.. uh why below five is very dangerous...[rare important complication], you should have seen the look on his face, I don't think he has ever heard about it	
B1.3	TB1/TB2 independently mentioned learning about surgical decision making at several points; whereas SB did not talk about teaching these things	Trainee (TB1)	Trainee (TB2)
		So normally those that we see, are super huge. So clear cut, just take, just remove it. But uh, for cases like that where it's not totally occluding, but uh, there's still a bit, we aren't sure lah so we ask	She was talking through a bit of um, you know, in terms of the adenoids, why we take it out even though it wasn't enlarged. So this bit was more on the knowledge bit, you know. It confirms what I know, lah. I mean I've read about it, but, never quite sure about



**Table 3** continued

B1.4	TB1/TB2 mentioned learning about ergonomics—in response to a direct question about what SB was talking about at a particular point in surgery	One is uh, positioning yourself during surgery, So the position plays a very big role. If you can position yourself well, see your field quite well, you will be able to operate better	I think also the bit about the ergonomics. Like how you, how you actually, uh, should keep your elbows closer to you to make it more sustainable. I think that's something I've sort of heard of, but something she consolidated a little bit
B2	Teaching–learning behaviours	Evidence Surgeon teacher (SB)	Trainees (TB1 and TB2)
B2.1	SB/TB1/TB2 agreed that SB gave running commentary, offered guidance regularly but didn't insist on a particular way of doing things All 3 agreed that SB did not have to takeover during the operation	Tell him what to do, lah. Put in...the steps... is not smooth He's quite stubborn, he doesn't want to try it! Cos it works for him	She's uh, she always gives her input, and what she thinks is best, but if she sees that, whatever you are using, is serving the purpose and you know you're doing good, she doesn't force her way. Yah she doesn't insist  She was telling me, ah, you know, details of how I could improve things. I've done a lot of tonsils, I know how to do it, but, I think ah, you know it helps that she points out the finer bits
B2.2	TB1/TB2 mentioned specific areas they received guidance that SB did not recall.	Trainee (TB1) ...so the way to, the way to retract, way to handle the equipment, ah...for the adenoidectomy, the technique using the micro-debrider	Trainee (TB2) ...the tonsil was actually more buried than usual. Then you have to figure out, she was actually showing me, which direction to traction as well.
Case C: Surgeon (SC) supervised Trainee (TC) on chest closure after major cardiac surgery. This was TC's first time doing this procedure. Traditionally only more senior trainees were allowed to do this procedure but with the change in national surgical training system, it is now a logbook requirement. This was the first time SC had supervised such a junior trainee in this operation. Although this operation is technically not that difficult, a potential life-threatening complication is hidden bleeding that occurs after the patient has been sent to the intensive care unit. Hence the surgeon needs to check very carefully for hemostasis before completion of the operation, which may entail changing position for better view			
C1	Teaching–learning content	Evidence Surgeon teacher (SC)	Trainee (TC)
C1.1	SC and TC agreed about teaching and learning the operation technique	Interviewer: "So she learnt your method?" Right. Which I think is the best method I've come across in my 14 years in heart surgery	I actually thought you need a lot of strength, to close chest. Because that's the impression that I was given. But I realise it's actually a lot more of the technique and the angle

**Table 3** continued

C1.2	SC also talked about the surgeon's responsibility for ensuring hemostasis. TC seems to understand that concept quite well, although it is possible that she has learnt this from previous encounters rather than from this particular operation alone	I did tell her that I'll come back and verify that there's no bleeding. And also that, I also did tell her that, um, if she keeps telling me that's no bleeding, and if there's bleeding, then I'm find it hard to leave her alone. So she's. I'm just trying to teach her that um, there's some accountability in her actions	It's for patient safety. And especially if it's the first few times you are operating with the surgeon, it is very fair that they make sure that you have achieved good haemostasis
C2	Teaching-learning behaviours	Evidence	Trainee (TC)
C2.1	SC (when prompted) and TC both talked about guiding her angle for entry in the observed operation. The guidance used both verbal and physical feedback	Surgeon teacher (SC) Interviewer: "A couple of times I saw you correcting her hand movements..." Yeah, Because all these are learned movements, you see...Yah, so, so you gain muscle memory, and all that. So,... sometimes you need to just...you can't tell by just..uh, you can't instruct by just saying the words	Initially he told me that I was too far away, that I was more lateral rather than medial. So he was guiding me to find the correct angle. And the second time whereby, where I put in a second wire, so it was, 2 of them were supposed to be in the same intercostal space. So actually to me, I always thought that as long it's within the same intercostal space it doesn't really matter. yah, but then he showed me actually I should be lower, closer to the next rib
C2.2	SC felt that teaching responsibility was only possible through role modeling TC used reflection regularly in learning	Yeah, but can only learn if I do it lah, because you will not... how do I say this...uh, she'd not learn if I tell her this. "You need to be responsible". She'd only learn if I, I walk the talk lah, basically	You go back and think about what people tell you, and how you get better as you're doing it. If you're not improving, you're disinterested, then you are the reason why it's limiting your opportunity and learning
C2.3	During the skin closure, SC was dissatisfied with TC's initial stitches and made her redo it. As there was time pressure, he had to take-over. TC did not recall this. (During the interview, TC appeared very excited at having done her first chest closure, which could explain why she had forgotten about the problem with the skin closure)	Interviewer: "You didn't have to take over at any point during the bit with TC?" No, Except the skin, maybe I did three-quarters	Interviewer: "Did SC have to take over at any point during the surgery?" ..umm, the wiring? Interviewer: "No, ah?" I thought he would need to! Cos I always have this impression you need a lot of strength to do it. ... So I really thought the first wire he will need to do it for me. Ok, So I was quite surprised that it went in like quite smoothly

**Table 3** continued

Case D: Surgeon (SD) supervised Trainee (TD) on a patient who had 2 benign breast lumps. As part of routine preoperative evaluation under anaesthesia, SD supervised TD on using the ultrasound machine to locate both lumps within the breast, in order to plan and mark the skin incision. During the operation, SD was standing on the same side of the patient as TD, in the first assistant position. Typically for this operation, planning and good retraction of tissues is necessary to allow a cosmetic incision

D1 Teaching-learning content	Evidence	
	Surgeon teacher (SD)	Trainee (TD)
D1.1 SD and TD agreed about teaching and learning the plane of dissection and about pre-operative ultrasound	<p>The first thing is the umm... what do you call...you have to go to the the correct plane to do the dissection and the taking out the lump is easy</p> <p>Pre-op ultrasound he learnt! He learnt how to use the machine, how to get a correct angle.... He, he understood that the incision should be in the middle</p>	<p>For this case the most pertinent learning point here will be the correct plane, lah. and to hit the lump first, before start, starting to dissect</p> <p>One of the most important things we had today was, uh, we did our own ultrasound..... first of all mark out our incision, where it'll be the best incision for both, uh, the lump, the 2 lumps in the breast</p>
D1.2 SD mentioned gentle tissue handling and using both assistants' help appropriately. This was not remarked upon by TD. Also it was observed that SD mostly moved the retractor herself to give TD the best view. Thus, she was not really showing TD how to direct his assistants to retract for him	<p>Number two is be gentle to the tissues. Sometimes he's a bit too rushed. Then number three is actually using assistance properly. Because ahh, majority, not him alone, a lot of our residents are not too good in using their assistants properly. So I think, that, he has to learn how to retract properly by the two persons around</p>	
D2 Teaching-learning behaviours	Evidence	
	Surgeon teacher (SD)	Trainee (TD)
D2.1 SD and TD agreed about guidance needed for the ultrasound and to find the plane of dissection when approaching the lump	<p>The ultrasound itself, I think we discussed. For the operation, I think for him the preparation of the patient was okay lah, the cleaning, except he went quite far down like a mastectomy which I had to stop him, Um, So the incision part, he didn't need any guidance, because we draw that line, that... Finding the plane, I had to stop him, to, to go in the correct direction</p>	<p>She assisted in,uh, helping me localise the lesion, that's number one. Guided me first of all in the ultrasound, uh, guided me as with regards to how I should place the incision, ok, and uh, thereafter with regards to localising the correct plane, then after that it was all right</p>
D2.2 Both SD and TD agreed that SD had to take over for the 2nd lump because it was too difficult for TD to do	<p>The second I decided to do because I know it's more difficult to find a small lump</p> <p>Probably because smaller one is harder to localise? yah it's not... that easily palpable. And she probably wanted to do the smaller one which is more difficult, herself</p>	

**Table 3** continued

D2.3	Both SD and TD valued trainee preparation before an operation and considered it a key factor affecting whether the trainee is allowed to operate	If it is the first time the, the person is assisting me, I will ask him to go and read up about all the operative procedure, about the patient, the indication... how is it classically done, before I take them through. Uh, this guy has done with me before, so, he knows the steps	You have to be in theatre, you have to read up on the case, know what is the history, what is the presenting complaint, go through the past medical problems, go through the indications for surgery. I think that's the bare minimum to show, express interest
<p>Case E: Surgeon (SE) supervised Trainee (TE) on a case of open haemorrhoidectomy (removal of piles). Typically the surgeon first evaluates the last part of the colon using a rigid scope (rigid sigmoidoscopy) followed by the main operation. The key technical difficulty for this operation is ensuring hemostasis (all bleeding stopped) by stitching through the small anal opening. SE supervised while in the 1st assistant position, seated next to TE. In this position, SE had a restricted view of the operative field, so he changed position at the end of the procedure to countercheck TE's work. The patient was a Hepatitis carrier. There is concern of needle-stick injury especially when operating in narrow confined space which would put both SE and TE at risk of contracting the infection</p>			
E1	Teaching-learning content	Evidence	
		Surgeon teacher (SE)	Trainee (TE)
E1.1	Both SE and TE agreed about technique of haemostasis using backhand stitching	But more important, the skills today was haemostasis lah....She's never done it before, so this is all new, and obviously you can see she's still trying to figure out how to do it. But I'm quite happy with the way that she does it, lah. She responds to the, the suggestions, uh, and obviously able to carry it out lah	So his, is more like a figure-of-eight stitch, at the base. Which adopts the same outcome, ...So initially you can think that, that might be quite difficult, because you're not really, you don't really know whether you're stitching the pedicle. But his technique is that he stitches it proximal to the apex, and if you do it correctly you, when you pull it down the way he shows you, it's quite simple to do, lah Now I realise that forehead, the angle is just not as good. So if you backhand, it's a lot better
E1.2	SE said surgical decision making in terms of where and what to cut. Initially TE felt that she already knew that, but on later discussion, changed her mind and said that was something new she learnt	...the assessment is important lah, ok. Basically planning what to cut, before you start lah. Making the cut is important, then planning how to cut uh, is also important	...so the way he chooses the plane of dissection is probably the same Because sometimes you don't know how high up, how high up your apex should be. Yah. So initially I think I was going to take it a bit higher, than what he said. But then he pointed out that that's already rectal mucosa, so now looking back, yah, it did help, lah. In that sense. I may have taken it higher if I had done it myself, yah

**Table 3** continued

E1.3	Both SE and TE mentioned the rigid sigmoidoscopy as something new to TE. Both SE and TE raised learning points not mentioned by the other—SE mentioned not doing too many things with one hand while TE talked about management of smaller type piles	The one thing I told her is not to do too many things with one hand. She's holding the gauze, holding the diathermy, trying to stop, and trying to, you know, and that's the problem with a lot of them	I also, also learned that sometimes you don't actually need to remove all the smaller piles. You can just diathermise at the base, lah. Which I've not done before. And, um, the entire rigid sig setup. I've never done it before
E2	Teaching-learning behaviours	Evidence Surgeon teacher (SE)	Trainee (TE)
E2.1	SE and TE agreed that SE had guided quite a lot. While SE felt that it was mainly about assessment and haemostasis, TE felt that SE was guiding on almost all of the steps of the operation. The observer agreed with TE Both SE and TE agreed he did not takeover completely but often recommended and demonstrated ways to improve her techniques of instrument handling	So preoperatively I told her what to look out for lah. Especially this is a Hep A Cirrhosis case, potentially bleeding might be a problem. Uh before we cut, I, I alerted her to the red flags lah. Like not to cut too far into the rectum cos those are bleeding spots. Um I told her to assess what not to cut also, and as we progressed, I sort of warned her, this part will start to bleed, you know, if we cut, and it did lah! Uh, and during the haemostasis I sort of guided her on the technique to improve on	Actually he guided me all the way, if I would say. So kind of, he told me to inject LA, When I do it, he always reinforces, like aspirate before you...so it helps. Erm, when you examine, to locate the piles, so he corrects the way you hold your, the...what you call it, the ...proctoscope, Yah...He corrects the angle. So he tells you that it should be deep, all the way in
E2.2	SE and TE both recognised that teaching takes time. However, TE did not realise that SE specially arranged his operating list to allow time for teaching	Teaching, I think, if there's time, there's no rush... today's list is short lah, ok. And obviously if there's a pressure of time, then it becomes the issue I try to keep it to a slower pace, lah. For, to allow people to train and it works both ways. Anaesthetist trains, we should be able to, given the chance to train. But there are days where we can't, lah. Even though the case is suitable	SE's cases are always quite well spaced out, on time... But I've had other experiences, in teams where the OT is really just packed, so you don't want to hold them up too much Interviewer: "Why is it SE's list is better spaced, compared to some of the others?" Um, I think it's uh, just his style? He doesn't like to cram too many things into one list

\* We designated participants using S to denote surgeon teachers and T to denote trainees. Each participant was identified by an alphabet that corresponded to the case study. i.e. teacher SA supervised trainee TA in case study A

operative skill. However, there was less shared recognition of other learning points like surgical reasoning and team management skills. In two cases, trainees discussed important things they had learnt but their teachers did not mention teaching these things (Table 3B1.3, E1.3). Four teachers did not recognise when some things they wanted to teach were either not noted or not valued by the trainee (Table 3A1.2, B1.2, D1.2, E1.3). This was both teacher-related and trainee-related. This discrepancy is illustrated by Case B,

where two trainees were present in the operating theatre while the teacher supervised them in turn, on the same patient. During her interview, SB thought she had emphasised a rare but important complication whereas neither TB1 nor TB2 remarked on it during their interviews, suggesting that it had not registered strongly with them. In contrast, when asked about things learnt, TB1 and TB2 highlighted similar aspects of surgical reasoning that they had learnt from SB, which SB herself had not mentioned. This lack of shared recognition of learning points and/or different learning goals resulted in teachers and trainees valuing the process differently.

In all case studies, teachers and trainees expressed satisfaction with the main operation because the trainee successfully completed most of the operation without need for the surgeon to take over.

Because I think everything went smoothly, everything went the way it should go, so that's why he didn't take over. (TA)

Four trainees described a positive learning environment and two mentioned having learnt new things as contributing to their satisfaction with the operation. All agreed about the teaching–learning environment encountered.

I think it went quite well. I think, one, it was quite... a relaxed environment to learn, so I wasn't scared to ask questions. Sometimes you do feel intimidated, you don't ask questions. I think with SB, it was quite nice. (TB2)

Teachers and trainees sometimes differed on minor aspects of the operation. This occurred when the teacher and trainee focused on different learning objectives as in Case C where SC was happy with main operation performance but not skin closure, whereas TC forgot the skin closure problem because she was so excited about having successfully completed the main operation (her first time); or when there was a difference between trainee self-assessment and teacher's assessment as in Case D where SD was dissatisfied with TD's pre-operative ultrasound technique while TD did not realise his technique failed to meet SD's standards.

## Observed teaching and learning behaviours

The cognitive apprenticeship model (Collins et al. 1991) recommends teaching strategies using *modeling*, *coaching*, *scaffolding*, *articulation*, *reflection* and *exploration*. While the first three methods were regularly employed and experienced by participants, there was a relative lack of reflection and articulation.

For all cases, the trainee had prior experience or had observed the case *modeled* by the surgeon before being allowed to do it. The observer noted that all the teachers used *coaching* through guided practice (Shumway-Cook and Woollacott 2007), which consisted of giving regular intermittent feedback on the way the trainees were performing the various operative tasks and the achieved results. Specific feedback about technique was reduced during parts of the operation familiar to the trainee and was replaced by other forms of guidance like warning about risks and justification of surgical reasoning.

Trainees occasionally did not register verbal feedback when they were concentrating on the operation. Besides verbal feedback, four teachers also frequently used physical feedback, to demonstrate manoeuvres or by direct contact to move the trainee's hands appropriately. Trainees found physical feedback useful when learning the specific operative technique (Table 3C2.1, E1.1)

I think when he turned my hand, and then I realised that I was making it very difficult for myself, when I could actually overcome the problem by just turning my hand. (TC)

In one case, the teacher (SD) temporarily took over tissue dissection to show the trainee the correct plane. In two cases, the teacher had to temporarily change places with the trainee to visually check the trainee's work. Their trainees understood the need for these steps and appreciated the guidance given.

Aspects of *scaffolding* with provision of support fading in tandem with increasing learner competence were described by all teachers and recognised by most trainees. During the observed operations, every teacher provided the trainee with subtle support (e.g. arranging ergonomic positioning of equipment, readjusting theatre lighting or enabling tissue retraction). Teachers also discussed using *scaffolding* methods like teaching surgery in steps and by allowing progressive trainee autonomy.

And there are different levels of training. One you scrub, with the person to show, one you don't scrub, and then you watch, and then you decide call for help lah. Because the independent surgery and bringing-through surgery there's different learning values. (SE)

All teachers used guided practice for coaching. Trainees shared other experiences of being allowed independent *exploration* (discovery practice (Shumway-Cook and Wool-lacott 2007)) which was liked, but tempered by anxiety about patient safety. Only two surgeons discussed *exploration* as a teaching strategy and both highlighted that this was limited by the surgeon's threshold for risk.

Some teaching-learning strategies were used infrequently. Only one trainee (TC) reported that she regularly *reflected* on the learning experienced in the operation (Table 3C2.2), and none of the teachers demonstrated or mentioned using methods to facilitate trainee reflection. In contrast, several teachers showed evidence of practising reflection on their own surgical and teaching practice.

Because there's certain way I do things. Usually I hardly explain, but there's always a reason, lah, cause I always...[launches into prolonged description justifying the specific surgical technique] (SB)

So let me clarify, so you were teaching him the way you do things because? (Interviewer)

Because I think my way is easier! Yes, I think my way is easier because I've crystallised what are the challenges on table. (SB)

*Articulation* was not used as a strategy by the participants. However, it was noted that the process of the interview required several trainees to articulate when explaining the specifics of the operation, which subsequently helped them to recognise and organise the things they had learnt.

## General ideas about intra-operative teaching-learning

Participants all held strong beliefs about different systemic and cultural factors that govern teaching-learning behaviours and opportunities in the operating theatre. Several expressed concern about reduced operative opportunities for trainees compared to previous years.

If you interview each trainee now, the training opportunities are a lot less. We can say there are simulators, that the learning curve is shortened, but nothing beats cutting on a real patient, lah. And the amount of cutting now, from when I was a registrar to consultant, for a registrar, is definitely less.(SD)

## Discussion

Our study shows that teachers and trainees who experience the same teaching operation often differ in their recall of the teaching–learning related to aspects of practice such as surgical reasoning and team management skills, while there was strong agreement on technical elements of operative skills. Teachers and trainees differed in the value they attached to what was taught and learnt because of non-recognition of learning points and/or different learning goals. Nevertheless, all teachers and trainees in our study were satisfied with the teaching operation. The reasons contributing to satisfaction were learning new things, an encouraging learning environment, successful operative outcome and the trainee’s ability to complete most of the operation without the surgeon taking over.

Our findings suggest that contrary to previous studies (Claridge et al. 2003; Jensen et al. 2012; Levinson et al. 2010) dissatisfaction with the quality of intra-operative teaching may be unrelated to quality of feedback and amount of autonomy given. In our study, even the two trainees who preferred being given greater autonomy were satisfied with the intra-operative teaching. With regard to the quality of feedback, we found that there was good, specific verbal and physical feedback given frequently and that trainees mostly recognised and appreciated feedback. The few occasions where feedback was not recognised were because the trainee was preoccupied with operative tasks. Even though the teachers in this study understood the importance of scaffolding, several overestimated the trainee’s ability to listen well when operating. Considering that operative conditions in our study were ideal, it is probable that in more challenging situations, stress would definitely reduce the trainee’s ability to recognise and respond to feedback (Wetzel et al. 2006). Physical feedback on the other hand, was very effective in teaching operative technique, and some teachers found demonstrating by movement easier than explaining. Physical feedback likely aids trainees in learning to recognise haptic and visual cues (sensory semiosis) that have been described as an important subdomain of operative skills learning (Cope et al. 2015). Another form of feedback was to take-over dissection, indirectly by using the retractor or directly, to show the trainee the correct tissue plane. Although taking-over may be related to other factors than trainee incompetence such as time pressures or to demonstrate alternative techniques, both teachers and trainees recognised that taking-over too much of the operation would significantly impact trainee satisfaction.

Trainees have different ideas of learning needs compared with teachers (Pugh et al. 2007). This is intuitively understandable as the learner is often unable to tell what he does not know (Eva et al. 2004). Four trainees had self-assessment of operative skills that differed from teacher assessment, one lower and three higher. Only two teachers reported regularly asking their trainees about learning goals before the operation. We recommend that teachers should negotiate learning goals with the trainee prior to the operation to maximise learning from every teaching case (Roberts et al. 2009; Ahmed et al. 2013). For example, if anticipating time pressure, let the trainee choose which part of the operation to perform, rather than simply taking-over when time runs out.



The paradox of expertise is that the teacher who has crossed the threshold to expertise may no longer be able to appreciate the viewpoint of the learner (Kneebone 2009). As in Case B, the trainee may sometimes need to ask the teacher to explain aspects of surgical reasoning or operative technique. Such behaviour would be discouraged if prevailing surgical culture promotes confidence and certainty (Jin et al. 2012). Hence teachers need to ensure the intra-operative learning environment allows trainees to display uncertainty without repercussion. The paradox of expertise also makes it difficult for the expert surgeon to deconstruct what has already become intuitive, hence some teachers may find it easier to demonstrate the whole operative manoeuvre rather than describe the component parts.

Intra-operative training is time-consuming. In the last decade, most countries have introduced restrictions on trainee duty-hours so as to reduce fatigue-induced patient safety errors. Duty-hour restrictions range from a 48-h working week mandated by the European Working Time Directive to an 80-h working week in the United States. This has resulted in reduced operative training opportunities for the surgical trainee (Purcell-Jackson and Tarpley 2009) and significant global concern that shortened training time precludes achieving surgical expertise. As it is difficult to control the situated learning curriculum in a busy operating room, we should revisit notions of what should be taught-learnt intra-operatively for better curriculum planning.

Simulation training is increasingly promoted as an efficient method to replace intra-operative teaching. However, a US surgical resident is estimated to spend 20 % of the workweek in the operating room (Chung and Ahmed 2007) compared to less than 3 % in the simulation lab (Singh et al. 2014). The transfer of technical skills learnt from simulators to practice has been demonstrated only in laparoscopy and endoscopy, not open surgery (Fonseca et al. 2013) while teaching of surgical judgement using simulation still requires significant teacher involvement to provide feedback (Andersen 2012). In our study, all participants indicated their preference for authentic activity in surgical skills teaching. The cases exemplified the situated learning concept of learning with tools (Brown et al. 1989) as participants described learning from different surgeons about operative decision-making and techniques not found in textbooks in response to unique situations (e.g. changing hand direction to traverse a smaller-than-usual opening). This may explain why senior trainees (Boyd et al. 2006) and surgeons do not believe that simulation can replace the hours spent in the operating theatre for advanced surgical training. However, simulation training can be reconceptualised as more than just psychomotor task-training in the skills laboratory. Integrated skills training where simulator-based resources are provided alongside the clinical workplace allows safe contextual learning. (Kneebone et al. 2004). Unfortunately this integrated approach is constrained by present systems of training and clinical care delivery.

We need to find ways of enhancing intra-operative training. Our study showed that teachers and trainees typically remembered the technical learning points while learning points like surgical reasoning or team management skills sometimes did not register within the teacher-trainee pair. Teachers and trainees had strong impressions about technical skills probably because both were actively involved and invested in that aspect. A study on surgeons' perception of operative room learning has subcategorised technical skills into the domains of sensory semiosis, motor skills and adaptive strategies (Cope et al. 2015). All our study participants were able to provide detailed descriptions about tissue recognition, the mechanics and considerations of operative techniques suited to the specific case. For other skills, the lack of recall in some cases was related to trainee's level of development, as the more junior trainee either did not grasp the concept or did not register the teaching. In other cases, the reason seemed to be that the individual valued learning technical operative skills above other skills. It suggests that teachers need to accurately assess the

trainee's intra-operative cognitive load to reduce extraneous load (van Merriënboer and Sweller 2010) and be explicit when teaching non-technical skills in particular.

Despite medical education being traditionally described as a form of apprenticeship (de Cossart 2005), there is little in the healthcare literature regarding cognitive apprenticeship models for teaching. It has been described in student internships (Stalmeijer et al. 2009), paediatric resident-preceptorship relationships (Balmer et al. 2008), interdisciplinary consultations (Pimmer et al. 2012), but not in surgical disciplines. In our study, teaching strategies commonly applied were modeling, scaffolding, and coaching while articulation, reflection and exploration were less commonly employed. While exploration is limited by other factors of patient safety and surgeon threshold for risk, reflection and articulation are two strategies that can improve intra-operative training. Teachers can encourage reflection by modeling their own reflection processes and by requiring the trainee to articulate about parts of the operation that went well or poorly (Ahmed et al. 2013).

During the interviews, all participants when discussing intra-operative training raised many systemic and cultural barriers that prevented access to practice (Lave and Wenger 1991). High quality intra-operative training requires system and cultural change in addition to improving teaching methods.

### Strengths and limitations

A strength of the study design was that it ensured the observer, teacher and trainee all shared a single reference point on which to base discussion of beliefs and values about intra-operative teaching and learning. Case study methodology enabled the foregrounding of the context and relations as emphasised by situated learning theory. Our study provided in-depth direct investigation of operating theatre teaching–learning, a situation that is not commonly accessible.

Some limitations remain since special preparations and the observer's presence may have altered the participants' behaviours. The participating surgeons were potentially different from typical teachers so we directed trainees to discuss prior experiences with other teachers. Possible bias remains from CO's "dual position as both cultural member and cultural commentator" (Braun and Clarke 2006, p94) as surgeon teacher employed in the same institution. As an experienced surgeon educator, CO could easily navigate the operating theatre environment and identify teaching–learning behaviours during observations. It is possible that participants self-censored with a familiar interviewer. Alternatively, since CO is viewed as community-insider, it might instead have encouraged more open sharing by participants. CO was familiar with the vernacular lexicon of participants and the institutional sociopolitical culture which likely enriched data gathering and analysis. To guard against bias from over- or misinterpretation, CO regularly clarified her observations and understanding directly with the participants during the interviews. Potential bias during data analysis was also mitigated by alternate views of other study team members who are non-surgeon educationalists from external institutions.

### Conclusions

Teachers and trainees often differ in what they recall and value about intra-operative teaching and learning, especially surgical reasoning and team management skills. Satisfaction with intra-operative training is largely related to successful operative outcome

where the trainee completes the operation without the surgeon taking-over, learning new things and the learning environment. It is important to consider the situated learning curriculum that occurs in the operating theatre and utilise appropriate teaching strategies.

**Acknowledgments** The authors wish to thank the surgical teachers and trainees who participated in this study.

**Compliance with ethical standards**

**Conflicts of interests for authors** None.

**Ethical approval** The study was approved by the Human Ethics Advisory Group of the Medical Education Unit at the University of Melbourne (HREC 1441645) and received exemption from the SingHealth Centralised Institutional Review Board (CRIB 2014/425/D).

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