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"I can do better": exploring purposeful improvement in daily clinical work

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Abstract Clinicians' purposeful improvement of practice is vital to maintaining excellence in patient care. This activity is understood as a core competency of adaptive expertise. As part of a broader program of research exploring adaptive expertise in healthcare, this study explored purposeful improvement in paediatric minimally invasive surgery. A cognitive ethnography was conducted, with the aim of identifying and elaborating distributed cognitive processes that occur when an individual enacts purposeful improvements in a clinical context. A saturation sample of data from weekly pre-operative meetings, 13 observed minimally invasive procedures and 12 semi-structured interviews was collected over 6 months. A concurrent analysis of field notes and transcribed interviews was done inductively to uncover emergent themes. An audit trail was maintained throughout the research. We analyzed the interview and observation data with particular attention to the ways in which the activity of purposeful improvement is distributed socially (e.g. patient families, health care team) and materially (e.g. procedure, patient position, instruments, OR equipment) as well as over time (i.e. before, during and after). These results made visible the distributed nature of purposeful improvement, building on our understanding of this important adaptive expert activity in clinical settings and suggesting implications for more effective

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training of future adaptive experts. In particular, our results inform how purposeful improvement can occur during daily work and highlight two related forms of integration that occur during this activity: integration of individual competencies and integration of individuals and their social and material context.

Keywords Adaptive expertise · Purposeful improvement · Distributed cognition

Introduction

Over the last 25 years researchers have extended their explorations of expert performance to activities not captured in traditional models of expertise (Bransford et al. 2000; Hatano and Inagaki 1986). The resulting theories of expertise emphasize flexibility, adaptation and innovation as core competencies of what has been termed 'adaptive' or 'true' expert practice (Bereiter and Scardamalia 1993; Hatano and Inagaki 1986). Researchers have spent some time elaborating these competencies, perhaps most notably defining processes of 'progressive problem solving' and 'optimal adaptability' (Bereiter and Scardamalia 1993; Schwartz et al. 2005). Progressive problem solving is the process by which experts continually reinvest the cognitive resources gained though routinization into progressively more complex formulations of their problems of practice. This continual reinvestment of resources into practice is premised on a lifelong process of continuous improvement through active engagement in daily work (Mylopoulos et al. 2012). Further elaborating the critical interplay between routinization and innovation, researchers have described expert practice as occurring within the 'optimal adaptability corridor', articulating the importance of experts maintaining a balance between complementary 'efficient' and 'innovative' dimensions of practice by making use of previously acquired knowledge to solve routine problems, as well as introducing or creating new solutions in response to novel problems (Schwartz et al. 2005).

The current study is part of an evolving program of research focused on defining the activities and processes related to adaptive expertise in healthcare, with the ultimate aim of optimizing the development of healthcare trainees into future adaptive experts (Mylopoulos et al. 2012; Mylopoulos and Regehr 2009; Mylopoulos et al. 2011; Mylopoulos and Scardamalia 2008). This growing body of interview-based, grounded theory work has elaborated individual perceptions of adaptive expert practice and development, identifying key habits, attitudes and approaches to practice. For example, our exploration of elite clinicians diagnostic reasoning resulted in an elaboration of the process of 'optimal adaptability' in diagnosis: the ways in which elite clinicians use their extensive knowledge, while also working flexibly and reflectively outside the boundaries of that knowledge when necessary (Mylopoulos et al. 2012).

One activity of adaptive expertise that is central to both progressive problem solving and optimal adaptability, but remains largely unelaborated is the activity of purposefully improving practice through daily clinical work. This process is understood to be vital to maintaining optimal patient care at both individual and community levels of practice (Brown and Duguid 1991; Mylopoulos and Scardamalia 2008; Rachlis 2004; Shojania and Levinson 2009), thus our lack of understanding of how it occurs inhibits our ability to inform the training of future adaptive experts in this important activity.

Defining the activity of purposeful improvement

While the expertise literature embeds purposeful improvement in articulations of expertise, the phenomenon itself is not well specified. Other literatures offer us frameworks through which to begin to understand purposeful improvement. Perhaps most influential in health professions education has been Schön's (1983) articulation of 'reflective practice': the process by which professionals reflect both during and after activity (Mann et al. 2009). In particular, reflection-on-action, the process by which professionals consciously reflect post-activity on what they did, and what they might have done differently and consider this reflection as part of their future problem solving. Essentially, reflection-on-action is a form of continual professional development and as such can be understood as purposeful improvement driven by failures in practice.

However, purposeful improvement can also occur in the absence of failures of practice and rather as an effort to embrace and embed new ideas, technologies and guidelines into practice. The practice-based learning literature offers the construct of 'exploitation' as a lens to understand purposeful improvement of this kind. Exploitation is understood as the integration of new ideas into practice. Importantly, exploitation is distinct from 'innovation' in that it is not focused on discovery of new ideas, but rather "the implementation of new ideas into local contexts" (Crossan et al. 1999; Fenwick 2003). In that sense, it doesn't preclude discovery, but also doesn't require it. As such, it's a useful concept for understanding purposeful improvement, which may or may not be 'innovative' in the sense of "creation or discovery of new solutions" (Fenwick 2003). It is this form of purposeful improvement that was the focus of the current research.

Exploring expert activity in context

Critically, expertise in the 'adaptive' or 'true' expert framework is an activity experts perform rather than an attribute they possess through credentials, experience or education. Thus, it is important to understand purposeful improvement as an activity that occurs in the world and to theoretically frame the resulting inquiry appropriately. There are a number of theories that seek to situate cognitive activity in context (e.g. Greeno 1997; Hutchins 1995a). For exploring expertise in context, distributed cognition offers a powerful lens as it recognizes both individual and situated knowledge (Bereiter 1997) and seeks to explore the ways in which the same cognitive activity might look different when enacted by an individual as opposed to an individual in context (Hutchins 1995b). Thus, we can understand how a goal (like purposeful improvement) is achieved only when we understand, as a unified whole, the contributions of the parts in the system and the coordination necessary among them to achieve the goal (Nardi 1992). Perhaps most famously, Hutchins (1995a) has elaborated a comparison of how a navigator (on land) uses a mathematical formula to determine the location of a ship, with the way in which that same navigator (at sea) uses the world around him to perform the same calculation. Thus the focus is on the ways in which individuals effectively negotiate the intersection of their own cognition with the context they find themselves in. Crucially, in a distributed cognition framework, while the analysis is at the level of systems function, system goals remain located in the minds of individuals (Nardi 1992). In the broader picture of exploring adaptive expertise, distributed cognition is a valuable framework in that it does not deny individual knowledge or agency, and thus allows exploration of expertise in context without losing the expert in the analysis.

Current study

In the current research we sought to use the framework of distributed cognition to explore the phenomenon of purposeful improvement. The objectives of the research were first, to understand the expert activity of purposeful improvement in a single clinical context and second, to use this understanding to contribute to our broader, evolving understanding of the processes of adaptive expertise.

Methodology

Design

Cognitive ethnography is a methodology developed specifically to explore distributed cognition (Ball and Ormerod 2000; Hutchins 2003). It allows researchers to explore how cognitive activity is distributed across social and material artifacts (people and objects that aid, enhance or impede cognition) as well as over time. A cognitive ethnography involves integrating data across observations, interviews and exploration of social and material artifacts. By conceptualizing material and social artifacts not only as aids to individual cognition, but also as integral elements of distributed cognitive activity, i.e. activity grounded in the interaction between individuals and their environment (Hutchins 1995b), a cognitive ethnography provides a process analysis of cognition as it is enacted in the real world. Thus, the results of cognitive ethnographic research have the potential to "change our minds about what counts as a characteristic human cognitive task" (Hutchins 1995b), thereby adding to our understanding of the repertoire of processes and activities that underpin adaptive expertise.

Site and participants

The purpose of this study was to explore the activity of purposeful improvement performed by an individual expert in a single clinical context. The aim was therefore not to generalize or predict, but rather to create a deeper understanding of the phenomenon being investigated (Patton1990). In order to achieve this aim, we used a critical case sampling strategy to establish observational specificity (Ball and Ormerod 2000). In doing so we maximized opportunities to observe purposeful improvement (Patton 1990) by intentionally seeking to investigate a setting where it might occur more regularly. Minimally invasive surgery was selected to fulfill this requirement. Progress in surgery has been characterized by the increasing use of minimally invasive procedures in an effort to make surgical procedures less invasive and decrease recovery time for patients as well as costs for hospitals(Moore et al. 2012). These techniques continue to evolve in a variety of ways, including clinicians seeking to effectively teach established procedures to trainees, improve currently used minimally invasive procedures and explore the feasibility of new procedures(Turner et al. 2012). Therefore, minimally invasive surgical procedures offered a powerful opportunity to explore purposeful improvement in a clinical domain.

We explored minimally invasive surgery at the Hospital for Sick Children, a teaching and research hospital affiliated with the University of Toronto. A staff surgeon with expertise in minimally invasive surgery was invited to act as a key informant for the project. The key informant was selected for their ability and willingness to provide the research team with broader knowledge and perspectives (Gilchrist and Williams 1999).

Other participants were members of the surgical team for each observed procedure. Members varied, but generally included one staff surgeon, surgical fellows and residents, an anesthetist, a scrub nurse and a clinical support nurse.

Data collection

After obtaining ethical approval from the Hospital for Sick Children, one researcher observed 13 minimally invasive procedures over the course of 6 months. The choice of sample size was determined through saturation sampling (Glaser and Strauss 1967), that is we explored the phenomenon of interest until there were no new interpretations relevant to our exploration emerging from the data. We conducted a total of 78 h of participant observations (Hammersley and Atkinson 2007), including weekly 1-h pre-operative planning meetings and 3–5 h of observation in the operating room for each procedure. Data from the participant observations were comprised of descriptive and reflective field notes, including recording of the physical setting, events and activities, exchanges between individuals and the researcher's own reaction to the observed phenomena.

In addition to observations, we conducted semi-structured interviews (5 with surgical fellows, 6 with the key informant, 1 with a scrub nurse) after each observed procedure. Participants were asked to reflect on specific events observed by the researcher as well as more general questions about their surgical practice. Topics for questions included: clarification of a particular decision, response or action by a team member and elaboration of the participants' conceptualization of the procedure. The semi-structured interview guide served as an outline, rather than as a definitive list of questions to be asked, and was modified over the course of the data collection to focus attention on emerging themes from the concurrent analysis (Lofland and Lofland 1984). Interviews were audio recorded with permission from participants.

Our third source of data was the ongoing interaction between the key informant and the research team. This included emails and informal conversations, which were recorded through field notes. The key informant provided an insider interpretation of events and information and this perspective was carefully combined with the observation and interview data to develop a sophisticated understanding of purposeful improvement in a clinical context (Gilchrist and Williams 1999).

Data analysis

For each case, the research team (MM and a research assistant) analyzed textual and contextual data through analysis of field notes and interview transcripts. We analyzed field note data immediately after each observation to inform the semi-structured interview protocols for each procedure. Interviews were immediately transcribed and analyzed to inform subsequent interviews and observations. This constant comparative analysis of field notes and transcribed interviews was conducted inductively to uncover broad, emergent themes(Hammersly and Atkinson 1995), as well as deductively with specific attention to the theoretical frameworks of adaptive expertise and distributed cognition. We maintained an audit trail throughout the process of data collection and analysis. Management of the data set was supported by NVivo 8 qualitative research software (Kelle 1995).

Results

Our cognitive ethnographic approach allowed us to analyze the interview and observation data with particular attention to the ways in which the activity of purposeful improvement is distributed socially (e.g. patient families, health care team) and materially (e.g. procedure, patient position, instruments, OR equipment) as well as over time (i.e. before, during and after procedures). This analysis made visible distributed processes involved in purposeful improvement in the clinical setting we explored.

Before: selling and constructing

The staff surgeon (key informant) was a driving force behind introducing laparascopic techniques into practice in his clinical context, commenting:

> People may sometimes find that laparoscopy is not that important for their practice. What are the benefits and the risks? All of these are going to play a role in how you want to sell your idea.

In this context of minimizing perceived 'costs' and enhancing perceived 'benefits', the surgeon worked to introduce laparoscopic procedures, instruments and techniques. There was a recognition that comparing traditional open versus laparoscopic procedures in terms of time in the OR was going to be a 'cost' rather than a benefit of laparoscopy:

> This goes into the reason why people don't like to start something new. If I had done it laparoscopically, most likely it would have taken the first time about 3 h and this case took about an hour and a half. So that's the problem.

Thus, the surgeon carefully selected procedures in order to minimize impact of time on both patients and staff:

> One side surgery takes less time. So I figured it would be good to start a new procedure on one side rather than on both sides. That's why we thought it would be a good case to do laparoscopically.

The problem was not only an issue of impact on those directly involved, but also the broader clinical system within which the surgeon worked. A first year surgical fellow commented:

> I think there's a lot of time pressure on certain surgeries because there's a need to prove that the surgery is time-efficient or that it's not time inefficient especially when it's a novel or new technique. So yeah, there's this pressure on the next patient, when the OR is going to end, you don't want to cancel anybody.

In addition to reducing the impact of time, selecting patients in order to minimize risk and boost the potential for a successful outcome was a key consideration. Cases could be considered fairly simple technically, but pose challenges like patient comorbidities that would 'raise the stakes' of the procedure:

> The laparoscopic procedure is simple but in this particular case it's so important not to have an error or complication. You always aim at a 100 % success rate, but sometimes when you have a problem in a certain situation it moves from a simple to a complex procedure because now the stakes are so high.

Mitigating risk extended beyond the patient and procedure to the perception of risk held by patients and families. This made relationship building between the surgeon and patients and families critical to the implementation of any new laparoscopic procedure or technique. The surgeon commented:

> When it comes to something new being done, I personally think there's no limit, except for the family. If the family is aware of what the expectations and goals are, then you can proceed.

Preoperative meetings were scheduled every Thursday to discuss and plan cases for the upcoming week. For each meeting, the team would vary based on availability: the staff surgeon, senior and junior fellows, scrub nurse, head nurse, child life specialist and social workers could be present, depending on the cases being planned. The senior fellow would often lead the meetings, however the staff surgeon would take over for minimally invasive cases. For these cases, we observed the surgeon designing the physical environment in the operating room: 'he went over the positioning of the patient and instruments for the case scheduled'. 'The OR nurse was making notes of his requests for instruments'. Not surprisingly, a critical aspect of the procedures was the nursing staff in the operating room. This was perhaps best reflected in choosing the time of day for the procedure to be performed based on nursing staff availability. Our key informant commented:

> Most of the time permanent nurses are the ones who work from seven-thirty to three-thirty. They are aware of all the details of the operating room. So, if you ask for an instrument, they will just go and get it. The majority of afternoon nurses are floaters. So they float from one room to another and they may not have a good grasp of what needs to be done and what they need to do.

When asked to further elaborate the importance of the nursing staff with respect to the introduction of laparoscopic procedures and techniques, the surgeon explained the dependency he felt on the nurses for the use of certain equipment:

> So this is an evolving technology. For example, next time you go to the operating room you will see that we'll have different monitors. Nurses are the major source of how to use this technology. So we have complete dependency on them.

The scrub nurse described this dependency in more detail, explaining nuances of monitor placement that she considers when setting up the operating room:

> As for monitor placement…ha…that's a challenge. The surgeons need to look directly across from the patient to see the monitors. Unfortunately they have two monitors, which is very distracting when you're doing laparoscopy. It should be one monitor that you're focused on.

The importance of the physical and social construction of the procedure was observed in the thoughtful enactment of the preoperative instructions: 'The patient was positioned and the surgical fellow started prepping the site while the nurse and charge nurse positioned the monitors. It seemed like there was quite a bit of strategy involved; and though it was hard to hear everything they were saying, it was along the lines of "if we do this, then they can go here…'. In particular, the impact of more experienced nursing staff was observed during preparation for morning procedures: 'The nurses blocked the window on the door on the OR, saying that they have a better view on the screen when the light is blocked'. 'A nurse was fixing the monitors. The nurse asked the charge nurse if she wants to check to see if the surgeon wants the procedure tapes. The charge nurse asked the surgeon, and he

said yes, to tape it'. Thus, before the procedure took place, the surgeon actively engaged in preoperative construction of the social and material context for the planned purposeful improvement.

During: enacting, adapting and reinforcing

During procedures, we were able to see the ways in which preoperative construction of the context played out. For example, the critical role of minimizing the impact of introducing laparoscopy was observed during a case that was not done laparoscopically at the last minute: 'He went into the OR, I followed, and he told the team that it wasn't going to be laparoscopic. They were obviously relieved. The nurses spoke amongst themselves and said that it was probably going to be finished around 2:30 PM, (the surgery was scheduled to go until 5:30 PM)'. The impact of not developing the patient and family relationship was observed in another case where the planned improvement was not enacted: 'The surgeon came up and said "You're not going to believe this but we're not going to do it laparoscopically"'. In explaining what happened, the surgeon stated:

> The main reason was that the family and patient were not mine. I never saw them in the clinic. If I had had the chance to talk to them ahead of time, I could have told them that the success rate was not 100 %, but I could still get them to accept the laparoscopic approach. With this family, meeting them for the first time in the operating room I decided not to do it. I think there's a rapport between us and the patient and their family and when it comes to new procedures you can't really surprise the family on the day of the surgery.

The impact of less experienced and engaged staff was observed during an afternoon case: 'The surgeon said said "OK, let's start". He got no response. Then he said "OK, I'm starting". Nurses seemed a lot more laid back than the ones in the morning procedures'. 'Surgeon had to ask twice for suture when he was closing the right side'. 'The scrub nurse overall didn't look as "capable" as others that I have observed. She didn't seem to be paying very much attention to the procedure'. 'Surgeon was doing lots of explaining to the Fellow and had to physically move her over at one point'.

During procedures, the surgeon directed and continually reinforced the purposeful improvement, for example adapting existing routines like the preoperative huddle in order to support the ongoing introduction of improvements. The surgeon explained:

> So traditionally we don't like to do minimally invasive cases in the afternoon. But over the years, I've changed because I figured out I know what I want and I can ask in the huddle for what I want.

At other times, the surgeon had to insist that the procedure be done a certain way despite the obvious discomfort of members of the surgical team, commenting later:

> In my mind it's the best approach. But it's a little bit disorienting. I don't know if you noticed yesterday but I kept on asking him not to change the camera because we're used to this approach when we cut open but he was not very clear on how I want to look at the kidney.

We observed moments where the surgeon was alert to particularly exemplary performances of a laparoscopic procedure, technique or use of instrument and wanted it recorded: 'He asked if anyone had a camera because he wanted to take a picture of the table and the patient position'. 'He said, "Can you write down the sutures we are talking about so that

next time I know what I want to use?"' These activities during the procedure were key to the ongoing process of building and sustaining the purposeful improvement.

After: building and sustaining

While the enactment of purposeful improvements occurred during individual surgical procedures, these improvements were also collectively harnessed as part of a broader sustained practice improvement process. After each procedure, the staff surgeon thought quite purposefully about the case:

> When I finish a case I try to think about the things that frustrated me or that I enjoyed very much and I go back and say this is what I'd like to do.

He used this reflection to further design his clinical context to support the ongoing use of previously enacted improvements, including the development of an audiovisual library: 'He told the nurses that he wants to show whoever is helping him in the next case a video of how he wants it done'. 'He went over to the Fellows and told them that the more movies of the surgeries they watch, the more they see what they need to do'. Thus, through reflection and development of resources, purposeful improvements performed during individual procedures were translated into broader sustained practice improvements. Moreover, embedding practice improvements into the physical structures and social environments of the broader clinical context also resulted in more opportunities to explore the possible use of minimally invasive techniques:

> As we get more experienced, the threshold becomes very low so you can jump on a lot of things and say 'I want to do it laparoscopically'.

However, this excitement was tempered by procedures that did not go as planned, leading the surgeon to reflect on the need for changing how he approaches certain patients that might be at higher risk during laparoscopic procedures:

> I think now because we are evolving in this technology, we need to be very cognizant about the fact that some of the kids who are very young may not tolerate this type of procedure and I learned that from now on I will communicate more with the anesthesia when I know I have a sick patient.

Interestingly, keeping up with laparoscopic techniques and instrumentation occasionally had adverse effects on other aspects of the procedure, requiring an ongoing commitment to addressing emerging problems in a systematic way. For example, one highly anticipated new laparoscopic instrument had an unexpected impact on the procedure overall:

> Surgeon: We have been asking for them [new instruments] for almost 6 months. It's a surprise, nothing is perfect in instrumentation. They are so suitable and good for younger age group; they are small, they are very narrow, they allow us to work in a very unique dexterity. So they are good, but they are not good in other things.
>
> Interviewer: So does that mean you're going to find different ways to deal with the problem?
>
> Surgeon: Yes and that is why I already have a plan to adjust how I want to do it.

This type of feedback from experiences during procedures was part of an evolving systematic approach to developing and introducing laparoscopic procedures by considering specific costs and benefits and working to address them in the clinical setting.

> Since we started doing more and more of these cases, now we're at the stage where we can start to streamline the steps we want to do surgically. So for that case, it was going to be more of how can we do it and make it faster. Because again, the major drawback to doing it laparoscopically is that it takes much longer time.

This process in turn informed the 'selling' of laparoscopy by feeding back into the construction of the social and material context for the next planned improvement, with specific attention to reducing costs and enhancing benefits.

Discussion

This research explored purposeful improvement in daily clinical practice, building on our understanding of this important adaptive expert activity in health professional settings. Using a cognitive ethnographic approach allowed us to recognize distributed cognitive processes that occur as the activity is performed in the real world over time. We elaborated the ways in which individuals construct their context for purposeful improvement, adapt and reinforce the improvement during its performance and purposefully build best practice through systematically sustaining improvements in daily clinical work. While this study represents one clinical context, interpreting our results within the broader framework of adaptive expertise (Bereiter and Scardamalia 1993; Schwartz et al. 2005) and in parallel with additional literature in health professions education research (e.g. Mylopoulos et al. 2012; Mylopoulos and Scardamalia 2008; Sklar 2013) suggests important implications for more effective training of future adaptive experts. In particular, our results make visible how purposeful improvement occurs during daily work and highlight two related forms of integration that occur during this activity: integration of individual competencies and integration of individuals and their social and material context.

While practice improvement is widely recognized as an important part of excellence in health care, previous work has shown that it is perceived by physicians as research based activity located outside of daily clinical work (Mylopoulos and Scardamalia 2008). This perception renders invisible the activity of purposeful improvement explored in the present study. Nonetheless, its importance and value cannot be underestimated. Ignoring or devaluing the potential impact of knowledge that clinicians develop during the course of their daily work represents a missed opportunity for both individual and community practice improvement (Mylopoulos and Scardamalia 2008; Shojania and Levinson 2009). By providing a distributed account of the activity of purposeful improvement within the daily work of clinicians, we were able to identify types of activities that might otherwise not be understood to be components of purposeful improvement. For example, in the clinical setting we explored, specific activities such as scheduling, establishing patient relationships, designing physical space and building supporting resources were crucial to practice improvement. More broadly, this study adds a repertoire of distributed processes to the adaptive expert constructs of progressive problem solving and optimal adaptability, which have thus far been described as cognitive events bounded within an individual mind. For medical educators, our results demonstrate the ways in which the purposeful improvement can be conceptualized and taught as a form of daily problem solving activity, particularly at the postgraduate levels of training where our previous research has demonstrated that trainees become increasingly aware of the need to continually reinvest into improving their practice as a vital and unavoidable part of their expertise (Mylopoulos et al. 2011).

In addition to deepening our understanding of how distributed processes can underpin expert activities like purposeful improvement in daily clinical work, our results inform the evolving conceptualization of an integrated construct of expertise (Mylopoulos and Regehr 2007; Norman 2005). It is increasingly recognized that experts are routinely required to move beyond application of their knowledge in order to do their work well (Sklar 2013). Distributed, real world processes like the ones described in this paper are beginning to be understood to be part of expert work and integration of individual competencies as well as individuals and their social and material context are at the core of these forms of activity.

There is a growing body of research and thinking that posits that individual experts actively integrate several physician competencies as they work. For example, when explaining diagnostic reasoning, renowned physicians describe integration of the medical expert, communicator, and scholar CanMEDS roles, or the medical knowledge, interpersonal and communication skills, and practice-based learning and improvement ACGME competencies (Mylopoulos et al. 2012). In our study, this form of integration was again visible as the surgeon interacted with the patient and family, (CanMEDS communicator) and with other health professionals (CanMEDS collaborator), maintained good patient outcomes (CanMEDS medical expert) and systematically sustained the purposeful improvements (CanMEDS scholar). All of these competencies came together during purposeful improvement of practice. Moreover, our results also highlighted the interrelated nature of each of these competencies. For example, lack of effective communication with the patient and family prevented the purposeful improvement from occurring, and lack of effective collaboration made performing and sustaining an improvement more challenging. Essentially, performance in one competency was necessary, but insufficient for the activity to occur. For educators, this integrated nature of expert activity raises the challenge of making visible the multiple competencies that are part of any given activity and perhaps more importantly, the issue of when and how to foster trainee participation in and coordination of these competencies.

Integration of individuals and their social and material context was less well explored in this study. By using a distributed cognition framework, the individual remained at the center of our analysis. However, our results raise some interesting questions related for further inquiry. In particular, while context is often conceptualized as the environment that individuals must negotiate in order to perform a given activity (Gibson 1977) our results reframe individuals as active participants in constructing their own contexts for clinical activity. In the medical expertise literature there is a widespread understanding that contextual factors impact clinical reasoning. For example, Durning et al. (2012) have explored the ways in which physician, patient and encounter factors impact clinical reasoning performance. Given our results, and in particular the ways in which the physician in our study carefully constructed and systematically reconstructed the social and material context, one can imagine that exploring other clinical activities, through this lens would lead to understanding the ways in which physicians might construct their context along dimensions relevant to whatever clinical task they were undertaking. Using clinical reasoning as an example, Durning et al. (2012) identified physician, encounter and patient factors that impact performance. The perspective afforded by the results of the current study would lead us to explore how, and the extent to which, physicians can exert some control over these factors when setting the stage for activity, as well as exploring the barriers and enablers to doing so. Essentially, our results position individuals as active participants, rather than passive recipients of context. This reframing offers an opportunity to identify additional expert processes that occur as clinicians perform in the real world, actively integrating themselves and their context.

Our aim in this research was to add empirical and theoretical depth to the construct of adaptive expertise and in doing so articulate possible implications for educators engaged in the challenge of training future adaptive experts. This research had some notable limitations. First, we observed purposeful improvement in the practice of one key informant in a single clinical setting. While this allows deep understanding of the phenomenon, it also limits transferability of the results. We enhanced transferability by drawing on the broader theoretical implications of our results, however these will require further exploration in additional clinical settings and activities. Second, using a distributed cognition framework allowed us to understand how individual cognitive activity can be understood to be distributed in the real world and draw out the resulting implications of that analysis. As part of a research program focusing on understanding and fostering adaptive expertise, this methodological choice has clear advantages, as outlined in our methodology section. However, the dialogical and institutional factors that can be understood to be part of purposeful improvement in clinical settings were not included in our study and represent interesting areas for further inquiry on the "sociomaterial contingencies" of clinical work (Fenwick 2014).

As we continue to explore adaptive expertise in clinical contexts, next steps will be to evolve our understanding of specific expert activities through comparing and contrasting multiple cases, adopting the same methodological approach to explore additional adaptive expert activities and investigating the ways in which adaptive experts coordinate all their activities, thereby deepening our understanding of an integrated construct of adaptive expertise (Mylopoulos and Regehr 2011).

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