Simulating Medical Patients?

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Abstract

Medical simulators are being used to teach and examine medical students and professionals. Simulators can provide frequent opportunities for training and allow students to practice techniques without endangering patients. However, simulators also do more then provide training sessions, they reveal medical understandings about the patient body. This is because they simulate medical practice rather than recreate physical anatomies. Considering that it is practice which provides the foundation of simulator design, this paper asks what the implications of including patient experiences in simulators would be.

Medical simulators are models of patient bodies, these days often digitally enhanced or even completely virtual. They are used for students to learn new skills on or to train and perfect a medical practice. They are stand-ins for a patient, and because of them a student can work on a specific skill or medical practice before encountering a real patient. Simulators can be used to train skills, but they can also be used to examine if a student (or practicing doctor) has mastered those skills. Simulators can be both teaching tools and testing tools.

One of the benefits of simulators is that they allow for the repeated training of specific skills, without having a patient whose medical needs require the presence of a doctor or nurse to carry out an entire procedure. Thus, a student can practice tying a knot, for example, or setting a drop, over and over again without having to worry at the same time about what other procedures need to be done to the patient. This can give a student the time to master a specific skill before having to place that skill in its proper constellation of other actions. By learning basic skills this way, it is often thought, the students can focus on more complex aspects of medicine when they eventually meet the patients on their rounds or in the operating theatre.

Sometimes the amount of training available to a student is limited by the number of patients which are available with a specific illness or medical case. Simulators can solve this problem by creating specific medical cases which can be treated over and over again and at times that fit into a student's schedule and educational plan. Using simulators can also help standardize the educational experience. Each student can have access to the same medical cases, and instructors can be sure of which cases the students will be able to train when planning a course.

Simulators have other benefits for instructors, as well. For example, not only can the instructors know ahead of time which training opportunities the students are going to be able to encounter, simulators can also help the instructors evaluate student's performance. Many of the simulators being used today have been designed to give feedback directly to students and instructors about the student's performance and abilities. Sometimes this feedback is even given in terms of grades and scores, which can seem to make it easier for the instructors to objectively and fairly judge the student's learning.

The additional training simulators offer can increase patient safety, as can the fact that they reduce the need for beginners to learn the basic elements of new procedures on patients. Simulators can replace training on animals, which are very expensive and present ethical issues, and cadavers, both of which can mean a significant cost savings to university hospitals. In addition, some people assert that students can train on a simulator without having a doctor-instructor with them, thus freeing up doctors to treat patients instead of spending their expensive time instructing new students.

As simulator technologies are advanced, simulators are also being developed which can be used to plan and practice patient-specific procedures before an operation, giving surgeons the chance to do a 'run through' before actually touching the patient.

Thus, there is a large role that simulators can play in teaching medicine. That role, however, is multifaceted. This text will examine some of the different ways simulators can be used in medical education and what sort of understandings about their construction lead to the ways they are designed to look and work.

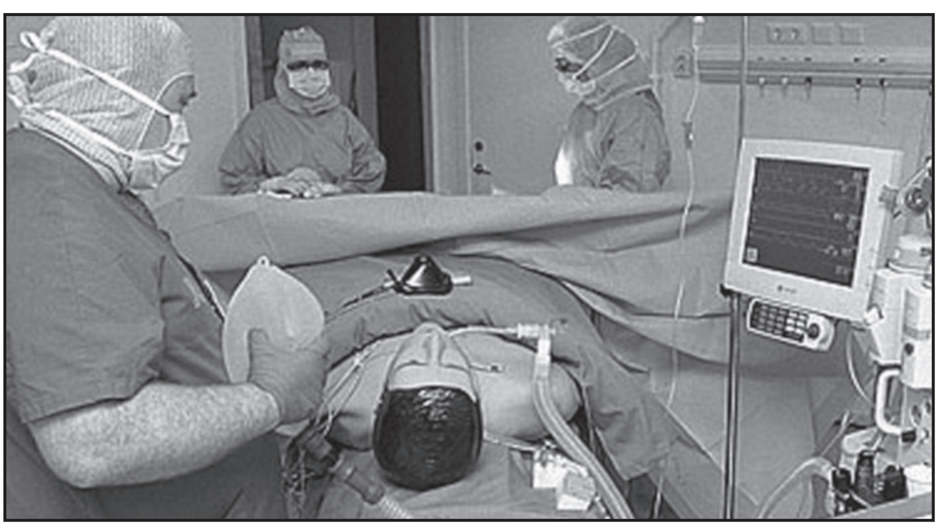
Teaching tools?

Teaching with simulators can allow students to practice a skill without using a live patient as a guinea pig and this is good both for the patients (who wants to be a guinea pig?) and for the students, since many students can think it is awkward and embarrassing to try something new on a patient who may not be keen on having a young, new doctor try to draw blood, fumble around and miss the vein or, even worse, make a mistake in an operation that could put the patient's life in danger. Because of this, using a simulator to train the first attempts can be a relief for both the patient and the student.

In addition, simulators can be good because they can allow a student to try certain medical procedures before they are really ready, to test things out early on in their education and see if they really do want to become a surgeon, for example, or work on a specific part of the body. In this way, simulators can give the students the chance to test out specializations before they have to decide where they want to go with their career.

Simulators share more than just the skills they have been designed to teach, however. When being used by students the simulators can express subtle ideas about the understandings of the patient and the medical values associated with different specializations and different treatment options.

Figure 1. A full body patient anaesthesiology simulator



Consider, for a moment, the full body anaesthesiology simulator (Fig. 1). This simulator does more than just allow the students to train the skills of anaesthesiology, it also shows the students that the anaesthesiology patient is a full body attached to an anaesthesiology machine, and that the students need to read the physical signs of both the body and the statistics that the machine is displaying in order to understand and monitor the patient. In a similar vein, the minimally invasive surgical simulator (Figure 2) shows the students that the surgical patient is a patient that is observed and treated in localized areas. Rather than being a full body beneath a surgical blanket, the surgical 'patient' is displayed on a video screen and manipulated through tools inserted in small holes in the body. This patient is much more an internal volume than a full body of the anaesthesiology simulator, with dilated or contracted pupils and blood pressure and a pulse.

Figure 2. The minimally invasive surgical simulator

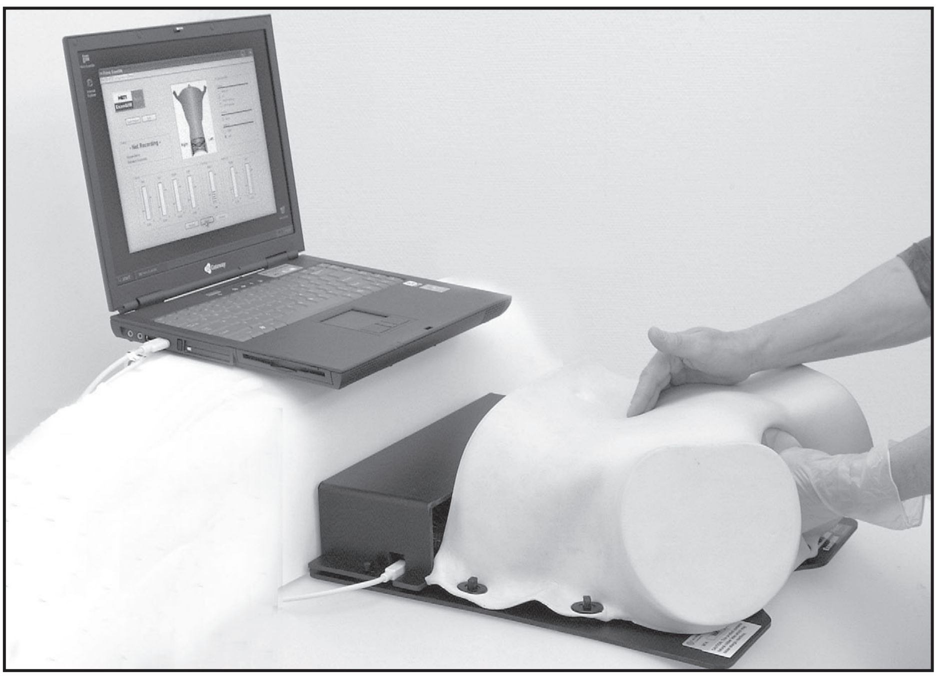
Simulators like these can work as ambassadors or messengers of new types of medical techniques. The minimally invasive surgical simulator can be used to explain *and show* the benefits of this type of surgery to others, and to let surgeons who are unfamiliar with the techniques try them out in a relaxed teaching environment. This can be true for many different types of medical techniques. For example, the development and use of a simulator designed to teach how angioplasty and stents can be used to treat clogged arteries in the heart can also work as a tool to show how this new type of treatment can be used for medical professionals who are not accustomed to treating clogged arteries in this way. This is particularly true in places where angioplasty has not traditionally been the standard treatment. When the simulator appears at cardiology congresses and when the machine attracts a great deal of attention at these events, it is also attracting attention to the actual method of treatment and working as an advertisement for angioplasty. One could argue that the 'teaching' simulator is teaching *what* the technique is as much as it is teaching *how* to do it. Understandings about what the patient is, which parts of the body are interesting and relevant, and how the patient body should be approached, considered, and manipulated are also taught by the simulators, even if these are perhaps not intentional in the simulator's design.

Examination tool

While many simulators may be designed to be used to teach a skill or task, they are also being used to examine or assess students and practicing medical professionals, to test if these people really know what they are doing. Simulators are even being used in licensing exams, as a sort of driver's test to see if a person should be allowed to practice certain medical procedures. There are different ways to use a simulator as an assessment tool. The scores some simulators produce after the user has trained on them can be good for summative assessments—which evaluate the student's learning at the end of a session, class or course—especially if the simulator is being used to test a practitioner before their license is granted or renewed. In these cases the scores can determine if the user has mastered the skills the simulator tests and then a base line result can be set that the user then has to meet or pass.

Simulators which give a score at the end of the session can also be used in formative assessment—which evaluate the student's learning during the process of training, giving the students feedback while they are still learning more. This is done when the score produced is discussed during the simulation, the users understand how the score relates to specific elements of their performance, and then the users are allowed to retry the simulation or continue working on another, related, task, reintegrating what they have learned into their training session. The computer screen attached to the gynaecological simulator in Figure 3 is a good example of this, which shows how hard the student is pressing on internal organs during the bimanual pelvic exam.

Figure 3. The gynaecological simulator



Other assessment methods, like video tape, can also be a useful with simulators. While the scores produced by some simulators can be an 'objective' measure of a student's performance, video taping a simulation and then discussing it with the students afterwards can be a valuable way of bringing home specific points the instructor would like to emphasize and also helping the students digest what it was they did during the simulation. This type of evaluation is used most often to discuss simulations that involve several students or users and which train not just medical skills but also team work and communication skills.

If a simulator is being used as an examination tool, it is just as important that the simulator is valid as when it is being used as a teaching tool. Those using the simulator need to know that they are testing the skills the simulator says they are, and that the results of the test are really reflective of the user's medical skills. Especially when the exam is used to pass judgment on the user, to say they are qualified to begin or continue practicing medicine, it is essential that the simulator be a 'valid' testing tool. What is a good way to test someone's skills and decide if they can practice medicine is a debate that is older than simulators and has been around at least as long as qualifying exams have been used to license doctors and other medical professionals (see Starr 1982). But the questions of validity with simulators are just as important as the questions about other means of examining professional skills. Especially as there are discussions about using simulators to issue and renew 'drivers licenses' for medical professionals, an individual's career can hang in the balance just as much as a patient's life can be at stake.

One way to determine the validity of a simulator is to test scores from it against other examination tools, other ways of testing students' knowledge and performance. Arguably, if the simulator gives the same results as a more traditional test would give, it would be a valid way of testing the students. This could be done through case studies and comparisons. Alternatively, the simulator could be first used by experts, say practicing surgeons who know how to manoeuvre a tool, and then by beginners. The respective scores received by both groups could set the standards for good and poor performance. Likewise, having experts and beginners use the simulator this way can also test the simulator, since an expert ought to be able to get a higher score than a beginner.

Creating a simulator

A simulator does not recreate a body in its entirety. In building a simulator, choices have to be made about which elements of the body to include and which to be left out. Some of these choices are obvious—perhaps it is not that important to include the feet when designing a pelvic simulator to teach gynaecological exams. There can be good reason to limit what parts of the body are included to make the simulator more manageable, transportable, and focused. Some of these choices are technical—it is still very difficult to simulate all the smells of an operating room, and surgical simulators have tended to rely on visual and tactile stimuli to recreate a surgical environment. Other choices are less obvious. Why, for example, are most simulators based on adult male bodies when medical patients come as both men and women in all ages, sizes, and shapes? (see Johnson 2005).

Many simulators are often designed through collaborative efforts between medical professionals, engineers, and commercial interests involved in the simulator industry. Sometimes academic funding bodies are also involved. This constellation of partners influences the way simulators are both developed and tested, but it also influences the way the simulators can be used as teaching tools because the product they develop is a direct result of these parties' understandings of medical practice and when, how and where a simulator will be used.

Interestingly, though, when talking about validity the debates seem to focus on discussions about how well the simulator represents the anatomy of a patient, rather than the actual medical procedure. Some argue that a simulator design needs to focus on things like the touch and appearance of skin, for example, to give the visual and textual impression of reality (Dawson & Kaufman 1998). To make the simulators even more realistic, high tech solutions are also employed. Other simulators are being developed to take advantage of new media technologies. For example, some simulators use haptic feed back so that a user can actual feel what certain medical procedures feel like when training on a computer simulator. Still other simulators use virtual reality technologies to model the body, both using data from, for example, the visible human projects and from CT and MRI scans of patients (see Cartwright 1998 for an analysis of the visible human project).

These sources of data about the body are based on visual representations of real anatomies, rather than textbook data about how a body is configured. But sometimes model developers also rely on standard measurements and images published in medical journals or anatomy books. Questions about which body is a standard body have been asked often of medicine, not least in relation to anatomy books and the construction of models to teach students about 'the body' (Jordanova 1999; Laqueur 1990). These debates are just as pertinent to the development of simulators. Why are certain bodies represented in the simulators and not others? Why do the simulators tend to present adult patients? Why are most of them male? Why are many of them white? What do these 'standard bodies' tell students about the patients they will meet and what a healthy, normal body is? And why does this not seem to spark debate in the medical community?

The questions about which body is used to model the patient or what type of body also lead to questions about how much of the body should be included and whether or not the body can extend beyond the skin, hair and toenails we usually associate with the boundaries of a body. Think back to the image of the anaesthesiology simulator (Figure 1). This is the full patient body simulator, which includes the digital mannequin and the anaesthesiology machine attached to it. Why is this machine part of the simulator and what does this say about the anaesthesiology body? Could we, by looking at how an anaesthesiology patient is simulated, be prompted to think that the anaesthesiology patient includes both the 'human' body laying on the table and the signals being interpreted on it by the machines to which it is attached? That the body of anaesthesiology is an extended body?

These may seem like trivial questions, but when I was watching the simulator being used, I was struck by how the instructor was continuously pointing out to the students that they should be reading a combination of signals from the body and the machine to know how the patient was doing. The students were supposed to gather information from both the body and the machine, which would suggest to me that the anaesthesiology patient is not just the skin and bones body on the operating table, it is also the information being gathered from the anaesthesiology machine.

Evaluating a simulator

Once a simulator has been developed, however, there are other ways of determining its validity, other than comparing it to anatomy texts. Even though the simulator may have been modelled on images of bodies or on data gathered from dissections, virtual or otherwise, when it comes to evaluating the validity of a simulator, the machines are sent out to be used and tested by experts. What these experts are looking for is how well the simulator mimics the 'real thing', when the 'real thing' is a specific medical practice; a surgical procedure, an examination method, a heart attack or stroke (…) The medical experts who are testing the machines are actually testing how well the simulator is reproducing a medical situation and action, rather than how closely and how well the physical body of a patient is being modelled.

The difference here is important. The simulators may have been designed using models of the body, but they are being tested against models of medical expertise and practice. It is possible (and likely, and actually true) that a simulated body based on an anatomical image would be different than a simulated body that was based on how that body reacts and responds during very specific medical practices.

The difference between modeling the body as an anatomical structure and modeling the body as a medical practice can be thought of as the difference between ontology and epistemology (Johnson, forthcoming). If we think of simulators as models of a generic body, ontologically independent of medical practice, a model that is objectively realistic and valid in terms of an anatomical structure, the same simulator should, in principle, be useful for many different medical procedures, just as a person's body can be subjected to many different medical procedures. But this is not the case. There are many different simulators on the market, each designed for a specific area of medical expertise and each built to facilitate specific types of medical practice.

This is explainable if we think of simulators as recreations of medical epistemologies. As different medical experts work on different parts of the body, and more importantly, do different things to the body, they develop very different understandings of what a body is and how it behaves. When it comes to simulator development, then, this means that two simulators can model the same part of a body differently, depending on which medical experts were going to do which medical practices on it. For example, the heart could and should be modelled differently if the simulator is going to be used to train heart surgeons or anaesthesiologists, because their ways of finding out knowledge about the heart's functioning are very different, and their tools and techniques for treating the heart are very different.

Simulators are not so much representations of the human body, they are practice turned into a machine. It is the execution of medical practice that is being simulated in simulators which can be seen in the way that simulator developers rely on medical experts to help design and, significantly, test the validity of their simulators (see Prentice 2005 for a description of this practice). Medical experts carry out the medical tasks, the medical practices on the simulators and see if the simulators can recreate their practices in a valid, realistic way. If the simulators were only simulating the body, different types of testing methods would be used. But because the simulators are recreating knowledge in practice about the body, knowledge as a phenomenon (see Barad 1996) rather than static, unchanging, un-interpreted facts about the body, the simulators have to use experts who are familiar with the specific ways of knowing to test their validity.

In this sense, then, the simulator is simulating how medical professionals interpret and read the patient body, not the patient body as such. The validity or fidelity of the simulator is based on how well the simulator recreates the signals medical professionals use to understand the body, how well the simulator recreates the *way* we know the body. Discussions about how this can be done sometimes use the terms 'engineering fidelity', which means how well the simulator replicates the physical characteristics of the medical task, and 'functional fidelity', which means how well the simulator recreates the skills of the real task (Maran & Glavin 2003). What both of these terms take for granted, though, is that it is a task—a practice through time—that is being simulated, not an unchanging, objective anatomy. The simulators are not recreating bodies *per se*, they are recreating the necessary environment and *ability to execute* specific medical practices. The simulators are recreating the experienced body, and how the body is *experienced* is dependent both on what types of technologies are used to know it, and what specific medical practices are done to the body.

Realizing that it is a specific medical practice that is being recreated in a simulator highlights another consequence of simulator use and development. If a simulator is designed to replicate a specific expert medical practice, and tested for validity against the execution of this expert practice, then the simulator is also going to teach that specific expert practice. Above, I spoke briefly about how simulators can work as ambassadors or physical, mechanical salesmen for specific medical practices. This is because it is the practice that is embedded in the machine. When we realize that it is a specific expert practice that the simulator has been built to teach, we should also ask ourselves how relevant and universal that practice is. There may exist the idea that medical techniques and procedures are universal, that there is one best way to cure every disease or problem, one best way to examine a patient and determine health or illness, but the truth is that medical practice can vary, both over time and across cultures.

Simulators, though, are being spread across existing differing communities of practice. To develop, construct and sell a specific simulator for every specific community of practice would be economically unfeasible. So a simulator that has been designed and tested with one understanding of expert knowledge can easily be found spreading that understanding of medical practice to new groups of users, and teaching the specific ways of doing medicine that were incorporated into the simulator's design without questioning the culturally specific basis of knowledge that the design relied upon.

I started this chapter with a discussion of simulators as models of the body used as teaching tools and examination tools, but at this point I would like to propose that simulators are participation with the patient body reified into a machine.

Further thoughts

Simulators are simulating the specific medical practices that are carried out on patient bodies, and these specific practices on the body are what is being turned into a simulator, not the complete and objective anatomies of human patients.

There are several implications to this statement. The first is that in the design and evaluation of simulators, it is going to be important to develop research tools that can capture the practice of medicine, not just the way the body or a simulator is constructed. It can be good to use different methodological tools to evaluate expert medical practice, for example qualitative methods like observation, interviews and surveys, rather than those methods one uses to learn about the physical anatomy.

Likewise, in the development of simulators it is worth considering which experts are used to design and test them. What is it about an expert practice that makes it 'expert'? Why is a specific expertise used for the development of the simulator? And which medical experts' practices are being made invisible. Many, probably most, medical practices rely on teams of doctors, nurses and technicians, yet I would posit that when developing simulators these teams are not always consulted. Often only the most prestigious exert in the group is brought in to work with the engineers. When developing surgical simulators, for example, how many operating room nurses are consulted and used to test the simulation? And if they are not involved in the development of the simulator, what does this say about their role in the procedure to those students who later train on the simulator? Are these values about 'who' an expert is the values we want to teach to future doctors? Are there other ways we could incorporate the concept of team work in the development of simulators?

There can be good reasons to limit the number of experts consulted during the development and testing of a simulator, and certainly economical ones, but the practice makes invisible or silences the experiences and practices of the other members of the team. Likewise, the resulting simulator only expresses a part of the medical practice, that which is experienced and known about by the consulted expert. It also teaches, and thereby even tests, a very limited picture of that specific medical practice.

When I ask which experts are being used and suggest that these choices be carefully considered, I am not saying experts should not be used, only that because their knowledge practices are reified into the simulator, the simulator is potentially going to be a powerful tool for spreading those practices to others in the medical community. Simulators can play an important role in making specific practices into standards. They can be very politically charged objects, not at all the objective, neutral representations of the body that they are sometimes claimed to be.

It is also relevant to start asking which expert practices are being evaluated. Given that simulators are an extension of specific medical practices and understandings, developed out of 'expert practice', it is important to note that expert practice may actually vary from place to place and time to time. Because of this, it is not enough to blindly accept that a simulator has been validated and then use it to teach medical practice to new students or in new contexts. Those using simulators should also be concerned that the simulators they are using are bringing with them ideas, values and understandings of the body from other places and other experts. This can be a good thing. This can be an effective and efficient way of sharing and spreading knowledge about medical developments and best practices to the wider medical community. However, it can also be a way of standardizing practices which are not necessarily suited for new places. Just as the cultural values of a society differ from place to place and time to time, so do the medical practices that have been developed to meet the needs of patients with specific values also vary from place to place and time to time. Medicine is not universal, it is full of local variations, and simulators can sometime negate these variations or not be flexible enough to adapt to new contexts.

One thing that this analysis shows, however, is that the practices on a patient body as they are carried out by trained medical experts is what is being turned into simulators, not the practices as they are experienced by the patients. I would like to end this chapter with the question: How would the simulators be different if they were to incorporate the way patients experience medical practice as well?

In the course of my research, I have seen the people who use simulators try to adjust for this missing component on their own. For example, when watching people use a full body patient simulator for the training of anaesthesiologists, I have seen the instructor giving voice to the simulator during the simulations, speaking as if he were the patient and making the patient's concerns, worries and feelings a part of the simulation. This can be very effective, and is a great way to teach the students about the doctor-patient relationship during the simulation. This impersonation of the patient incorporated elements like having the students warn the patient that the injection they were about to give would probably sting a little bit, and asking the patient to help them get the intubation guide out of the throat by coughing at the end of the anaesthesiology process.

Even though the mannequin on the operating table was not designed to provide verbal feedback on how the patient was experiencing the anaesthesiology or even helping in the process as an active participant, the instructor was able to incorporate the patient through role play and a bit of ventriloquism.

Of course, this type of patient participation can be more or less relevant depending on what sort of practice the simulator is designed to simulate. With a simulator that is made to help teach the knot tying skills of minimally invasive surgery, for example, which can be done on a patient who is under the influence of anaesthesia, it may be less important to incorporate the way a patient experiences the knot tying. Though even here there is still a patient to consider. Some aspects of such simulators can do this, too. For example, many of the simulators that are working with minimally invasive surgical procedures are designed to give scores to the students at the end of a simulation, and these scores can, in some way, be interpreted as how the patient will have experienced, or at least fared during, the operation. The score can report how many times the student bumped up against other organs during the procedure, potentially causing damage to the patient, or how quickly the student performed the task, thus minimizing the length of the operation and reducing the stress on the patient of a long, drawn-out operation. So even in these medical procedures which do not obviously involve interaction with a conscious patient, the patient can still be a participant whose experiences can be incorporated into the simulator design.

The gynaecological simulator that I discussed is a good example of how thinking about the patient's experiences can be even more relevant during simulator design. In some ways, thoughts about the patient are already incorporated in the simulator. It has been designed to measure the amount of pressure the students put on the various organs, both to see if they are pushing hard enough to actually feel the organs, but also to indicate if they are pushing too hard and potentially causing pain to the patient. But there are other aspects of a gynaecological exam which a patient can experience as more or less pleasant that are not built into the simulator as it is currently produced. One of these is the temperature of the instruments being used during the exam. One could imagine developing the simulator so it also registers if the speculum is cold when inserted into the vagina or if the students first place a reassuring hand on the thigh before beginning the exam. These elements of a gynaecological exam are perhaps not as obvious during the teaching process as whether or not the student feels the various internal organs, but for the patient they are very relevant.

Thinking about how simulators can incorporate the patient's experiences could give very different, and arguably richer, better, simulators, than those currently being developed. Of course, there are technical and economical frameworks which may restrict aspects of simulator development. But, even so, it may be useful when thinking about how a simulator is designed to realize that simulators simulate medical practice, not patient bodies, and that medical practice is experienced by both medical professionals and by patients. How the patient experiences a practice could be just as useful for the students to learn as how to do the actual procedure.

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