Maintaining Sofia – or how to reach the intended learning outcomes during a medical simulation training

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Abstract

The study aims to understand what makes a “successful simulation”, one that follows the planned sequence of events embedded in the simulated scenario, thus producing the intended learning path and learning outcomes for the participating students. The study is based on observations of 15 full-scale simulation sessions of acute trauma handling during interprofessional training of medical and nursing students. The study shows that the briefing preceding the simulation frames the students’ emergent actions during the scenario by demarcating “possibilities” and “impossibilities” for actions during the exercise. This in turn defines what actions are “appropriate” and “inappropriate” when the scenario is enacted. The simulation exercises are emergent and co-constituted by the diverse participating, socio-material actors. The extent to which this socio-material assemblage manages to produce and maintain the enactment of the patient during the simulation signifies the success or failure of the intended learning path of the exercise.

Key words: technology-enhanced simulation, simulation training, learning path, enactment, actor network theory

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Introduction

Technology-enhanced simulations have become established as a common and popular teaching strategy in health education. Simulation as a teaching strategy in medicine dates back to 17th century France, where birth manikins were used for medical education (McGaghie et al., 2010). However, the development of new and technologically enhanced simulators offers fresh possibilities for educators to design pedagogies aiming at different learning outcomes. Given the cost of running simulation training, there has been a great interest in how efficient an educational model it actually is. A number of meta-analyses of simulation studies (e.g. Cant and Cooper, 2010; Cook et al., 2011) have shown that this type of training has a significant positive effect on learning, knowledge, skills and behaviour of medical and nursing students. Simulation training is also seen to increase group performance, interprofessional communication and understanding, as well as satisfaction and confidence among the participants (ibid). High fidelity simulators are regarded to be especially suited for training students (and professionals) not only in technical and medical skills but also in non-technical skills such as team-building, leadership, communication and decision-making (e.g. Eich et al., 2007). By using technology-enhanced simulators in realistic environments, for example in an emergency room, students can receive repeated training to develop various aspects of their professional competence, including communication with other professionals and the patient in a pre-designed medical situation without risking injury to a real patient (Ahn, et al., 2015; Frenk et al., 2010; McGaghie et al., 2010).

Authenticity, reality and simulation training

Simulators are designed with the aim of representing a specific aspect of the real world (Cooper and Tacqueti, 2004). The concern for fidelity, or for how ‘realistic’ a simulator is, has been one of the main themes of research in simulation training. Indeed, Rooney et al. (2015) point out that because fidelity has been such an important theme in literature on simulation training, it fundamentally underlies the assumptions that a simulator can imitate, and has the potential to even replace reality. While fidelity has been associated with better learning outcomes in earlier studies (cf. Rooney et al., 2015), there are also studies that question whether high fidelity simulation is *a priori* a better pedagogical tool for learning compared to low fidelity simulation. Some studies have found that there is no difference in performance between students who have trained in a low versus high fidelity simulations (e.g. De Giovanni et al., 2009), while some studies argue that low fidelity approaches may even be preferable since these focus on limited aspects of what students are expected to learn (e.g. Tosterud, 2015). Assumptions of the superiority of high fidelity simulators can be seen as a myth. It is naive trust and misplaced faith in “realism” and in technology itself, which leads to relevant pedagogical considerations being ignored (see also Smallman and St John, 2005).

The assumption that there is a reality out there that exists independently of us, and which the simulation can stand in for or reproduce, is grounded in objective ontology (cf. Law 2004). Most of the discussions on the relationship between high fidelity simulation and learning are based on this world view. As Rystedt and Sjöblom (2012) point out, authenticity is often treated as an unproblematic, static variable, and participants' experience of realism is thought to result from the real-life imitating features of the simulator. However, attributing the realism of a simulation to the physical characteristics of the simulator alone is misleading, as simulators have many unrealistic features and functionalities. Dieckman, Gaba and Rall (2007) distinguish three modes of thinking about realities: physical (the material), semantic (the construction of meaning) and phenomenal (related to experiences). Based on their experience, Dieckman, Gaba and Rall (2007) argue that the semantic fidelity of the simulation is more important for the students' experiences of realism than its physical fidelity. Rettedal (2009) also stresses that the lack of realism in a simulation exercise is inevitable, and there is therefore a need to strengthen the overall realism of a simulation, for example by using professional clothing. This helps bridge the gaps in realism. The realism of a simulator is something that students are coaxed to believe.

Rystedt and Sjöblom (2012) emphasize that simulation as a realistic activity does not depend only on how realistic the mannequin, the simulated scenario or the technology used are. Rather, the realism of a simulation is seen as emerging from the interplay between these elements and the active engagement in the simulated scenario by the participants. The authors suggest that in order for the simulation to go on, students need to understand what the simulation is a simulation of, and to distinguish and act on the relevant similarities and the irrelevant differences between simulation and the simulated practice as well. Following this argument, the participant's experience of realism is not a result of the real-life imitating features of the simulator, but something that is experienced and emergent. When authenticity is defined through experience, it is not a static condition but something that is achieved through the simulation. It is along these lines that we approach simulation in our paper: we consider reality to be emergent in the simulation exercise rather than as something that exists out there and is simply being imitated (e.g. Law, 2004). Instead of imitating reality, what we have is a realistic scenario that the students enact in the simulation exercise. In doing so, we argue, they *produce* a reality within the simulation exercise. As this is a learning exercise with expected learning outcomes, our main research question has been "How does a successful learning path emerge through a simulation exercise?". This entails focusing on practices and unpicking the relationships between the assemblage (humans and non-humans) that comes together during the simulation exercise, the scenario and the intended learning outcomes embedded in the scenario.

Following an object to distinguish practices

We have approached our research question socio-materially (cf. Fenwick and Nerland (Eds), 2014; Law, 2004; Mol, 2002), especially drawing upon Actor network theory (ANT). To study what happens during the simulation, our analytical focus has been upon *practices* - the doing - taking place during the simulation exercise (Mol, 2002; cf. Knorr-Cetina, 1999). "Doing" becomes visible to analysis as our attention shifts from what goes on solely between humans to following specific objects (focal actors, cf. Latour, 2005), and how these are being treated as part of the practices they are entangled in (Mol, 2002; Rimpiläinen, 2015). In this study, the simulation mannequin SimMan3G[tm] emerged as the central object to follow as part of the simulation session. Over the course of three simulation training days we observed how the mannequin became *enacted* as a patient during the exercises and how these enactments related to the experienced realism of the enacted scenario, as well as the success or failure in producing the intended learning path. (cf. Ahn, et al., 2015; Mol, 2002; Rimpiläinen, 2015).

Mol (2002) and Johnson (2008) show examples of multiple enactments of objects in healthcare. Johnson's (2008) study on the use of the pelvic simulator shows that differences in medical care practices between different countries impact the experienced fidelity of a simulator. The simulator in question does not represent the female body, but how the body is experienced when it is examined in a specific way. When this simulator, designed for use as part of a medical practice in one cultural context, is taken up in a context where the examination practice is different, the same simulator no longer represents the experience of the female body in a medical exam. Hence it does not fit all training purposes. This highlights the context-specific nature of simulation training and the medical practice itself. Mol (2002) shows that diagnosis and treatment of atherosclerosis varies while the disease (within a body) moves through different practices in a hospital. These studies illustrate that there is no single "body" but a body that multiplies as it becomes enacted as part of different practices.

In this paper, we describe how the SimMan mannequin was enacted as a patient during the simulation exercises, and discuss the relations between the enactments and the intended learning path designed for the exercise. Enactments are characterized by certain features. Firstly, they take place in physical locations – in this paper, the simulation room - and are inseparable from practices or doing. Secondly, enactments are achieved in, by and through the relationships among heterogeneous entities in those physical locations. This means that ANT locates action, which often is treated as solely belonging to the human domain, as emerging from the relations between humans and non-humans. (Law, 2000) In other words, ANT seeks to de-center the role humans are usually attributed in studies of the social; instead, humans are approached as one type of actor among many, such as the mannequin in the assemblage that enables the simulation of the chosen medical case. (cf. Latour, 2005; Law, 1999; Mol, 2002; Rimpiläinen, 2015; Sørensen, 2009) While enactments on the one hand produce an object - something known or to know about - they also "produce a subject, something or someone that does the knowing that corresponds to what is to be known" (Law, 2000, p. 349). This is the third feature of enactments: they are interactions between the knower and what is to be known, the result of which is knowledge. The subjects and the objects of knowledge are understood as being co-produced and performed jointly within a practice (Nicolini et al., 2003). Tacit skills, talk, discourses, emotions, learning - all of these can be understood as knowing effects of a specific enactment. Knowing is therefore not tied to a particular location, such as someone's head or a text, but instead, it is a relational effect (cf. Rimpiläinen 2011).

Data

The data for this study were generated through observing three simulation training days arranged at a Health University in Sweden in winter 2012-13. These brought together mixed groups of nursing and medical students to carry out full-scale simulations of acute trauma handling. In total, 15 such sessions were observed by a small team of four researchers. Each observation was carried out by two researchers, one taking notes in the simulation room, the other in the observation/control room. Both researchers attended the de-briefing session following each simulation. Five of the simulation sessions were also video-recorded. The video data were used for writing more detailed notes on the simulation events, with partial transcription of the dialogue. Repeated observations of the repeated runs of the structured simulation exercise taking place in the same setting have allowed for a pattern or a "usual" sequence of events to emerge. This has enabled us to compare the different types of effects that have arisen as a result of the changing assemblages of the human and non-human in the simulation, and to follow how the patient Sofia was enacted into being, or not, in each setting.

In the following text, we present our results and discuss the realities that were enacted in simulations and the relation between the enacted and experienced realities and the produced learning paths.

Enacting the SimMan3G^{tm} as a patient

Briefing and scenario: creating a space to act

Figure 1. Acute trauma simulation session. Photographer Rickard Kilström

Each simulation session began with Medical Teacher A and Nursing Teacher B briefing the student group and introducing them to the simulation room and its equipment, including the SimMan3G^{tm}; a computer-operated full-body simulator. The purpose of the team exercise was *to treat an acute trauma patient.* The simulation room was furnished as an emergency room with medicines, medical equipment, furniture, an oxygen tank, gloves, a telephone, drips and computer monitors. In addition, there was a one-way window behind which Operator C, Medical Teacher A and the observer students would sit and observe the exercise.

The mannequin/simulator was lying on a hospital bed in the simulation room connected to computers via leads and wires. The computer screen next to the bed displayed readings of the mannequin's bodily functions. The mannequin allowed for a range of common clinical procedures to be carried out. These included, for example, measuring the pulse on the mannequin's *left* arm, taking the temperature, giving oxygen, inserting a catheter, or inserting a drip in a vein in the mannequin's *right* arm. The mannequin could "breathe" (rising and lowering of the chest), but it could not move by itself nor respond to touch. The patient's movements would be produced verbally (for example, "lifting the right arm") by the operators (sitting in the control room) through a loudspeaker located in the simulation room for all participants to hear. Similarly, the students would receive the patient's replies, and any other possible sounds s/he made, through the loudspeaker. Furthermore, it was possible to manually change the pupils in the mannequin's eyes in order for them to "alter in size", an important indicator of brain damage. The teachers emphasized that the team were supposed to treat the mannequin as if it was a *real patient* and take any action they would ordinarily perform as *interns* at an emergency ward, including calling for extra assistance, if necessary.

During the initial briefing two parallel, partly overlapping framings for the simulation were produced. One was about the types of actions that the mannequin and equipment of the simulation room afforded: *possibilities* and *impossibilities*. The other was about creating a boundary for what types of actions were *appropriate* and *inappropriate* to be carried out during the simulation (cf. Rystedt and Sjöblom, 2012). Actions that were physically possible to perform on the mannequin did not always correspond to what was *appropriate* to do as part of the scenario, something that will be described and discussed later on in this article. The students needed to understand this difference in order to perform the simulation, as was intended by the teachers.

The second framing suggesting what was appropriate and inappropriate was also embedded within the scenario. The scenario entailed a 17-year old female, Sofia, being brought into the Accident and Emergency ward from a scene of a serious car accident in the neighboring city N. Sofia had no visible injuries other than some bleeding on the left side of her head. She had groaned a little during transport, but was at present unconscious. The ambulance team had only given her some oxygen and had put on a neck rest to support her head. The scenario contained information about what had happened to the patient before she arrived at A&E, but it also simultaneously gave clues for what *should* happen to her at the ward. In a medical emergency case the medical team should follow what is called the "ABCDE" routine: to check Airways (Stage A), Breathing (Stage B), Circulation (Stage C), Do a neurological check-up (Stage D) and Exposure and environmental control (Stage E). Following the routine means the medical team would repeatedly re-evaluate the different stages in that order should new symptoms signal a change in the patient's condition. As a result, not only were the students' activities structured according to the procedure, but this also determined how the patient would be taken care of. The changes in the mannequin's condition were controlled by Medical Teacher A and Operator C. The changes, together with the ABCDE routine affected the actions of the medical team. Students' medical knowledge and skills became visible when they conducted their actions according to the procedure. The patient, for example, "vomited" (sound via the loudspeakers), usually after the team had carried out stage B of the routine. This prompted the medical team to turn the patient onto her side in order to prevent her from choking on her own vomit, something that tested the team's communication and organizational skills (cf. Ahn, et al., 2015). Another change that spurred the team into action was a dilated pupil in the patient's eye. The team would notice this if they followed the ABCDE procedure, as the pupil was *always* changed after the team had gone through the procedure once. In this way, the scenario signposted the intended learning path for the students.

In the following section, we will show how the team succeeded or failed in enacting the mannequin as the patient Sofia while they navigated among the different framings, and how this affected the emergence of the intended learning path.

Will the patient emerge or not, that is the question

One purpose of the simulation trainings we observed was to give the students an opportunity to learn how to treat a patient in a trauma situation. The presence of a patient in a simulation exercise, however, is not self-evident. In the following section we explore, through some empirical examples, how the patient is enacted into being, and what specific features these enactments have.

Example 1: She is alive!

The patient (SimMan3G^{tm}) was wheeled into the emergency room on a stretcher. Doctor 1 (a medical student) touched her arm and talked to her and called her by name:

"Sofia, you are now at the N hospital, you have been in a car accident. I am your doctor and we will take care of you. Can you hear me?"

Sofia groaned. Doctor 1 went through stages A and B in the ABCDE routine, checking Sofia's airways and her breathing. The nurses inserted a drip into Sofia's arm and gave her oxygen, checking her bodily functions displayed on the computer screen next to her stretcher. When Doctor 1 was about to move onto stage C (circulation), Sofia suddenly vomited (sound via the loudspeaker). The team turned the patient quickly onto her side to prevent her from suffocating in her own vomit, but in doing so, they forgot to take care of her head. Suction was used to clear the vomit from Sofia's mouth, and Doctor 1 returned to carry out stage C in the procedure.

Doctor 2 proceeded to take the patient's pulse, but announced that she could not feel it. The Nursing teacher, who always stayed in the simulation room, advised Doctor 2 that the pulse could not be felt if the mannequin's wrist was pressed too hard. Doctor 1 continued the ABCDE procedure with the patient, explaining: "Now I will check her eyes. Fine, fine, it is RLS4". The team then wanted to examine Sofia's back for possible injuries, which meant that they had to turn her over again. This time Doctor 1 took care of the patient's head. While examining Sofia's back, he explained what he was doing: "turning the patient over, examining her lower back". The ghost voice (information given by the teaching staff from the adjacent room via a loudspeaker) confirmed that the spine was OK and that there was no blood. Doctor 1 continued to examine Sofia's spine rectally. He went over to the medicine trolley and said: "I'll put on some lubricant", pretending to squeeze some onto his glove. Once he had carried out the examination, the ghost voice confirmed there was no blood on the glove. Doctor 1 proceeded to change his gloves.

The Nursing Teacher quickly switched the pupil in the mannequin's eye socket after the team had evaluated stage D (Neurological check-up). The doctors went through the procedure from A again, but they missed the dilated pupil when they came to stage D. When they re-evaluated the patient's condition the second time, Doctor 1 noticed the dilated pupil. "Call (the anesthesiologist) now", he ordered his colleague, Doctor 2. Doctor 1 began to assist the patient's breathing manually by hyperventilating her using a piece of equipment available on the medical cart, while Doctor 2 made the phone call to the anesthesiologist.

After the simulation, the performing students often spontaneously remarked how authentic the simulation experience had felt for them. The simulation exercise consisted of a mixture of details that both highlighted its "authenticity", while simultaneously pointing to its artificial nature. These details were not present from the beginning, but they emerged as the students engaged with the available materials, with each other, their teachers and the scenario. The result was that the students performed a very specific reality (as opposed to imitating one) that was only comprehensible as a simulation (cf. Nicolini et al., 2013).

For example, the students were expected to treat the plastic mannequin as if it was a real patient the moment it was wheeled into the emergency room. This was signaled by talking to the mannequin as they would do to a real patient, and generally treating the situation as if it was for real. The students were expected to address the mannequin as Sofia, use that name when talking to her, and continue to do so throughout the scenario. The team was expected to continue to follow the ABCDE procedure throughout the scenario, just as they would in an actual medical situation. The more the team acted the "as if" ("theatre", acting as part of a realistic scenario) was "as is" (a real-life situation) - for example, by changing their gloves after examining the patient - the more the simulation became like a real-life medical case.

This state of acting "as if" was "as is" could be easily interrupted. The team members found themselves suddenly switching between the simulation act ("theatre", "on-stage", performing "as if" was "as is") and the training moment (medical education, "off-stage", "as is"). For example, when Doctor 2 could not feel Sofia's pulse, he wondered if this was because the patient *Sofia* had no pulse, or because the *mannequin* had some fault. At that moment, the Nursing Teacher stepped "off-stage" into the medical education mode, instructing the student about the technical properties of the mannequin, explaining that if the mannequin's wrist was pressed too hard, the pulse could not be felt.

Some theatre-like, unrealistic actions were also necessary in order for the simulation exercise to carry on. For example, the doctors had to vocalize some of their actions, such as when squeezing lubricant onto a glove before carrying out a rectal examination of the patient's spine. Stating something like this aloud would be an artificial and possibly unnecessary action in a real-life situation. Here, however, this was a necessary interaction between the Operator C in the observation/control room and the performing students, and essential for the medical education situation to continue.

Medical mistakes were made during the simulation. For example, the team forgot to hold the patient's head when they turned her over for the first time; they accidentally gave her too large a dose of medicine; the doctor started hyperventilating the patient, when it was not part of his responsibilities given the team members were interns. The medical mistakes highlighted two different sides of the coin relating to the mannequin-cum-Sofia. For the patient Sofia, these medical mistakes might have been harmful, or even life-threatening. However, these might not have been obvious to the team at the time, as they did not affect the mannequin, and it continued to function. The patient-Sofia-in-the-simulation-room is not the same as a patient-Sofia-in-an-emergency-room. As long as the students took care of their patient within the boundaries that the scenario afforded them, the patient Sofia remained on the scene. The mistakes made during the exercise became material for pedagogical discussions later on.

This case exemplifies that the reality that emerged during the simulation exercise was specific and only comprehensible within the context of the exercise. The students' experience of the "realism" or "authenticity" of the simulation should not be related to how well the simulation exercise might have imitated events unfolding in a real emergency. Rather, the sense of authenticity and realism can be taken as an indication of how deeply the students were engaged in the enactment of the scenario as if it was real, and how they interacted with the available socio-materiality and the scenario.

Example 2: Technology interrupting the enactment of Sofia

During one of the simulation exercises, Sofia suddenly stopped breathing. The medical team and the Nursing teacher, who was in the simulation room, were confused, becoming stressed out over this sudden emergency, asking each other: "Sofia is breathing, isn't she?" The doctor/medical student thought the course of events was part of the simulation, and she proceeded to listen to Sofia's chest, which had stopped rising and sinking. The computer screen beside Sofia/mannequin showed, however, that her vital bodily functions were fine, and that the patient, in fact, was breathing normally. The nursing teacher, who knew that Sofia was never meant to stop breathing during this exercise, did not understand what was going on. The teaching staff in the control room were also confused as their computer screen showed everything was fine, while the team in the simulation room was behaving erratically.

“What is going on there? Why are they asking about the breathing? “inquired the Medical Teacher in the control room: “Why can’t they check the computer? Why don’t they believe the computer?” The Nursing Teacher appeared in the doorway of the control room to ask if Sofia was breathing or not.

“Yes, she is!” exclaimed the Medical Teacher.

“Ah! But *it* is not!” realized the Nursing teacher.

At that moment both parties understood what had happened and where the problem of “Sofia-not-breathing” was located: a mechanism in the mannequin’s chest had malfunctioned momentarily. The Nursing Teacher returned to the simulation room, banged the mannequin’s chest with a fist and the mechanism re-started to raise and lower the mannequin’s chest. Sofia breathed again. The students, who had suspended their actions during the confusion, returned to continue the exercise.

Example 1 showed how small moments of interruption generally took place during every exercise and that in some cases these were even necessary in order for the simulation to keep going. Here, however, a different kind of disturbance took place: a total halt of the scenario caused by a temporarily malfunctioning mechanism in the mannequin. As a result, the simulation exercise fell apart as the students were unable to figure out if the situation was part of the intended scenario or if there was a technical problem, and whether they should act as doctors and nurses at an A&E ward, or as students on a course. The kind of interruption to the simulation exercise as described in this example could not be explained by human agency or human interaction alone. The heterogeneous assemblage of humans and non-humans that enacted Sofia into being in each simulation exercise was fragile and temporary. As long as the assemblage held together, we could not see the different participants that allowed Sofia-the-patient to emerge (cf., Latour, 2005; Law, 1992; Sørensen, 2009), but she unraveled as soon as any one of the participants in the entanglement fell apart or stopped working. When the mechanism in the mannequin malfunctioned, the students in the simulation room did not know if they were interacting with the patient or with the mannequin. At that moment, the patient Sofia disappeared, leaving behind a malfunctioning mannequin, an array of medical equipment, computers and a confused group of humans.

In order for the simulation to continue, it was necessary for the students to be able to determine whether they were interacting with “Sofia” (on stage), or whether they needed to switch to interacting with technology (off-stage). With this type of interruption – betrayal by the technological devices - to the exercise, the framings embedded in the scenario for what was possible, what was appropriate, and what was intended, became blurred, and the students and teachers could not enact a reality that followed the intended learning path. This resulted in a weakened ability by the students and teachers to distinguish between relevant and irrelevant differences in the events they were participating in (cf. Rystedt and Sjöblom, 2012), which is why they could not enact a reality that followed the intended learning path.

Examples 3: Humans betraying the pedagogical intention

One of the teams performed the scenario in a markedly different fashion from the other groups. For example, this team never completed the ABCDE procedure, but checked breathing (B) twice. They did phone up the anesthesiologist as was expected, but not for the reason intended by the scenario, i.e. to call for help. Having not followed the ABCDE procedure, the doctors failed to spot the dilated pupil (marking potential brain damage) in Sofia's eye. Because of this, the patient's condition deteriorated, becoming life-threatening, and hence she was in need of immediate care by an anesthesiologist. The team should have phoned for emergency help at this stage for the second time, requesting immediate assistance, but instead they just accepted that the anesthesiologist would arrive when they had finished caring for another patient. When the team realized that Sofia had lost consciousness, and there really was an emergency, they called for an X-Ray instead of an anesthesiologist.

The team also used inappropriate equipment for treating the patient. The doctor, for example, intubated Sofia even though she was breathing normally; the nurse hyperventilated her; and the team even inserted a tube into Sofia's nose, a very dangerous procedure for a patient with potential damage to the brain.

The Medical Teacher A and the Operator C had difficulty in following the team's actions because these deviated from the intended pattern of the exercise. The teachers could not understand what the team were trying to do (for example, in intubating the patient) and therefore spent time trying to figure out how to guide the team to follow the ABCDE procedure and to call for help.

Afterwards, in the debriefing, the male nursing student, who carried out most of these deviant actions, explained: "I just thought that I could try things out. Good, good, now I know. It is why we are here, isn't it? To learn?"

The briefing preceding the simulation had been the same as for the other groups, the scenario had been introduced in the same way, and all the different technical devices functioned. While every member of this team was engaged in some activity, the team as a whole failed to follow the ABCDE procedure. This made the course of events change to such a degree that the Medical Teacher And the operator in the control room had to find a way to *make the team* call for an anesthesiologist, i.e. they had to help keep the team's performance on track within the frame of the simulation. After the simulation, the researchers and the Medical Teacher Agreed that this team had been different and a difficult one to follow. What happened here? While in example 2 it was the technology that betrayed the scenario, here it was the human actors. Although the scene was full of activity, the team members did not act within the frame of what was *appropriate* and *expected* for the scenario to proceed as intended. The team understood that the purpose of the training was to learn, but learning for them was trying things out and testing different equipment - not following the scenario and treating the mannequin as a living patient. While the other teams acted "as if" (play-acting) was "as is" (real) during the simulation, this team failed to relate to the simulation as an instance of medical practice. This was the crucial difference. For this team, there was no patient whose death they might cause, only a mannequin representing a patient.

By the same token, the participants did not enact their professional roles of doctors and nurses taking care of a patient. Even though the some of the individual team members were able to take actions in the intended professional roles and act "as if" was "as is", this was not enough to save the exercise, given that this scenario assumed *team* effort. Actions of one or two "deviant" and dominant team members were enough to derail the intended course of events. While the mistakes made in example 1 were logical within the framings of the scenario, and became subjects for discussion and learning about professional conduct, here the mistakes did not relate to the intended course of events, but rather stemmed from play-acting in the mannequin set up instead of taking the scenario as if it was real.

It is important to distinguish activity from intended action. The simulation room and its equipment afforded numerous possible actions to be performed around the mannequin. The team was definitely actively working with the mannequin and trying to understand its functionality. However, their actions were not those that the teachers had intended would emerge during the exercise. On the contrary, these resulted from the students' failure to understand which expected actions were embedded in the scenario. As a result, the patient never emerged on the scene. The team's actions became incomprehensible to the teachers and observers, as they did not fit within the frame of what was appropriate and inappropriate, nor possible and impossible to do within the scenario. The students failed to understand what the purpose of the simulation was (Rystedt and Sjöblom, 2012). This example shows that the intended learning path, and the sense of authenticity, only emerged through appropriate interactions among the various actors. Even if the students interacted with each other and other materials in the simulation exercise, the patient Sofia never emerged, as the students did not engage with the scenario, and did not relate to the simulation exercise as if it was real.

Discussion: Maintaining the enactment of the patient – finding the intended learning path

In this paper, we have examined simulation training as a socio-material enactment of a realistic medical situation with a particular educational purpose - to train medical and nursing students to take care of a patient as a team in an acute trauma situation. We have been interested in examining the relationship of the simulation to reality and learning. Contrary to the more traditional view, which sees simulators as mimicking or imitating reality, we take these as emergent phenomena (cf. Rystedt and Sjöblom 2012), being produced as part of practices. Our main research interest has been to investigate how a successful learning path emerges through a simulation exercise.

In our analysis, we have approached simulations as socio-material practices, and the fidelity of the simulation as a phenomenon emerging out of the entanglement of humans, the mannequin, medical equipment, computers and other materials, and the scenario. The focus of our analysis has been on the mannequin, and how that became enacted as a patient during the simulation exercises. Placing an object at the center of the analysis has enabled us to focus on what is going on around it and, on the practices taking place, and to unpick the relations between the different actors in the assemblage that come together during the exercise. This approach has enabled us to detect boundaries for actions that were appropriate and inappropriate in terms of the medical scenario, and those that were possible and impossible in terms of the simulation set up. Certain actions that were deemed appropriate (and expected) by the scenario, such as doing the rectal examination on the patient to check for spinal injuries, might not have been "possible" within the materiality of the simulation set up. These situations gave rise to artificial actions, which were comprehensible and necessary within the simulation exercise, and vital for the enactment of the patient. The boundaries between these actions were, however, very delicate, and could be easily blurred because of a technical failure or human activity.

The scenario presented for the students at the beginning of the exercise was realistic (while imaginary), carefully designed to reach the desired *pedagogical goals* set for the exercise. The number of medical staff present, and the course of events in the scenario, had been meticulously planned in advance, including the timing and sequence of events. The scenario thereby indicated the intended learning path for the task. The scenario could be called a pre-determined reality-in-the-making (cf. Suchman 2007). Both the students' and the teachers' actions occurred in response to the scenario and the pedagogical *intentions (that which was expected to happen)* embedded into it. In order for the students to find the right path, they had to understand what the simulation was about, and be able to relate to the scenario as if it was real. They had to adopt their designated roles and interact appropriately with the other team members, teachers and surrounding materiality within these roles. As Niccolini, Gherardi and Yanow (2003) and Law (2000) point out, both the subject and the object of the enactment are produced at the same time. Here, both "the medical staff" and "the patient" became enacted into being simultaneously during the exercise. The knowledge effects of the simulation exercise are the gained knowledge, experience and potential for learning (as learning something is not self-evident). These effects will stretch way beyond the simulation moment, into the debriefing following the simulation and beyond, into further studies, and potentially into working life, something we cannot evidence within this study.

Questions of fidelity of a simulator have often been related to how well these are seen as representing reality or mimicking it. Our study has shown that the sense of authenticity experienced by the students during the exercise *emerged* from the coming together of all of the different elements. How "authentic" an experience of A&E life the simulations were depended on how well the students managed to enact the SimMan as Sofia-the-patient, and maintain her for the duration of the exercise. This also kept the students on the intended learning path. Each session produced its own simulation reality that the students experienced.

Recommendations

- Approaching simulation training socio-materially can help us understand how to design and organize simulation training sessions better. It is useful to consider how manipulating the scenario and the socio-material setting of the simulation can impact learning outcomes. Small changes in the setting can produce entirely different outcomes. Consider, for example, what effect does the availability of different medical equipment, or altering the physical properties of the mannequin, have on the intended learning path.
- It is important to appreciate that students may need to be guided on *how to do* simulation training in order for them to reap the benefits of these exercises. The main point is for the students to understand that the simulation is not a game, but something to take seriously, and to relate to as if it was a real-life situation.
- Considering that the students need to be able to distinguish, and suddenly switch, between on-stage (acting as doctors and nurses) and off-stage (being instructed as students) modes, scenario-based simulation will benefit groups who already have a sufficient level of medical proficiency, for example, in this case all of the participating students were final year medical and nursing students, who already had some real-life work experience from A&E.
- The presence of teaching staff within the simulation room was vital for the simulation exercise to stay on track.

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