A SEMI-FIDELITY TRAINING SIMULATOR: PROMISING OPPORTUNITIES FOR STUDENT-CENTERED LEARNING

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Abstract

The most training simulators are high fidelity ones, which means that they look and function similar as the real one (i.e. the machine that is simulated for training purposes). Those simulators are useful for learning situations. As they are expensive, they are not commonly used. One alternative is a semi-fidelity simulator, which includes some elements of the real one but lacks some other elements. Creation and modifying such simulator is inexpensive and quite quick. We study whether a semi-fidelity training simulators are useful in education. This is done by focusing on users’, i.e., students’ and teachers’, views on how a semi-fidelity simulator can be used in education. In our study, a group of test users individually used the training simulator. Afterwards the participants were interviewed. Based on a phenomenographical analysis of the interviews, we found that the users had five alternative understandings of the training simulator. Three of those understandings are categorized mainly as teacher and technology centered, and the last two as learner centered. Our result supports the idea to promote and develop semi-fidelity simulator training as their exploitation area was seen versatile.

Keywords: Fidelity, machine training simulator, user understandings, interpretative studies, phenomenography.
1 Introduction

Virtual environments (VEs) offer several advantages for education: they improve knowledge transfer from teacher to student, reduce costs of teaching, and provide a challenging training method (Stedmon and Stone, 2001). VEs have been used in game-like simulations for education (Salas and Canon-Bowers, 2000) and in real-world situations with simulated actions for training professional skills, as flight simulators for pilots (e.g., Birchfield and Megowan-Romanowicz, 2009) or dental doctors action with a tooth (Rhienrome et al., 2011).

The development of simulators has mainly been technology-driven and focused on the improvement of VE technology; such as visual systems (e.g., higher resolution, greater visual angles; Seron et al., 2003, Duh et al., 2004, Groot et al., 2011), use of several interaction tools (e.g. haptic feedback; Moody et al., 2008), and realistic actions of the objects (e.g., Sierra et al., 2006). The prevailing assumption states that increasing fidelity increases the quality of training (Kincaid and Westerlund, 2009).

The high fidelity training simulators are used with good results in several situations, especially in those situations in which human mistakes can cause serious problems. One such example is nuclear power when a simulator provides a platform for training the operators on normal and emergency conditions including all types of scenarios that would arise (e.g., Dudley et al., 2008, Jayanthi et al., 2011). Other examples are medical cases (e.g. Bayona et al., 2008, Rhiermora et al., 2001). Simulations can provide an environment that is safe for the patient, because a simulated patient is used (Keskitalo and Ruokamo, 2009), and a training simulator provides task feedback to the trainee (e.g., medical simulators designed for training in endoscopy and minimally invasive endovascular surgeries) (Kincaid et al., 2003).

Besides of using training simulators for teaching, they are useful for evaluating the students. They support making difference between novice-level and expert-level professionals. This result has been reached in the research of dental doctors (Rhienmora et al., 2011) and surgery doctors (Bayona et al., 2008).

High fidelity training simulators have been compared to lower fidelity simulators with a result that encourages using high fidelity ones (Moody et al., 2008). However, when comparing high fidelity simulators with other training situations, the results are not always promising. Such an example is a medical study which compares fresh-frozen cadavers with a high fidelity virtual reality simulator as training tools in minimal access surgery for complex and relatively simple procedures. The result presents that fresh-frozen cadaver is perceived as a significantly overall better model by all training grades (Shame and Horgan, 2012).

Although the learning results are mostly promising, high fidelity training simulators are rarely used. The limiting feature of their use is their high costs. Solutions for creating low costs simulators have been studies (e.g., White et al., 2011). Also, it has been pondered if low fidelity simulators could be used in some situations. The fidelity of the simulator describes how close to the actual simulated machine the simulator is, so low fidelity simulator lacks some interaction tools or actions of a real machine (Egger, 2000). Few studies have focused on the usefulness of low fidelity simulators. They have been found as being flexible tools for applied cognition research (Loft et al., 2004). Our study continues of studying the usefulness of lower cost simulators. We focus on the semi-fidelity training simulators, which have some features of real machine (views and actions) but something is missing (as the real cabin).

In our paper, we study the question of whether a semi-fidelity training simulator is useful for users. This means the level when users can understand the simulator as a tool for education. When focusing on using training simulators in learning, we have to understand that positive experiences are needed right from the beginning of training, as is the case in general with virtual learning environments (e.g.,
Cretchley, 2006, Vuojärvi et al., 2010). This means that if users’ understandings are negative they will not start using training simulators. That is also why we are motivated to study the first understandings gained by users and based on their initial experiences with the simulators. Researchers have observed that formal usage of learning systems by students is unsatisfactory (Selwyn, 2007). Also, the training systems cannot support learning without student participation (Shin, 2009, Zhang et al., 2012). To focus on the user view-point, we employ an interpretative research approach in our study of user understandings of a semi-fidelity training simulator.

First, in this paper, we focus on the research procedure, which consists of user tests with a semi-fidelity simulator simulating actions of a mining machine, with interviews and with a phenomenographical data analysis. As training simulator use in education is a relatively new field, most students and teachers are inexperienced in this matter. So we decided that the users should first try our prototype of a semi-fidelity training simulator to have a concrete idea about how to use it before evaluating its suitability for training situations. By analyzing situational descriptions expressed in interview discussions after test uses, we can obtain more concrete information about the use of the technology. When we understand that people can have alternative conceptions (phenomenographical thinking, Marton and Booth, 1997), it enables us to see how users view a system. After that we describe the results. They outline the differences in user views, lending support for further work in the development of semi-fidelity training simulators and for organizing future training.

2 Research Procedure

2.1 Setting

The research setting is a prototype of a loader machine simulator. It was designed and developed during our research project with a connection to one educational institution training machine operators. One of the early decisions in the semi-fidelity simulator design process was that the costs for building a simulator should be relatively reasonable. Commonly, the technology costs have come down in recent years. Still, the simulator prototype has to have a sufficient feel of the real machine, and all the central components for learning to operate a real machine must be in place. This is what we mean by semi-fidelity in our case, and it is more closely defined in the following.
In our study, the semi-fidelity training simulator is a heavy loader employed in underground mines (Figure 1). This particular type of machine is especially suitable for simulator training because the training in the real world situation, in a tiny cabin, underground, is challenging as there is no space for a teacher or visibility for a teacher to guide with telepresence tools. The driving position in the tiny cabin is awkward. The machine operator sits sideways, facing to the right side of the machine, and must turn the head left when driving forward and right when reversing. Furthermore, the view from the cabin is very limited (Figure 2). Especially the view forward is very constrained, due to the large bucket, which blocks line of sight almost completely in certain positions. One special benefit with the simulator is that when training with it there is no risk that someone would get hurt or that any other damage would be inflicted.

An implemented 3D VE consists of a three-wall rear-projection based system. It takes advantage of active stereo projection and optical head tracking, which is implemented with markers on shutter glasses and six cameras. The three walls are straight-angled, which makes the setting quite immersive. The used visualization software is our own and it was created during the project.

The simulator includes some physical parts from a real cabin (i.e., mixed reality, Ellman et al., 2007): the operator’s chair is similar to the chairs used in real mining machines; also the control joysticks correspond to the actual controls of a loader (Figure 3). With the left joystick, the operator selects the driving direction and current gear as well as controls the orientation of the body of the machine. The right joystick is used for controlling the boom and the bucket. Most of the controls of the actual machine are present in the simulator. The gas and brake pedals are there: in the simulator they are electrically controlled, in a real machine the brake is hydraulic. The control panel of the machine is a virtual one. It has a display which provides the operator with information about the state of the machine, for example the driving direction and the current gear.

One part of our simulator is a pneumatic motion platform with six degrees of freedom (Figure 3). The actuators in the platform are pneumatic muscles, which are driven by proportional pressure valves. The control of the platform is implemented by an open loop pressure control. An inverse kinematic model is used to solve the muscle lengths and loads for the current position. Sounds are generated through a sound system.

2.2 Test Users

Participants were sought from an educational training institution and a technical university. We collected some background information to find individual test users with varying experience with large work machines and computer games to ensure diversity in their understandings. All test users had experience on working machines as tractors, some had experience on heavy loaders and mining underground.

As collecting data and analyzing it is time-consuming, the number of participants is typically kept low: about 20 is a common number in phenomenography (Richardson, 1999, Sandberg, 2000). The number of our test users was 22. The test group included:

- 12 students from a technical university,
- 5 students from an educational training institute, and
- 5 teachers from an educational training institute.

The test users were male because in practice almost all the machine operators are men. The test users’ age varied between 19 and 59 years (average 32 years).

2.3 Data Collection and Analysis

For data collection, the requirement was that informants’ can freely describe their views (e.g., Hirsjärvi and Hurme, 2000) and are not using a previously defined framework. From among interpretative approaches, we selected phenomenography since it is a qualitative, empirically-based
research approach that aims to interpret, describe, and categorize how a phenomenon is understood by a group of informants (Marton and Booth, 1997).

Marton and Booth (1997) recognized similarities with phenomenography and phenomenology: both are relational, experiential, content-oriented, and qualitative. There usually is a relatively limited number of qualitatively different ways of experiencing something, and the goal of phenomenography is to characterize variations in experience and the architecture of this variation (Marton and Booth, 1997, p. 117). This is different to phenomenology. Compared to ethnography, the difference is on the perspective of research. Phenomenographical researcher focuses on people’s views of the phenomenon, which is the second-order perspective research. Instead, ethnographical research focuses on the first-order perspective (direct to the phenomenon). In a second-order perspective study all understandings are meaningful to report, and their “rightness” should not been pondered (Kaapu and Tiainen, 2012). In a phenomenographical study, the result is a categorization of alternative ways to understand the studied phenomenon, and consists of some generalized findings, i.e., how to make sense of the world. Categorization does not just describe the studied situation but in a more general level helps to understand other situations of the same kind as well (Kaapu and Tiainen, 2012).

The roots of phenomenography are in educational studies (Marton, 1981). In an educational setting, it is important to find out ‘right’ and ‘wrong’ answers and, in order to improve teaching, clarify in which way the answers are ‘wrong’. In our case, to evaluate the semi-fidelity simulator further with the participating users, we focus on all the understandings they have. It does not matter whether the understandings are ‘right’ or ‘wrong’ in this situation: the aim is to comprehend them all to be able to evaluate the simulator’s suitability for training.

To practice and test the data collection method before actual test uses, we started the data collection phase by conducting a pilot test with two participants. The timetable was found to be too tight. The time for arranging the tests being limited, we reduced the number of the planned tasks from three to two. In the test use of the simulator, the task was to operate the virtual machine in a mine setting where rocks are moved from one place to another. This same task was done twice. Each individual video-recorded sample lasted for about an hour and included an introduction, a test use and an interview. During the test use, the participants were instructed to think aloud.

The main question in the interviews concerned the use of semi-fidelity training simulator in machine operator training. We decided to follow interviewees’ answers and not to use a ready set of interview questions. This was possible because the interviewer also observed the test uses and used that information in the interviews. For example, the interviewer could say: “When using simulator, you said --- what do you mean by that?” In this way we succeeded to keep a phenomenographical line in interviews and to focus on interviewees’ different conceptions.

When the aim is to get to know all alternative views (Richardson, 1999), it needs some analysis of the collected data to make any determination about what the sufficient number of participants would be. The advice for phenomenographical studies is to continue data collection process until a saturation point is reached (Marton, 1981). In the saturation point, the same themes keep on emerging continually, and additional interviews would not uncover any new themes (Pang, 2003). During data collection, we followed the saturation point principle.

The phenomenographical data analysis is solely based on collected empirical data and not on previous literature (Marton and Booth, 1997). We started the analysis by selectively scattering the interviews (discussions about the simulator in machine operator training). In the analysis of the interview data, we made a coding paradigm, which facilitates the identification of the meanings in the data (similar to Glaser and Strauss, 1967, p. 46). The data analysis continued iteratively and comparatively and involved continual sorting and re-sorting of data and ongoing comparisons between data and the developing categories of description as well as between the categories themselves (e.g., Marton, 1986, Marton and Booth, 1997).
In practice, we read all the interviews several times to find the sentences that describe interviewees’ views on simulator in machine operator training. We were able to find different focuses, approaches, and views on the training situation. We marked these with different colors. After this, we collated similar views and then arranged the categories. We repeated reading and sorting as long as the categories corresponded to the interviews. Finally, we formed individualized use categories by determining the categories that each of the participants used.

3 Result: Categorization of Conceptions

The result shows how users understand a prototype of a semi-fidelity training simulator. In the following, we present the categories of conceptions formed and illustrate each of them with a quotation from the interviews. With two categories, we use one quotation from a student and one from a teacher because in their views, which belong to the same category, there is a minor tone difference. This is related to their position as diverse stakeholders. However, our aim was not to go to a deeper analysis of those differences, just to report them.

Originally the interview were in Finnish (the native language of the interviewees), and the authors translated the quotations for this paper. Each of the quotations here is preceded by status (student, teacher, or interviewer) and number for informants. Brackets () within the interview quotations mean that the text inserted there is to allow the readers to understand what the informants are commenting on.

3.1 Categories

A. Simulator as It Is

The informants in this category acknowledged the existence of the training simulator with ‘is’ but did not otherwise comment on it. This means that the training simulator ‘exists’ but is somehow irrelevant for training in the real world, and, in some cases, simulator training shows little or no awareness of what occurs in the real world.

The narration is self-focused towards learning situation. This means describing the student’s own preferences in relation to the teacher’s instructions. The interviewed teachers in this category tended to use the existing ways to teach and gave little consideration to the use of the training simulator. So training with the simulator is teacher and technology centered. The learner mostly works alone and has limited or no communication with other students. This category emphasizes that the old ways of learning are better.

Interviewer: What do you think about the simulator in training?
Educational_Training_Student_4: Well... Of course it needs my attention. The corridors were quite narrow. I drove some way towards the walls. Of course I have to use a real machine to learn to operate that machine. --- I wouldn't anyhow be able to substitute with it really driving that (loader machine).

B. Simulator as a Real Machine

The second category describes the training simulator as a real machine. In other words, the participants in this category were quite sure of their own (and in many cases of others’) skills to operate real machines in mines after the simulator training. The simulator was regarded exactly as a real machine. The emphasis of describing the simulator training is more on the machine than on the training process, and the informant in this category views himself as an anonymous student. The teacher is responsible for the use of the technology. However, the interaction between the student and the teacher is largely one way, the teacher being in charge of the activities that are available via the training simulator. The narration in this category was largely positive toward simulator training.
Interviewer: So that simulator is meant for training. What is your view about it?
University_Student_5: The driver there is sideways. Because of that, it is slightly different from the other machines that I have driven. Usually in vehicles one's head is towards the direction you are going. (In this machine) you have to look back and front. The centre of gravity is far back. --- Trying this machine once in a parking lot would make it feel like other wheel loaders.
Interviewer: What do you mean by that?
University_Student_5: This kind of new type of machine is easy to drive. We just need someone to show the basic functions.

C. Simulator as a Machine Model

The third category focuses on the simulator as a model of a machine, and not exactly as a real machine as in the previous category. The informants in this category understood the differences between the simulator and the actual machine, as the simulator was a semi-fidelity training simulator.

However, the simulator was still thought of as being useful in many cases. In some cases, some students did not find the training simulator useful. The word contradictory describes this category. In the teaching situation, the students are seen as more than just passive participants in the learning process. They are viewed as a group with differing prior knowledge and learning styles. In the following interview quotation, an informant describes the simulator training as insufficient from the viewpoint of more advanced machine operators, but, nevertheless, probably useful for diverse groups of students.

Interviewer: So you said that you are not interested in this type of training?
Educational_Training_Student_3: Supposing we talked about some other kinds of persons (some other kinds of people = people who have no or very little experience with machines like the simulated loader): for example, about my dad. You should ask him (to use the training simulator). He has been driving tractors in forests for ten years now. He could get something out of this (simulator training). It could be possible for those kinds of persons.

D. Simulator as an Attraction

In the fourth category, a marketing approach was thought appropriate: the training simulator was seen as an attraction for new students and as giving them some prior idea about what it would be like to work in mines or with large mobile machines. Again the informants in this category viewed students as groups with differing prior knowledge and learning styles, but this time the narration was more related to the professional context. The teacher’s role was seen to facilitate the student and design appropriate learning activities for future work in mind.

Interviewer: What is your view about the simulator in training situations?
University_Student_7: I noticed that, for example when I used brakes, the brakes were there. Also (during braking), some rocks fell off. It is realistic, as it shakes and jiggles when driving it – like that kind of machine does. Most likely it (the simulator) imitates the actions of a real machine, but I don’t think it is exactly the same in reality. I don’t know whether the mine is hot or what. But students can get the first impression (with the simulator) about how it is to work in there (in a mine).
Interviewer: OK. Why it is not “exactly the same”?
University_Student_7: As I said, the surrounding is different when working. There can be different sounds and so on.
Interviewer: Yes. So what do you think about using it in training?
University_Student_7: Certainly it is interesting to use something like this. But is it useful for persons who have driven many years with these kinds of machines? Probably not. It is also nice for teachers: they can just let people to try the loader.
E. Simulator as a Part of Learning

In the fifth category, the training simulator was seen as innovative teaching. The following quotation is from an interview where the informant points out that the teacher cannot be with a student in a real loader machine because the cabin is very tiny. Based on his experience, the simulator could be used, for example, to train in the use of the bucket.

**Interviewer:** What do you think about the simulator in training?

**Educational_Training_Teacher_4:** Let me tell my personal experience. In the beginning I was little a bit sceptical, I have to admit.

**Interviewer:** Yes?

**Educational_Training_Teacher_4:** First time (when I used the bucket) I saw an empty bucket. Then I reversed. Then I laid the bucket down, noticing from the commotion that the bucket is down. Then I put my hand down to lighten it a bit. And after that a little bit up: I managed to get a very full bucket. It was good in there --- you could sense the position of the bucket and its front end ---It was fantastic to use that bucket... Many of our students do not know how to do that. It would be good to learn that with this (training simulator).

In this category, students engaged in the learning process are understood as individuals with something they do not know how carry out. They can learn through different methods such as simulated machine actions. The responsibility for learning is centered on the student rather than the teacher, and learning occurs through the actions of the student. The teacher is concerned with the issues the students will encounter in their future employment, preparing the students for maybe lifelong work. The students are encouraged to take responsibility for their own learning, the teacher being more like a facilitator. Some also said that students can be learning together with other students the machine functions.

3.2 Summary

Based on an analysis, we formed a categorization of conceptions that is a result of our phenomenographical study (Table 1). The categorization is hierarchical, and attention is paid to the related view of the training situation. In educational context, this mainly refers to the informant's view about the student’s (and teacher’s) role in a learning situation. The last categories are deeper in the sense that they include a deeper and wider understanding about learning of use.

<table>
<thead>
<tr>
<th>Focus</th>
<th>Approach</th>
<th>View of Training Situation</th>
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<tbody>
<tr>
<td></td>
<td><strong>Negative:</strong> Old ways are better / <strong>Positive:</strong> Just like a real machine</td>
<td>Innovative: Improves marketing of education or training</td>
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<tr>
<td>Presentation technology</td>
<td>A: Simulator as it is</td>
<td>Similar students in training situation – teacher centered</td>
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<td></td>
<td>B: Simulator as a real machine</td>
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<td>Simulated machine</td>
<td>C: Simulator as a machine model</td>
<td>Different students need different issues (in their profession) – the teacher guides them</td>
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<td>Simulator education</td>
<td>D: Simulator as an attraction</td>
<td>Individual students learning through different methods</td>
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<td></td>
<td>E: Simulator as a part of learning</td>
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Table 1. Summary of user understandings.
The first two categories focus on similar students in a training situation while the teacher takes care of what to do with the simulator. The third category conceptions acknowledge differences between students, but still the teacher is in the guiding role in the training situation. So the emphasis in all of these three categories is teacher and technology centered and controlled. There is a shift in the last two categories, which may be described as learner (student) centered and participatory. This means that individual students learn best with different methods and maybe also together with other students. The students become responsible for their learning. The teacher is not in a key role.

Other related shift is on focus from presentation technology to simulated machine and simulator education. In the first two categories, understanding is mainly related to negative or positive features of the presentation technology. In the third category, the simulator was seen as a model of a real machine, and in the last two categories the focus was on simulator education.

The third shift is approach that is related to the attitude towards using a training simulator in machine operator education. The approach of informants could be negative, positive, contradictory, or innovative.

4 Discussion of User Understandings

We used phenomenographical research approach to see the variation in user understandings regarding the semi-fidelity training simulator. The diversity of views describes also the complex and intertwined process of users adopting a training simulator. Adoption here means taking into use a new technology which the educational institution has acquired. The situation here is different from a purely domestic context: most likely it is not for the user (at least the student) to decide what kind of hardware and software should be used in an educational institution. In the following, we discuss our findings (i.e., categorization of conceptions) in terms of developing semi-fidelity training simulators for learning.

Participant concerns focused sometimes to the relevance of the simulation. In the formed categorization, particularly in category A: Simulator as it is (the lowest in the hierarchy), the participants described many conceptions that characterize the nature of starting to acquire new technology. The participants discussed new technology (a semi-fidelity training simulator) in relation to ideal use and ideal learning approaches.

Technology adaption in learning requires that the user is familiar with the technological device: learning the skills, rather than learning to use the learning device, is the main issue (Vuojärvi et al., 2010). The participants adopted the simulator by comparing it to the old ways to learn, i.e., by ‘operating a real machine’. Many participants, who had years of experience in driving large machines, did not value the virtual one. These participants stated that it is easier to start using real machines right away. In the beginning of the technology acceptance process, there is one particular central issue that categorizes new things, placing them in a certain box (Berker et al., 2006). When our informants came across a new issue, they made it a part of their familiar settings by placing it there. This may explain why the comparison to ‘real machines’ was used to make new technology understandable.

Teachers’ role was seen differently; from routine-like to supporting learner’s own learning process. In the lowest category, the teacher is someone who tells what to do and tends to use the existing ways in teaching. In the highest category, the teacher gives the responsibility for learning to the learner. According to good educational practice, teachers are facilitators in student-centered learning environments (Cretchley, 2006). In this sense, it is important to seek ways to promote more student-centered approaches in teaching, and we found that semi-fidelity simulator training can support that process. A teacher is still needed, however. For example, in the second category of conceptions, B: Simulator as a real machine, the informants were maybe even too confident about their own skills after simulator training. Sometimes they were sure that after a short semi-fidelity simulator training they would be able to perfectly control a similar machine in the real world.
Instead of category A, in conceptions of higher categories B - E the participants discussed much about how training of this kind could support learning and understanding problems that an operator in this kind of machine might encounter. Especially in categories D: Simulator as an attraction and in E: Simulator as a part of learning the participants consistently stated that this semi-fidelity simulator provides them valuable training for their actual work and explicitly wished for more training of that type. In particular, the participants with no mine loader background found the training beneficial.

The conceptions were mainly positive, and the informants brought the attention to the hands-on experiences that the simulator can give to the user. The informants even said that they could ‘feel’ the machine, i.e., how the loader works and how the operator knows the movements. These observations support the idea that a semi-fidelity training simulator is useful for learning.

5 Conclusions and Future Work

Our study focuses on the use of semi-fidelity training simulators. This focus differ from the main stream of training simulators; both their studying and using target to high fidelity simulators. They are known to be effective in learning but their creation and modification are expensive. Our aim is to find out if inexpensive and easier to modify semi-fidelity training simulators are useful in some situations.

Our study depicts behaviors associated with simulator acceptance. When inexperienced users are taken to a VE and tools which they have never seen are given to them, the most important feature of the ease of use in this situation is learnability (Tiainen et al., 2013). Learnability means how easy it is for users to accomplish some basic tasks the first time they encounter the design (Nielsen, 1994). Learnability can be supported by making things visible, exploiting the powers of constraint and designing for error (Norman, 1988). In our case, this means making it easy to perceive how the simulator works and what can be done with a real loader machine. Users accepted the semi-fidelity training simulator as a new tool for learning, and therefore developers should provide similarly usable platforms for education. These kinds of simulators have the potential to stimulate new forms of learning and will require developers to think differently about best practices to accommodate user needs in the learning process.

The results of this study are affected by limiting factors. First, the findings reflect only aspects from test uses of a group of users. As the tested simulator is still in its early stages of use, this research is exploratory. The test use comprised prospective users. We were motivated to study their first expressions, as positive experiences are needed right from the beginning of training (e.g., Cretchley, 2006, Vuojärvi et al., 2010). This means that if the initial user understandings are negative the users will not continue using training simulators. Future studies should focus to actual learning and training effectiveness. In this context comparing the learning that occurs using the semi-fidelity simulator and high-fidelity simulator is useful.

The second limitation is that we decided not to analyze individual conceptions further nor their use by individual informants. Still, there were several interview quotations in each category. It is possible to examine these understandings more deeply with phenomenography, and in the future we will continue the analysis towards this direction. One aspect to this is that the teachers are the ‘gatekeepers’ of the classroom. They do not let something pass through the gate if they do not feel comfortable with it themselves (Soloway et al., 1994). Thus, comparing individual conceptions of teachers and students would provide a new viewpoint, both in the case of technical universities and educational training institutes. Individual differences (for example, novice vs. expert) are a question for further studies.

We expect that the results can be generalized to same kinds of machine simulators and use in training. The machine simulation used in our study is a loader machine which may not have the sensitivity and critical aspects involved in another training environment (e.g. training potential airplane pilots, or astronauts). That may require studies with different scenarios. One prevailing characteristic related to our case is masculinity. In our context, the loader machine context generally being considered male, the atmosphere was very masculine. Masculinity can be present also when we situate a technology, for example when installing a computer to boys’ room in a family home, thus enforcing the connection.
between technology and masculinity (Nieminen-Sundell, 2003). The issues the study’s findings raise include the extent to which the samples are representative in more feminine areas such as simulation of actions in health-care.

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