Integrating Virtual Learning with Virtual Work

The industries of today increasingly use digital tools of different kinds, not only for design and construction but also in production planning and factory layout design. The consequence of this is that training and experimenting must also take place digitally and virtually, since there is no real environment available before the start of production. For institutions of Higher Education this raises concerns regarding how to develop pedagogical models for work-integrated learning that are adapted to the trends the virtualization in the manufacturing industries.

This paper describes the early stages of experimenting with virtual tools in a Swedish automotive company, in particular designing and evaluating ergonomically viable positions in car assembly. The virtually constructed designs were tested in a partially complete assembly station. The results from this exploratory use of the tool pointed to several important implications for the use and design of virtual tools and environments.

One important factor for the efficient and successful use of such tools lies in mastering or “breaking” the different “codes” to their functioning that are embedded in their design. This is to some extent made easier, if the tool either has features similar to other tools already mastered, or if it is built into and integrated with an already familiar environment.

Another such factor is the inbuilt or perceived relation between the virtual environment and its real world counterpart. What aspects of the real world environment and its way of functioning are primarily modelled by the design of the tool and in what way? How do the necessary simplifications of the tool’s environment and function correspond to the (unconscious) simplifications that result from our selective perception of our environment?

The aim of the paper is to present and discuss a case-based model for instructional design that has been developed on the basis of the pedagogical challenges presented above. Early results indicate that the model can be instrumental in adding a virtual dimension to work-integrated learning.

Keywords: Learning Simulation, Virtual Reality, Work-Integrated Learning.

INTRODUCTION

The industries of today increasingly use digital tools of different kinds, not only for design and construction but also in production planning and factory layout design. Increasingly, this means that the production environment is virtual and that no physical environment is available before the start of production. The consequence of this is that training and experimenting must also take place digitally and virtually (Malmsköld et.al. 2007a). This raises the issue of how to develop pedagogical models for work-integrated learning that are adapted to the trends the virtualization in the manufacturing industries.

The purpose of this paper is to start an investigation of how to use the combinded knowledge of educational simulations and case methodology to construct learning environment and learning situations that enable us to integrate virtual work with virtual learning. The combination of simulations and cases seems natural, since both approaches are based on the idea of presenting a specific context that is modelled on some part or aspect of reality (see also Lemkuil et.al. 2000)..

For instance, Percival & Ellington (1980) in an discussion of cases in a simulation or gaming context suggest that games, simulations and case studies as “instructional methods” are closely related and overlap each other. Van Merriënbor (1997) distinguishes between three different types of cases in the following typology for cases in technical training.

- Illustrations of conceptual models
- Illustrations of goal-plan hierarchies
- Illustrations of causal or functional models

Similar typologies may also be found in the simulation literature (see e.g. Alessi 2000).

The approach in this paper is as follows. We start by describing the early stages of experimenting with virtual tools in a Swedish automotive company, in particular designing and evaluating ergonomically viable positions in car assembly. The virtually constructed designs were tested in a partially complete assembly station.

Next we describe some of the results from this exploratory use of the tool and derive what emerges as important theoretical implications for the use and design of virtual tools and environments. These theoretical implications are discussed next, in the context of simulations and case methodology.

Finally, some proposals for further research are presented and discussed and conclusions drawn about the usefulness of the used approach and its relevance for WIL-based training and learning.

OVERVIEW OF THE PROJECT

The professional requirements of todays’ engineers more and more include a competence in working in virtual environments. In this context, the relevance of the project described here, lies in the development of learning modules, as WIL components in undergraduate enginering education.

The first phase of the project concerns simulations of ergonomi features, while later phases will focus on simulations of path planning for the assembly of solid and composite materials.

Since this is an area without much research, the approach taken is explorative, consisting of practical trials. The objective of these trials is to identify central issues, both for further research and for development of training methods. The software used to create the virtual environment is called VisJack, which allows for importing 3D CAD models of components, both of cars and of production tools. VisJack is a module in the overall production computer system.

The main feature of the program is the possibility to insert and manipulate so called manikins (simulated human operator) into the production environment. The manipulation includes positioning, motor activity and movement of separate parts of the body. The simulator also includes the possibility to change between an outside view and an manikin view. The basic idea of the simulation is to ascertain certain ergonomic qualities of the assembly operations.

THE EDUCATIONAL MODEL

The educational model used in the trials consist of four steps. The first step includes both instructions and demonstrations on one hand and practical exercises on the other The objective of the exercise is to introduce the basic functionality of the simulation environment. The practical exercises are goal-driven in the sense that the are learners are expected to duplicate chosen examples from practical assembly work.

The second step starts from open-ended case scenarios, involving the mounting of different car components, and the objective is to solve the engineering problems outlined in these scenarios. The scenarios exhibit increasing levels of complexity with regard to the ergonomic simulation.

In the third step, the learners move to a special cell of the simulation centre, where a partial full scale model of a car is erected. This is the same car as in the 3D models in the simulation. The objective here is to translate the results of the simulations to the real world and to compare them to solutions that offer themselves when interacting with the actual car.

Debriefing and discussion of experiences are the content of the fourth step and performed in a group setting with all the learners. Initially, the simulated solutions were enacted and checked for feasibility (see Figure 1). Alternative solutions, triggered by the interaction with the car were discussed and compared to the simulations. Finally, the participants were invited to reflect on the relation between the virtual and the real environments and to articulate insights about the affordances of the simulation tool.

1. Instructional Scenarios	**2. Engineering Cases**	**3. Virtual vs. Real**	**4. Debriefing Seminar**
			

Table 1. Four step learning model for the simulation trials.

EMPIRICAL RESULTS

The results reported here are based on an evaluation of two trials where the participants were experienced production engineers but with degrees of experience with the simulation tool, varying from none to slight.

One of the authors was in charge of the exercise, and the others acted as observers and also participated in the final debriefing session.

From the start of the exercise, the participants were focussed and dedicated and the joint group sessions were characterised by intense discussions and comments. The participants worked in pairs on the assignments and it was obvious that they really wanted to solve the case tasks and that they invested all their skills in it. There was also an unspoken but clear element of competition between the pairs.

Figure 1. Checking the feasibility of simulated solutions to Engineering problems.

This indicates that the tasks presented were seen as realistic and authentic, which is articulated in the following quotes from two participants: “*Is it possible to move the floor? Sometimes we stand on raised floors, you see.*” And “*Can you create snapshots repeatedly? They are very useful, if you show them to someone who is experienced, they can see right off if it is a good working position or not.*

The perceived authenticity of the trials also relate to the manner in which participants invest their professional pride into the educational setting. The following excerpt is from a conversation between the instructor and one of the participants:

Instructor: *“We are short of time, so I suggest you only tilt the major parts of the hood! Don´t bother to add all the small parts.”*

Participant*: “Oh no, I can’t leave all these bolts and parts hanging in the air, that would be to sloppy, and it only take a few more minutes to do the job properly.”*

Analysing the observations from step 1 and 2 described above led to the following overarching conclusions regarding what ”codes” that need to be broken in order to master the virtual environment.

The first code relates to competent navigation in the virtual space, as opposed to merely trial and error behaviour. In order to perform the required tasks, the participants have to be able to move, turn, zoom in and out, and change between different fields of view. This work involves, e.g., the setting of fixed points, as anchors for different movements.

All the participants mastered this part of the simulation quickly, on account of their prior experiences with similar tools in the production computer system. "*Nice that is possible to use the spaceball.*"

The second code relates to using 3D vectors to control the flexible joints of the mannikin. The simulation model exhibited a high degree of complexity, since the limbs of the mannikin are not independent of one another. E.g. you can flex the wrist independently but when you move the hand, it influences first the positions of both the elbows and the shoulders and finally also of the torso. "*You have to play around with it, it is not enough to know on principle how you do it.*" And "*Knees first or elbows? How far apart does she need to be?*"

From the observations of step 3 and 4, the following conclusions emerge. Firstly, all participants experienced that distances in the virtual world were perceived as shorter than in reality, i.e. they tended to overestimate the need for free space between the mannikin and the solid parts of the car in the simulation. The consequence of this was in general that positions, seen as comfortable and ergonomically sound in the virtual world had to be adjusted when interacting with the actual car.

Secondly, since it turned out to be difficult to control the motor activity of the mannikin, the participants consistently chose simple solutions to the problem of fine tuning the positions of the mannikin. Compound and asymmetric movements were avoided. E.g. it turned out to be easier to bend the knees to achieve a certain position in relation to the desired point of the assembly than to turn the head and bend the back. However, the later would be their choice when interacting with the actual car model. "*Is there a predefined position for this?*" And "*Never mind the hood, it is flexible, we need to find a good base position first.*"

Finally, observations from the concluding debriefing and reflection session indicate unequivocally both that the interface and the simulation tool as such are regarded as "true" representations of reality and are relevant for engineering work involved, and that there was also (even if unintended) some conceptual learning with regard to the functioning of the tool. "*I think you need to stand behind the manikin when you manipulate the arms, I had the feeling that the space vectors did not function properly otherwise.*"

IMPLICATIONS FOR THEORY AND PRACTICE

The simulation described in this paper is in some respects different from traditional educational simulations, in that it can be seen both as virtual and as ”real”, in the sense that it is the actual working environment for the production engineers. Nevertheless, it might be illuminating to look at it from some of the dimensions that are used for educational simulations generally.

Alessi (2000) describes different purposes of simulations in three dimensions:

- Procedural or conceptual; this dimension is related to learning outcomes; in this case the main object was to master the simulations software, rather than understanding its underlying model and the direction is thus *procedural*.
- Discovery or expository; in this case, instructor exposition was combined with student experimentation, which means that even if the main thrust of the exercises was towards *exposition*, elements of discovery and exploration of the virtual environment

were also present.

- The degree of transparency; in this case the simulation model is a *black box,* since the underlying model, e.g. of the motor activity, is not revealed.

As described and discussed above, the experiences from the trials reveals some fundamental aspects that challenges the way theoretical discourses normally understand and frame learning simulations.

In the following sections we briefly outline these concerns in relation to the concepts of *debriefing, situational awareness, fidelity*, and *transfer*.

DEBRIEFING

Thiagarajan (1998) stresses that what is learnt from a simulation is not necessarily more objective or proper than what you learn by, e.g., listening to a teacher or instructor. He therefore popints to the importance of debriefing, which includes a systematic discussion of the simulation and its relation to the emergent model of the student.

Homan (1998) has a similar point in relation to flight simulators: it is not enough to let students gain experience in the simulator, since it may lead to their learning to fly in risky ways. Also, it is not always clear in an exercise what is the point or why something went wrong.

In this case, a debriefing was performed, which also included the participants' perceptions of the underlying model and how it corresponded to e.g. actual movements and positions.

SITUATIONAL AWARENESS

A related concept, also found in Homan (1998), is ”situational awareness”. This relates to the need for not only using general procedures but also take what is specific in the situation into account. This is not usually a dimension of educational simulations, but seems to be of interest in the present context, where feasible engineering solutions depend as much on situation specifics as on standard recipes.

A prerequisite for situational awareness is that the reality that is modelled is sufficiently complex and contains enough of the factors that are usually at hand in a real working situation. This condition is fulfilled in the simulation described here.

FIDELITY

One aspect of simulations, that is discussed fairly extensively in the literature (see Rystedt 2002 for an overview) is fidelity. Usually this is taken to mean the correspondence between the reality simulated and the appearance of the user interface, what one might call the "face fidelity", rather than the correspondence between reality and the simulation model as such. (The later issue is mostly discussed as validity.)

In this dimension, simulations are classified as low fidelity (low-fi) or high fidelity (hi-fi), and the one or the other is seen as desirable, depending on the purpose of the simulation, the level of participants and the nature of the simulated reality. Experiences from the gaming field show that a hi-fi interface might include components or features which makes it unacceptable to users, while a low-fi interface might be seen as relevant and realistic.

The simulation, described in this paper, could be seen as both hi-fi or as low-fi, depending on one's view of how "lifelike" the manikins and their motor activity are perceived. Our observations from the exploratory exercises with the ergonomic simulation model indicate, however, that the issue of fidelity must be understood in a more nuanced way.

Our participants bought into the environment from the start, except the difficulties involved in manipulating the manikins. Their reactions and comments, however, indicated that their acceptance of the model and the virtual environment was based on more than the degree of “face fidelity” of the user interface. To borrow from learning theory, one might say that they perceived the tasks and the environment as “authentic” (see e.g. Petraglia 1998).

Our preliminary conclusion here is that there is a need for a discussion of what makes the model accepted or why it works that is grounded in a higher level of magnification, i.e. closer to the actual tasks and performances of the participants, and that includes not only fidelity but also acceptance and authenticity.

One of the pedagogical ideas of our project is to explore the distance between reality and simulation, and arrive at a learning model that takes these distances into explicit account. The reason for this is in the introduction to this section: that it is about real working tools, which the engineers of today need to master and has real consequences in actual production. The solutions must work, so it is imperative that the participants learn enough from the simulation.

TRANSFER

It is usually assumed that learning, based on simulations, can lead to learning about the real world that is simulated (Swaak et.al. 1998). It has been hard, however, to ascertain whether transfer actually takes place, even in well established practices like flight simulations. (See e.g. de Jong & van Joolingen 1998 for an overview of learning from computer simulations.) This is in line with general research which indicates that “problem-solving transfer seems to be rare” (Mayer & Wittrock 1996, p. 51).

In this context is, the issue of transfer is somewhat different from educational simulations in general, again since the virtual environment also is the “professional reality” of the participants. They are not required to take what they have learnt from the situation and apply it to some real situation; rather they are required to create a solution in the virtual context, that can be applied in the future assembly of cars and which is ergonomically sound.

The issue of transfer, which will be further explored in this project, consequently becomes an issue of the ability to evaluate what is created in the simulation tool with a view to how the positions created will function in a real work situation.

CONCLUSIONS

The trials reported in this paper suggest that scholar discourses on learning simulations need to be integrated and expanded in several pivotal aspects. Even though concepts such as fidelity, transfer, and situational awareness bring important pieces to the puzzle, they are still difficult to discuss and asses at an overarching meta-level of a simulation. Instead, it seems as though the engagement in, and acceptance of, a simulation should be analyzed on the very micro-levels of use, where the system, the model, and the program of the simulation are inherently integrated into the actions and the perceptions of the user.

Hence, the unit of analysis is probably not the simulation system, the simulation model, nor the simulation program – but rather the simulating user, and how his or hers acceptance of the simulation relates to various elements of the experience. By shifting the focus from the simulation to the simulator we believe that a richer understanding of learning simulations can be achieved.

When reflecting on the outcomes of the trials, it is of course important to acknowledge the fact that the participants were all experienced engineers. Consequently, it is difficult to grasp in what ways the learning simulation would play out differently in a setting where the participants are undergraduate engineering students (with limited references to the profession). Further research should carefully investigate how acceptance and perceived authenticity could be fostered in a setting of novice participants. To a large extent this challenge relates to the design of an instructional overlay that can provide students with a mindset that make them the equals of experiences engineers.

The trials reported in this paper show that learning simulations could be instrumental in bringing work-integrated virtual learning into the class room. However, there are still some major theoretical and practical challenges that need to be addressed before we can claim to be Integrating Virtual Learning with Virtual Work

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