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The design and effect of automated directions during scenario-based training

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ABSTRACT

During scenario-based training, the scenario is dynamically adapted in real time to control the storyline and increase its effectiveness. A team of experienced staff members is required to manage and perform the adaptations. They manipulate the storyline and the level of support during their role-play of important characters in the scenario. The costs of training could be reduced if the adaptation is automated by using intelligent agent technology to control the characters within a virtual training environment (a serious game). However, such a system also needs a didactical component to monitor the trainee and determine necessary adaptations to the scenario. This paper investigates the automation of didactical knowledge and the corresponding dynamic adaptation of the scenario. A so-called director decides upon and distributes the necessary changes in real-time to the characters. First, the nature and goals of the adaptations are analyzed. Subsequently, the paper introduces a conducted study into the applicability of directable scenarios. Thereafter, an experiment is introduced that investigates the effects of directorial interventions upon the instructive quality of the scenario. Qualitative results indicated that trainees experienced scenario-based training to be instructive and motivating. Moreover, quantitative results showed that instructors rated directed scenarios as significantly better attuned to the trainee's needs compared to non-directed scenarios. Our future research will focus at the design of an architecture for automatically directed scenario-based training.

1. Introduction

Professionals whose future jobs involve the need for complex skills, such as firemen, soldiers, pilots, or nurses, cannot learn their profession from books and lectures alone. Complex skills are comprised of integrated physical and cognitive abilities, e.g., situational assessment and decision making, and require practical training. Research by Kirschner, Sweller, and Clark (2006) showed that in order for practical training to be effective, careful thought should be given to the selection of suitable learning objectives. Moreover, there is a need for online control over the types of learning situations presented to the trainee over the course of training.

Scenario-based training (SBT) is a practical training form. Its goal is the acquisition of complex skills by letting the trainees perform their job in short realistic story lines, called scenarios, which address well-formulated learning objectives (Cannon-Bowers, Burns, Salas, & Pruitt, 1998; Oser, 1999; Salas, Priest, Wilson, & Adler, 2006). To increase the likelihood of the scenario resulting in useful learning situations, scenarios are selected and controlled as the research by Kirschner et al. (2006) suggests. Scenarios are designed and developed by professional instructors within the training domain to fit the learning objectives for each part of the training. Moreover, during training, these instructors make sure the scenario develops as intended by monitoring the course of events as well as the trainee's performance. If the scenario is not developing in a desired direction or if the trainee's performance indicates the need for a change of plans, they decide upon and execute interventions in the scenario where possible.

The adaptation of the scenario ordinarily takes place by altering the behavior of the characters with whom the trainee needs to interact (e.g., teammates, opponents, patients). Therefore, dynamic adaptation of the scenario often requires not just one instructor, but a whole

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team of staff members to play the roles of such characters. Professional SBT instructors use their creativity and expertise to orchestrate the scenario in a desirable direction as the scenario progresses. The scenario does not always unfold the way it was planned. The trainee might, for instance, make some unforeseen choice or the learning situation may turn out to be less suitable for a particular trainee. In such occasions the role players need to improvise and steer the scenario in a (from a didactical perspective) desirable and (from a domain expert perspective) realistic direction. Hence, staff members are required to play these roles.

Even though SBT is a very effective form of training (Cannon-Bowers et al., 1998; Oser, 1999; Salas et al., 2006), the organization of such training opportunities is cumbersome; staff members are not always available and their deployment is usually expensive. This has led to a growing demand by training organizations for forms of training that require less or no human resources (autonomous training). Applications for training purposes to meet this demand have already been developed; however, these applications usually merely simulate the environment and sometimes the characters. In order to exercise the necessary didactical control over the scenario, human instructors are currently still of essential importance, since the requirement for effective control over the training program needs to be satisfied. To truly offer trainees the possibility to engage in training independent of the presence of staff, instructors or teammates, more knowledge is needed about the way instructors control and alter the scenario as it develops. By developing applications that support autonomous training, the number of training opportunities could largely increase, but the question then remains: How can we automate effective didactical control over the scenario?

In this paper we investigate how control over SBT can be performed automatically by adapting the scenario in real time. We will call these adaptations directions, since they give direction, not only to the role players, but to the entire training scenario, hence, also to the trainee. Section 2 describes a theoretical exploration of the ways human instructors conduct their diagnosis and what types of interventions they consider to improve the learning quality of the situation. The theoretical section presents an overview of earlier work relevant for our purposes. Section 3 describes a first study into the creation of directable scenarios. Section 4 discusses an experiment which was conducted to test and evaluate the effects of directions upon the quality of scenario-based training. Finally, the resulting conclusions and implications for future research are presented in Section 5.

2. Automated directions in scenario-based training

The current section starts by providing the reader with some insights in scenario-based training. Subsequently, an argument is presented for the automation of directions in the scenario. This argument is followed by a further refinement of the nature and goals of these directions. Along the lines of reasoning, the envisioned technical realisation of this automation is explained as well.

2.1. Scenario-based training (SBT)

During SBT, trainees participate in story lines, called scenarios, which encompass a causally and temporally related series of learning situations. Each learning situation is linked to a set of learning objectives suitable for the trainee to learn from. To ensure the realism and the didactical value of the scenarios, they are authored and prepared in advance of the training session by an instructor, who is also a subject matter expert. As explained in the introduction, staff members are often required to play the parts of the various characters the trainee needs to interact with.

SBT is a training method directed at the preparation of future professionals to perform complex tasks, such as fire fighting, first aid, military missions, medicine, etc. Complex skill development calls for training methods that (1) integrate all of the constituent skills, knowledge and attitudes, (2) stimulate the trainee to coordinate the constituent skills, and (3) facilitate transfer of the learned skills to new problem situations (Merrill, 2002; Van Merriënboer, 1997). During SBT, this is done by requiring the trainees to prepare, execute and evaluate real-life, relevant and meaningful situations within a simulated environment (SE) (van den Bosch & Riemersma, 2004; Cannon-Bowers et al., 1998; Oser, 1999; Peeters, van den Bosch, Meyer, & Neerincx, 2012; Salas et al., 2006).

Training within an SE offers important benefits, since it can be reused and improved upon by making use of previous experiences. Moreover, it can be controlled, which means that, contrary to training-on-the-job (1) the risks and dangers involved (e.g., the danger of handling weapons or the risk of a patient getting severely ill) can be confined within a safe environment and (2) the complexity of the learning task and the amount of offered support can be gradually increased over the course of training.

To foster transfer, the fidelity of the SE may vary, ranging from the actual task environment to highly symbolic representations thereof. What is important though, is that the SE contains an acceptable level of resemblance to the actual task environment on its most important aspects, such as environmental features necessary for learning and cues that are similar to those found in the actual task environment (Baldwin & Ford, 1988; Young, 1993). Such meaningful, realistic learning tasks are referred to in the literature as “authentic tasks” (Grabinger & Dunlap, 1995; Rieber, 1996). The aspects most important for fidelity purposes vary with the task domain. SEs and scenarios should therefore be developed in consultation with domain experts in order for the SE to contain the necessary resemblances.

2.1.1. Virtual environment

One particular type of SE is the virtual environment. Within a virtual environment (VE), the task environment is simulated by a computer. The use of a VE creates opportunities to implement artificial intelligence techniques, i.e., intelligent agents, that control parts of the environment, such as non-player characters (NPCs) and dynamic environmental aspects (e.g., fires or doors). Examples of agent-based virtual environments for training purposes already exist (van den Bosch, Harbers, Heuvelink, & van Doesburg, 2009). Such systems allow for bigger reductions in costs because they require less organization, less needed man-power, less time to rebuild the environment, and less planning.

Several educational researchers have agreed upon the potential didactical power of such systems (Dickey, 2005; Egenfeldt-Nielsen, 2006; Rieber, 1996). The combination of a virtual environment and intelligent agent techniques can be used to replace the team of staff members by a multi-agent system. However, upon closer look, it becomes obvious that such a system still lacks an automated didactical component. The characters are represented by agents, but they are merely designed to play their parts. As stated in the introduction, control over the scenario requires for monitoring the course of events and the trainee’s performance as well as decision making processes about and