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Background

Organizational work is often described as knowledge work. As such, it requires the application of knowledge (facts and associations between those facts) in order to generate additional knowledge through inference. Part of knowledge work is decision making, the identification and formalization of problems, generation of alternatives, and selection of the best alternative. Yet knowledge work also incorporates other activities, some of which may not be as clearly and explicitly described as decision making. These activities, which generate, modify and apply knowledge may do so in tacit form (see Nonaka et al., 1994), meaning that the knowledge worker may possess some knowledge, can apply it, but is unable to articulate it (for a more formal definition of tacit knowledge, see Polanyi, 1966).

How can future knowledge workers be educated? Popular for the instruction in decision making and problem solving are methods such as case studies and role play. For the transfer of tacit knowledge little advice exists. Nonaka et al. (1994) identify the value of learning-by-doing and illustrate the role of apprenticeship programs for the "transfer" (more precisely re-creation) of tacit knowledge. This is where computer role play becomes relevant. Role play with computer software allows the execution of arbitrary (and infrequent) decision scenarios, the creation of dangerous decision scenarios (e.g., "battlefield simulations"), replay and review of decisions, to name just a few of the advantages. Does it also permit the transfer of tacit knowledge? This is one of the questions this research intends to answer. The purpose of this article is to determine the usefulness of computer role play software for education, focusing on problem solving knowledge transfer, and tacit knowledge transfer.

Problem Solving Knowledge

Following widely held beliefs of the nature of problem solving (e.g., Reitman, 1964, Pounds, 1969, MacCrimmon and Taylor, 1976), problem solvers have to learn how to bridge the gap between a not-so-desirable and a desirable state of affairs. Thus, they have to understand and learn state information describing physical objects and non-physical concepts. They also have to understand the connection between causes and effects (means-ends learning, Newell and Simon, 1972), and they have to be able to learn and understand plans (mapping out multiple steps to achieve a goal, based on cause-effect relationships). While this is not a complete list of problem solving related skills, it undoubtedly supports key elements of problem solving.

Tacit Knowledge

People know a lot more than they can express in words. "We know a person's face, and can recognize it among thousands, indeed among a million. Yet we usually cannot tell how we recognize a face we know." So illustrates Polanyi (1966) the phenomenon of tacit knowing. Of course, this creates enormous difficulties for knowledge transfer. After all, the teacher cannot tell the learner his or her knowledge, nor can the learner verbalize his or her knowledge later easily in a written or oral test.

Role Playing Software

Role playing programs, which train problem solving instead of decision making or resource allocation, have recently become popular. Oz and White (1993) report applications in such diverse areas as equipment operation, paramedics training, or training for employee-customer interactions. Holiday Inn has produced an interactive CD-ROM-based training tool for assistant managers. Benefits have often been measured in cost and training time reductions. For instance, Andersen Consulting reports that the use of an interactive

business-practices course is saving the company $10 million annually in costs (Earls, 1995) and over 30% in training time (Williamson, 1994). Other companies such as IBM, Ford, or EDS report performance improvements of about 20% and training time reductions of over 30% (Oz and White, 1993).

Role playing software needs to transfer knowledge which enables basic problem solving skills. This means, following widely held beliefs of the nature of problem solving (e.g., Reitman, 1964, Pounds, 1969, MacCrimmon and Taylor, 1976), subjects have to learn how to bridge the gap between a not-so-desirable and a desirable state. Thus, they have to understand and learn state information describing physical objects and non-physical concepts. They also have to understand the connection between causes and effects (means-ends learning, Newell and Simon, 1972), and they have to be able to learn and understand plans (mapping out multiple steps to achieve a goal, based on cause-effect relationships). While this is not a complete list of problem solving related skills, it undoubtedly supports key elements of problem solving.

The question then is, how good are adventure game applications in teaching these types of knowledge? To find an answer to this question for at least one role playing software, we had subjects use a role playing game and answer questions for each of the knowledge categories mentioned above. Questions were categorized as follows:

- Physical Object (PO) questions.
- Physical Object Attribute (POA) questions, which referred to attributes of physical objects.
- Concept (CON) questions, describing status information for non-physical, and thus more difficult to investigate objects.
- Cause-effect (CE) questions where variations of the question, "what happens if ... " or "how do you achieve effect ..."
- Plan (PLAN) questions consisted of multiple cause-effect steps which linked together would achieve a certain goal. Such questions were more difficult than CE, because they required memorization of a group of related CE links.
- Negative cause-effect (NCE) asked for a cause-effect relationship which was impossible to determine from the role playing software.

Empirical Investigation

Design

Subjects were asked to work through one sequence of a role playing software, chosen for its ease use, its reasonable level of difficulty, lack of an internal clock (ease of replication of the task), and the ability to re-load the same sequence of scenes to be loaded.

The study involved a relatively small group of 16 (12 + 4) subjects, recruited through a bulletin board posting and word-of-mouth. All of the subjects were college students. All had two or more years of computer experience and all used computers frequently (mean over 11 hours per week). 12 subjects were analyzed for decision making knowledge performance, 4 concerning tacit knowledge.

Dependent Variables

The study measured *explicit* subject knowledge concerning the role play based on subject answers to content questions (of the categories mentioned above). It measured *tacit* subject knowledge by measuring behavior changes (via differences in time taken and effectiveness in role play completion) and comparing them to subjects' explicit knowledge gains.

Results

Summary Findings on Performance Concerning Decision Making Knowledge

No subject answered all questions completely and correctly. The best subject received 26 out of a possible 33 scores (79%), the worst subject 12.83 (39%). The average was 18.36 (56%). High scoring subjects achieved their results by answering questions largely correctly and by completing the whole exercise. Low scoring subjects did not answer too well, but also got "stuck".

Response by Question Type

The two most simple question types, asking for a physical object (PO), or its attributes achieved mean responses of .83 and .84 respectively. More difficult concept questions (CON) resulted in a mean score of .55, questions requiring cause-effect (CE) thinking produced a response score of .50. Questions that required the user to answer with a "plan" or procedure (PLAN) brought an even lower response score of .38. The lowest response was received for the "trick" question which asked for an unobservable cause-effect link. Instead of saying "can't do that," most subjects did not answer at all, resulting in a response score of only .04.

Overall, four levels of difficulty became apparent, identified by similar response scores:

- questions which asked for plainly observable physical objects or attributes (PO and POA, about .8 response score);
- questions that required some concept thinking, either about imaginary (non-physical) objects or direct cause-effect linkages (CON and CE, about .5 response score);
- planning questions (PLAN), with an approximate .4 response score; and
- negative questions (NCE), with an approximate .0 response score.

Tacit Knowledge

Four subjects were asked to complete one role playing scene as fast as possible, then to answer questions about it, and then to repeat the same scene. While clearly too few subjects to generate expressive results, this group was selected as a pilot to determine whether subjects were at the same time unable to answer questions about the problem solving task, yet able to properly complete it (in accordance with Polanyi's characterization of tacit knowledge).

Although all of the subjects made several mistakes or omitted answers (7, 8, 9, and 9 insufficient answers out of 26) and gut stuck during the first round, all of them were able to complete the task in the second round. Furthermore, they completed the task much faster (average of 19 minutes in the second round, versus 50 minutes in the first round). Clearly, subjects had learnt from the first exercise round, even if they were unable to explain their learning.

Conclusions

Role playing computer programs clearly are a promising educational tool, particularly in environments which require the learning of problem solving skills, which involve many physical objects, and which focus on task performance rather than exam style question answering. Subjects learnt more than the knowledge they wrote down as their answer, especially concerning questions that required delineation of an entire task completion procedure (plan).

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