Learning from a Computer Workplace Simulation

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Abstract

Workplaces are rapidly changing, placing increased cognitive demands upon workers. The use of computer workplace simulations has been proposed to help students successfully make the transition from school to work. In this study, we examined what kinds of learning occurred when students used a computer workplace simulation called Court Square Community Bank. We hypothesized that three types of learning would occur: (1) students would gain knowledge about the banking business in which the simulation is situated and (2) students would also learn general business knowledge and problem solving/decision making skills that they could apply in other work contexts. Thirteen pairs of high school students used a workplace simulation. The results showed that students knew significantly more knowledge about the banking business. Students also adopted a new perspective to organize their knowledge and their problem solving activities became more coordinate. Taken together, the results of this study showed that computer workplace simulation can serve as a useful tool to prepare students to make a better school-to-work transition.

Introduction

There is a growing concern that many of today's high-school graduates are ill-prepared for succeeding in today's demanding and rapidly changing workplaces. The world of work is experiencing a dramatic transition: jobs increasingly require complex thinking skills and adaptive performance. As a consequence, there have been many calls for school-to-work transition programs such as youth apprenticeship or technical preparation. Recently, Ferrari, Taylor, and VanLehn (1999) advocated the use of computer simulations as a way to facilitate the school to work transition. They argued that computer simulations of workplace environments can help familiarize students with a particular workplace and assist them in developing the analytical/problem-solving skills needed to successfully participate in the workplace, while allowing them to remain safely situated in the classroom. The goal of this paper is to assess what kinds of learning opportunities are afforded and how much learning actually occurs when students use such a computer simulation.

For our study, we selected a workplace simulation called Court Square Community Bank (CSCB), one of the simulations recommended by Ferrari et al. (1999). CSCB is an episode-based simulation. Students play the role of vice president, engaging in activities such as interacting with bank customers, consulting the opinions of other bank employees, and making business decisions. Each of the 14 episodes poses different kinds of problems that the vice president of a small community bank must deal with such as approving mortgages or selecting the best candidate for a position (see Ferrari et al., 1999 and McQuaide, Leinhardt, & Stainton, 1999 for more details on the program).

In assessing learning from CSCB,[1] we were less concerned with evaluating the specific workplace simulation and were more interested in understanding the learning issues involved in workplace simulations in general. We hypothesized that two types of learning can occur when students interact with a computer workplace simulation. Students could acquire (1) knowledge about the banking business in which the simulation is situated, and (2) general business knowledge and problem solving skills that are applicable to a wide variety of workplaces. Below, we describe these in more detail and speculate on how learning such knowledge/skills might occur.

1. Knowledge about the Banking Business

One of the most notable features of the computer workplace simulation in comparison to other medium of instructions (e.g., reading an expository text or listening to a lecture) is its contextualized nature. In the case of CSCB, the specific business context was a small town community bank. The contextualization was done by using the problems that arises from the banking business (e.g., when to approve a mortgage) and implementing interactions with simulated characters who are primarily bank personnel or customers. This means that much of the information about banking business is embedded in the problem descriptions and the students' interactions with the characters of the simulation. In addition to this contextualization, declarative banking knowledge is presented in the form of on-line dictionary and procedural manual. In sum, the simulation provides extensive amount of information about banking business, either implicitly or explicitly. Although this banking knowledge is never the focus of the simulation (e.g., the program never asks stu-

[1] The effect of the simulation is likely to be different when used in schools compared to when it was used in the laboratory as in this study. For example, in one of the schools that used the CSCB as part of their curriculum, it was augmented with instructional and teacher supports (see McQuaide et al., 1999 for more details).

dents to supply the definition of various financial terms), it seems reasonable to expect that students would at least learn some amount of banking knowledge as a result of using the simulation.

2. General Business Knowledge and Skills

Although learning about banking is meaningful and could be helpful in other contexts, we hope that students would also learn general knowledge or skills that can be used in contexts other than banking. When students go through the simulation episodes, they need to process episode-specific information (e.g., salary of the mortgage applicants) as well as banking specific knowledge (e.g., interview loan applicant before approving the loan). Such knowledge, although useful in making banking-related decisions required in the episode, is largely irrelevant in other contexts.

Concrete contexts can help initial learning because they can be elaborated and help students appreciate the relevancy of new information in problem solving. Context can also be helpful to learning by facilitating the construction of a more accurate representation in a manner similar to how context helps to disambiguate word meaning. On the other hand, context can also present a problem for abstracting general principles or features (e.g., category structure). Overly contextualized learning tasks could potentially impede the abstraction of general principles (Bransford & Schwartz, 1999). Despite its benefits for learning, learning in context could also present a challenge to students in that the contextualized nature of the simulation may impede learning general knowledge or skills that can be useful in other work contexts.

It should be noted that this problem is not unique to computer workplace simulations. The same issue is present in on-the-job or apprenticeship training. There is an abundance of context/job-specific information in the actual work context. Although people need to pay attention to this information, often the ideal learning goal can be met only when people go beyond this information and understand more general business issues (Pearlman, 1997). For example, students need to learn that one needs to consider all the available options before making the final decision or that the role of the vice president may be complicated due to potential conflicts of interest or concerns about nepotism.

According to the analysis of Ferrari et al. (1999), approximately two thirds of the information presented in the two simulations that they examined in detail were specific to the particular type of the industry simulated (i.e., banking and software development). Only one-third of the information was general work knowledge that dealt with issues such as decision making, information management or interpersonal relations that occur across many jobs. In other words, unlike textbooks that often present this decontextualized knowledge in the form of abstract principles or concepts, simulations like CSCB embed this general knowledge in a specific context. The question then is what the kinds of general knowledge or skills students could learn from their experience with the simulation that could be used in other work or business contexts. In this study, we examined the following two candidates.

Perspective Taking In the simulation, students are asked to play the role of bank's vice president and interact with various characters related to the business (e.g., customers, managers, etc.). Given that prior to using the simulation, almost all of the students' interactions with business would have occurred while they were in the role of a consumer (i.e. purchasing items from stores), one would expect students to answer banking terms to be answered from a similar perspective. For example, a banking term such as *interest* can be defined from the perspective of a consumer or a business. When students approach the term from a customer's perspective, *interest* is more likely to be defined as an expense paid to banks. On the other hand, when students approach the same term from a business perspective, *interest* is more likely to be defined as a means for earning profit. The ability of students to take multiple perspectives would reflect a richer understanding of the terms and principles under discussion. Thus, being given the opportunity to take on new roles might affect how students frame their experiences, allowing them to think about the same issue in multiple ways.

Decision Making/Problem Solving Skills Most of the episodes in CSCB require some kind of decision to be made. In each episode, students are first presented with basic descriptions of the problem (e.g., the treasurer announces that the downtown branch has a shrinking profit margin). Students attend a meeting to hear what managers think may be the cause of the problem, read newspaper article about how the community is reacting to the possible closing of the branch, and evaluate various options to address the problem of the branch. The simulation provides a set of alternatives regarding the closing of the branch and asks the students to choose and justify their choice.

Although the decisions in the simulation are simplified by using multiple choice format, they are still complex in nature, resembling the kinds of decision making that might occur in real workplaces. In general, the problems given in the simulation episodes are different from the problems commonly dealt in the classroom (e.g., algebra problems). First, they require an understanding of a both specific context (banking business in this case) and general problem solving skills (e.g., goal state). Second, there is no single right answer as is the case in typical problems taught at schools. There often exist multiple equally viable options that can solve the problem, and even the best solution can be flawed in some way. Third, the problems are complex in that the goals and solution options of the problem are often unclear. The problems also have multiple, interacting causes.

Engaging in such decision making is a complex task. Successful problem solving requires students to understand several factors and their relationships (e.g., governmental regulations or why the branch is losing money). Like in real workplaces, problems in the simulation often do not have a single right answer. Additionally, students often need to evaluate each option based on their own criteria. For example, students need to evaluate the relative merits of advanced technology (e.g., ATM) versus personal attention to customers (e.g., human tellers). Due to such characteristics of the problem presented in the simulation, we postulated that students would learn how to solve such ill-defined problems better after using the simulation. According to the notion of "Preparation for Future Learning" proposed by Bransford and Schwartz (1999), the benefits of previous experience often do not reveal themselves immediately. Instead, the benefit takes the form of helping to prepare students to learn new information. Thus, we examined not only how the overall quality of their decision improved, but also whether they had a better understanding of the problem solving process after using the simulation.

In this study, to get a detailed picture of students' learning, we asked high school students to do eight (out of fourteen) CSCB episodes in the lab. We constructed three assessment tools to test and elaborate our hypotheses about potential learning outcomes from the workplace simulation. They were: (1) Definition Task, (2) Question Answering Task, and (3) two transfer problems.

Method

Participants

Twenty-six high school students (23 from public and 3 from parochial schools) participated in this study. The students were either juniors or seniors from local urban high schools. During recruitment, students were asked to bring a friend of the same gender to participate in the study, which resulted in four male and nine female pairs. On average, they had known their partner for about 4 years, having engaged in academic and after-school activities together. As compensation for participation in the study, students were provided with a base pay of $75 and up to $25 as a bonus if they kept their appointments. With regard to their familiarity with computers, about half of the 26 students (54%) reported that they had computers in their home. Almost all students (96%) reported that they used computers 1-15 hours per week and had experience with word processing or e-mail. A majority of the students (58%) reported that they used other computer simulations or games.

Materials

CSCB Episodes A representative subset of CSCB episodes (8 out of 14) was selected so that diverse topics would be covered (e.g., ethical as well as financial issues) with minimum overlap.

Definition Task The aim of this task was to assess the context-specific knowledge that students might learn about the banking business. This task consisted of 13 terms relevant to banking (e.g., collateral) that were covered in the eight selected episodes. Students were asked to talk about everything they knew about these terms.

Question Answering Task This task was to assess general business knowledge that students might have abstracted from their experience with the simulation. This task consisted of 12 questions that were constructed based on the propositional content of the simulation episodes. These were general questions about how business operates (e.g., name 3 ways that a business can stay competitive) or about a vice president's role (e.g., name three kinds of activities/jobs that a CEO or a vice president has to do in a company). We expected that students would find this task difficult due to the lack of specific contexts. We thus included in the instructions that they could use examples of specific businesses to help to answer these questions.

Problem Solving Task This task was to assess broad changes in students' problem solving. Two transfer problems called Fresh Food and Giant Gallery were constructed based on two episodes of the simulation (Episode 9 and 10, respectively). They were identical to the problems presented in the simulation episodes in terms of the underlying problem/goal, constraints, and options, but differed from the simulation problems in two respects.

First, instead of banking, the transfer problems used the supermarket business (also familiar to high school students) as the context. Thus, although the surface features were different, the underlying structures of the transfer problems were identical to the problems presented in the simulation.

Second, transfer problems were less structured than the problems presented in the simulation episodes. Unlike the simulation episodes that provide a set of alternative choices, in the transfer problems students were asked to generate their own solutions. A set of seven open-ended probes about various aspects of students' reasoning were included. Each transfer problem consisted of two general phases: information interpretation and probe answering. Students were first presented with a set of documents about the problem and then responded to a set of five probes. They were then provided with an additional set of documents and they responded to two more probes. The seven probes were the following:

Probe 1: Could you please state the store's problems in your own words?
Probe 2: If you could request more information about this supermarket's problem, what information would you request and how would you get this information?
Probe 3: As vice president of this supermarket, how (or where) would you get this information?
Probe 4: What factors do you have to take into account to solve the supermarket's problems?
Probe 5: As vice president, how would you go about implementing your options?
Probe 6: What do you think is the best way to solve the problem and why?
Probe 7: What kind of information did you use to make your decision?

Procedures

The study was carried out in the laboratories located in the Learning Research and Development Center at the University of Pittsburgh. Students visited the laboratory over four sessions: (1) pre-test, (2) simulation session I, (3) simulation session II, and (4) post-test. On average, each session was separated by approximately four days. All sessions were audio-taped. In addition, the two simulation sessions were video-taped to provide a context for the interaction between the students.

Pre- and Post-test During the pre-test and post-test, students were given the three tasks described earlier. Students first generated answered to the terms in the Definition Task. They then solved the two transfer problems, Giant Gallery and Fresh Food. Lastly, they completed the Question Answering Task. The order of the two transfer problems was counterbalanced across pairs and pre/post-test sessions. Throughout the sessions, students were asked to think aloud and to talk about everything that came to their mind. To familiarize them with think-aloud procedure, students were given a short think-aloud practice at the beginning of the problem-solving during the pre-test. The pre-test and post-test sessions were individually administered. The pre-test took about two hours, and the post-test took about one and a half hours on average.

Simulation Sessions The first three episodes in each simulation session (Episode 1, 2, & 5 in the simulation session I, and Episode 9, 10, & 11 in the simulation session II) were done collaboratively by the pair, and the last episode in each session (Episode 7 in the simulation session I, and Episode 12 in the simulation session II) was done individually. In the collaborative simulation session, the pairs were instructed to work as a team, in discussing how to handle the problems and to reach a consensus before making a decision. After the collaborative learning session, students were led to separate rooms and completed an episode alone while thinking aloud. Students took approximately 40 minutes per episode, a total of five hours on the simulation over both sessions (excluding time spent on breaks).

Results

Please note that only a subset of results was reported in this paper for the two types of learning examined: (1) learning about the banking business and (2) learning about general knowledge or problem solving skills. We presented two sets of results for the first type of learning and four sets of results for the second type of learning.[2]

1. Knowledge about the Banking Business

Increase in Correct Knowledge and Decrease in Incorrect Knowledge A Knowledge Piece (KP) roughly corresponds to an idea (e.g., ATM costs banks less than tellers). A template was constructed by identifying individual Knowledge Pieces (KPs) relevant to the 13 terms in the Definition Task. The template consisted of 113 KPs captured from the information presented in the simulation in various formats (e.g., on-line dictionaries or reports given to the vice president). The template represented the maximum possible knowledge that students *could* learn from the eight episodes of the simulation. Based on their answers to the Definition Task, students received one point for every unique KP that they stated (partial credit was given if their answer was vague or they expressed uncertainty). Students knew on average 24 KPs at the pre-test and 27.98 KPs at the post-test, $t(24)=3.79$, $p<.01$. In addition, we examined the terms in which students either provide no answer or provided incorrect (or irrelevant) answers (e.g. *principal* was a "person in school") and found that such answers decreased significantly from 2.28 (18%) at the pre-test to .88 (7%) at the post-test, $t(24)=4.09$, $p<.001$.

Schema about Banking Business A subset of questions in the Question Answering Task asked students to explain general business operations. The answers to these questions were analyzed in terms of the type of business schema used (e.g. manufacturing, retail, banking, etc.). For example, to the question "Please name three kinds of expenses that a business has," one student answered: (1) rent, (2) expense to make the product, and (3) expense to get the products out to the public (e.g., shipping or mailing expenses). In this case, the first answer was an expense that was applicable to the banking business, whereas the second and the third answers were not. On average, students' answers applicable to the banking business significantly increased after using the simulation (from 62% to 77%), $t(25)=5.02$, $p<.01$, suggesting that students learned some rudimentary schema about the banking business.

2. General Business Knowledge and Problem Solving Skills

From Customer to Business Perspectives To assess the change in the perspectives, we examined the perspectives that students used in defining the terms in the Definition Task. We coded their answers to each term in the following two perspectives: (1) customer perspective, (2) business perspective. The results showed that there was a significant decrease in answers with customer perspective (3.44 to 2.44), $t(24)=2.45$, $p<.05$, and a significant increase in answers with a business perspective (1.04 to 2.44), $t(24)=3.03$, $p<.005$. Thus many students now demonstrated the ability to think about banking terms from additional framework (i.e. a business perspective in addition to their initial consumer perspective).

Improvement in the quality of the students' final decision As mentioned before, due to the nature of the problem, it was often difficult to determine optimal solutions. What constituted the "best" solution was highly dependent on one's beliefs and priorities (e.g., the importance of technology versus that of renovation in business). Nonetheless, we examined whether there were any improvements in the quality of students' final decisions that they chose in the two transfer problems. This was done based on their response to Probe 6 ("What do you think is the best way to solve the problem and why?"). Based on the analysis of the

[2] Due to recording errors, the following data was lost: student 9B's pre-test answers to the Definition Task and in the Giant Gallery problem and student 8B's post-test answers to Question 3 in the Giant Gallery problem.

simulation episodes, we selected five constraints important to the decision-making and examined how many constraints each of their final decision satisfy. In the Giant Gallery problem, students' final decision met 3.20 constraints (out of 5) at the pre-test and 3.96 constrains at the post-test, $t(24)=1.93$, $p<.05$. In the Fresh Food problem, there were no significant changes in the numbers of constraints (3.62 to 3.54).[3]

Improved Understanding of the Problem Solving Component We examined students' understanding of problem solving components, specifically, their understanding of solution option. At pre-tests, when asked to generated options to solve the store's problem in Probe 3, students were more likely to generate options that did not really *solve* the problems that the supermarket was facing. For example, students answered "look [at] every aspect of the store" or "get ideas from other stores." These answers may be steps to arrive at the final solution, but were not options that could *solve* the specific problems that the supermarkets had. Generation of such *non-options* decreased significantly both in the Fresh Food problem (1.31 to .52), $t(25)=2.33$, $p<.05$, and in the Giant Gallery problem (.78 to .32), $t(24)=1.83$, $p<.05$, suggesting that students understood better what a solution option was after using the simulation.

Integrated Problem Solving In addition, students' problem solving activities became more integrated and coherent. First, students became better at gathering the information. In Probe 2, students were asked to request information they need to understand and solve the problem and then specify how to get it. At pre-tests, they tended to specify the steps to gather information in general rather than the information they requested. For example, in the Fresh Food problem, one student requested three pieces of information: (a) how old the current machines at the checkout counter were, (b) whether customers use the machines properly, and (c) why the machines at the checkout counter was not connected to the main computer system. Then, she specified that she would get that information by (a) asking the company that made the checkout machines in the store about how to fix it, (b) talking to the competitor whether they had similar problems, and (c) talking to the bank about the compatibility of the card and the machine. In this example, none of her information gathering methods were about the information she requested, although they were valid ways of getting information. At post-tests, students were more likely to specify information gathering methods to get the information they requested. Although the increase was only significant in the Fresh Food problem (53% to 71%), $t(25)=2.45$, $p<.05$, the trend was also present in the Giant Gallery problem (58% to 69%).

A similar finding was obtained when students were justifying their final decisions in Probe 6. We coded whether students actually considered the constraints that they listed in their response to Probe 4 ("What factors do you have to take into account to solve the supermarket's problems?"). After students did the simulation, they were more likely to consider the constraints that they listed in Probe 4. In the Fresh Food problem, students used .81 reasons at the pre-test (out of 1.58 reasons they used to justify their final decision) that they had named and 1.17 reasons (out of 1.96) at the post-test, $t(25)=1.74$, $p<.05$. In the Giant Gallery problem, students used .84 reasons at the pre-test (out of 2.04) that they had named and 1.24 reasons (out of 2.60) at the post-test, $t(24)=1.79$, $p<.05$. Thus, it seemed that students' problem solving activities became more connected or coherent in that they generated ways to get the information they requested and used more of the constraints that they initially thought were important in solving the problems.

[3] This seems to be due to the fact that students pre-test decisions were highly similar to the decisions that were reinforced in the simulation in the Fresh Food problem.

Discussion

In this study, we attempted to identify and assess the learning outcomes of computer workplace simulations. We first speculated that students would learn about the work context of the simulation. The CSCB simulation uses banking as a context, but other simulations have used other businesses (e.g., hotel management or software development). We also speculate that students would learn general knowledge about business and how to solve complex real-world like problems.

First, the results showed that the simulation helped students to learn about the banking business. They knew more knowledge about banking, which was accompanied by a corresponding decrease of incorrect knowledge. Students also acquired a schema about banking business. Such results are interesting, considering the fact that (a) students were never asked to learn about banking explicitly and (b) they were not likely to have accessed all the relevant information about the banking business even though they were provided in the simulation.

Second, the results also showed that the simulation helped students to learn general business knowledge and problem solving skills. Students learned to take a business perspective, one that they would not have likely gained from their everyday experiences. As a result, students' answers to the banking terms became more organized from a business perspective rather than from a customer perspective. In addition, students understanding of the problem improved and became more coherent, which seems to be one of the reason why the quality of their final answer improved after the simulation. Considering the fact that the simulation never teaches these knowledge and skills didactically and embeds them in contexts, it is encouraging to discover that students can not only learn about the banking business in which the simulation is contextualized, but also some general knowledge and problem solving skills that they can use in other business and work contexts as well. These results of this study are consistent with the findings obtained with other instructional mediums that use contexts or cases, although they did not deal with workplace issues (e.g., mathematical problem solving as in Jasper Series; see Barron, Zech, Schwartz, Bransford, Goldman, Pelligrino, Morris, Garrison, Kantor, 1995). Taken together, it seems that workplace computer simulation could be useful in preparing students for the future workplaces.

Acknowledgments

This study was funded by the grant to Michelene T. H. Chi, Gaea Leinhardt, and Kurt VanLehn from the A. W. Mellon and Russell Sage Foundation (495006544). The authors acknowledge the help of Cindy Hmelo and Alex Vincent who participated in the initial phase of the study.

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