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ADAPTING WORK SIMULATIONS FOR SCHOOLS

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ABSTRACT

Although computer-based simulations of workplaces are a promising way to prepare high school students for the world of work, it is unclear how many workplace simulations exist and how suitable they are for school-to-work programs. An extensive survey located 142 workplace simulations, many of which were not intended for the school-to-work market. Thirty-nine of the most promising simulations were obtained and analyzed to determine potential problems that might impede their use in school-to-work programs. These simulations were classified according to type (e.g., Skill simulations; Role-Playing simulations; and Strategy simulations) and then critiqued regarding common problems in using them (e.g., usability, learnability, content, and available teacher support). We indicate which problems are most common and what educators can do to overcome them. We close with a propositional analysis of two of the most promising workplace simulations that measures the job-specificity and implicitness of their content. We conclude that simulations can play an important role in school-to-work transition programs, even if not specifically designed for that purpose.

INTRODUCTION

Many of today's high-school graduates are ill-prepared for succeeding in today's changing economy, one that is increasingly adopting practices characteristic of the high-performance workplace [1-4]; such workplaces require critical thinking and adaptive performance on the job [1, 5-7]. Thus, there is an increased need for school-to-work programs that prepare students for entering the world of work.

*Order determined alphabetically.

There have been many calls for school-to-work transition programs that focus on direct workplace experience: for example, youth apprenticeship, technical preparation, and cooperative education. It is unlikely, however, that enough of these programs will develop at a sufficient pace for them to become the major environment in which most students can learn workplace skills. To have the necessary broad impact, workplace education must also take place *in the classroom.*

Yet everything we know about effective skill-learning suggests that workplace preparation must go well beyond visitors who talk about work, job fairs, or even videos of workplaces. Students need to become engaged in the complex decisions required in many workplace tasks, appreciate the social intricacy of work organizations by playing a role in them, use the technological tools and informational resources that modern workplaces rely on. The modern, high-performance workplace is a culture unlike anything the students encounter in school, at home, or on the streets, although it may share much with certain well-organized co-curricular and community-based activities [8]. To understand how complex and different workplace cultures are from those students are familiar with, they need to enter workplace cultures and engage in their practices.

To enter a workplace culture while remaining physically in the classroom requires the use of simulations. By "simulation," we mean a classroom experience, typically using a computer, which gives students information analogous to that obtained by working in a specific workplace, requires them to make decisions similar to those that the workplace demands, and experience the results of those actions. Simulation-based training may be advantageous for many reasons:

- Simulations provide greater accessibility over actual workplace-based education, at a lower cost.
- Many workplaces might not allow students to become workers. Students could watch but not actually make decisions and carry out actions.
- In a real workplace, the tasks are not designed to promote learning but rather to heighten productivity. The apprentice worker, therefore, might participate in the same task over and over rather than in a learning-rich sequence of tasks. A simulation not only can increase the variety of tasks that a student encounters, but also can manipulate the probability that pedagogically significant events will occur.
- Simulations allow a workplace experience to be played back for the student to reflect upon or be restarted so it can be carried out a different way.
- Simulations allow a group of students to play different roles and to stop the simulation for minutes or days in order to seek information or discuss options.

- Simulations can display aspects of the world that are not visible in real life (e.g., the amount of risk caused by an action).
- Simulations allow work to be seen from multiple viewpoints (e.g., customer to stockholder) that are not evident in the real life roles that the beginner can play.

Although simulations are sometimes based on text and other materials, this article discusses only computer-based simulations since these seem the most promising for this type of instruction. Computer-based simulations of workplaces have already been developed for many purposes besides school-to-work transition. For instance, flight simulators have been developed for both the aviation industry and for entertainment. Businesses and business schools routinely use simulations that put the students in the role of a CEO or other high-level decision-maker. Simulated workplaces are sometimes used to teach basic academic skills, such as math or science. Medical schools often let students practice diagnosis and treatment with computer-simulated patients.

The research question addressed by this article is whether it is feasible to use existing computer-based workplace simulations for school-to-work transition. This requires: 1) locating existing workplace simulations, especially those not designed for school-to-work, 2) rejecting those that are clearly infeasible and obtaining the others, 3) playing them and identifying problems with using them in school-to-work programs, 4) selecting the least problematic ones for further study, and 5) evaluating them in laboratories and classrooms.

In this article, we report on the results of the first three steps. Evaluations of workplace simulations are currently being conducted in both laboratory and field settings, and will be reported at a later date. Here we want to give an overall picture of both the kinds of simulations that exist and the kinds of problems that confront those who adopt workplace simulations. It is difficult to convey the experience of playing a particular simulation, and even harder to convey our experiences in playing many. The best method of describing such diversity seems to be taxonomic, so the centerpieces of the report are two descriptive taxonomies:

- A taxonomy of existing simulations.
- A taxonomy of potential problems of using simulations for school-to-work instruction.

These taxonomies are presented in the first two sections, respectively. In a third section, we further explore simulations by using a propositional analysis technique to explicate and categorize the content of the most two promising work simulations. Although we have learned a great deal from our survey and analyses, this article does not have a standard format for presenting scientific work (i.e., we present no explicit hypotheses with their supporting data). Instead, we began our research with the naïve belief that hundreds of workplace simulations existed and most could be readily adapted for school-to-work transition. However, our research showed that our initial beliefs about the ubiquity of simulations were off by an order of magnitude and that our blithe estimates about their ease of adaptation to school-to-work programs were also overly optimistic. Even so, there is much to be excited about, as seen through our taxonomic classifications of these state of the art workplace simulations.

WHAT COMPUTER WORK SIMULATIONS EXIST?

We conducted an extensive search of the Internet, trade literature, and professional literature in order to identify and catalogue existing workplace simulations. In particular, working through commercial channels, we searched the Internet, obtained software catalogues from multiple vendors, and talked to sales representatives and project managers in the simulation industry. From an academic perspective, we searched ERIC and other databases, back issues of relevant journals (e.g., *Simulation and Games, Journal of Research on Computing in Education, Educational Technology,* and *Educational Technology Research and Development*), and contacted prominent authors. Searching for military simulations was expedited by obtaining permission to consult DITIS, a major database used to catalogue simulations developed and used by the military.

It is sometimes difficult to draw the line between work and play. Although we included flight simulations, we did not include simulations of professional athletics (e.g., race car driving, basketball, golf) even though a few people do make a living at these exotic occupations.

Based on our search, 142 workplace simulations were located and catalogued. However, this total reflects a constraint: we limited the number of redundant simulations. Since our survey methods could not guarantee exhaustiveness, there was no point in collecting, for instance, every flight simulation.

The simulations we found can be classified into general categories based on the markets for which these simulations were originally developed. These results show that a large number of simulations are designed to teach about specific jobs or types of jobs. These included managerial and non-managerial skill-based jobs (e.g., flying a plane; troubleshooting electronic equipment). There were also a number of simulations designed for entertainment and for teaching basic academic skills. A few simulations were designed for use in research, such as psychology experiments on how people learn complex skills. Surprisingly few simulations were specifically designed to prepare students for the workplace (see Table 1).

Selecting a Subset for Further Analysis

The next step in the research was to obtain and analyze a subset of these 142 simulations in order to see how they would fare in a school-to-work program. For this purpose, simulations that were either clearly impractical for school-to-work could be eliminated, and groups of nearly identical simulations were represented by a single simulation.

Table 1. Intended Purposes of Simulations

Purpose of the Simulation	Number
Job-specific training	83
Entertainment	25
Basic academic skills	14
Research	11
School-to-work transition	9
Total	142

Of the 142 simulations catalogued, there were some that were clearly inappropriate for school-to-work programs. In particular, they had one or more of the following undesirable properties:

- *Unavailable technology.* Some simulations use virtual-reality hardware, or advanced computer systems that not readily available in schools; we eliminated fourteen simulations that did not run on Windows, Macintosh, or Unix-based computer systems.
- *Unobtainable.* Twenty-five simulations were unobtainable or had become obsolete.
- *Not English.* Fourteen simulations were not available in English.

Among the remaining eighty-nine simulations, there was considerable redundancy. For instance, there were seven flight simulations designed for entertainment and forty-six simulations of capital markets designed for use in business schools. When a group of redundant simulations was found, we selected for analysis ones that expert industrial and academic sources considered the best and most widely used. This selection process eliminated a further fifty-two simulations, leaving us with thirty-nine for the in-depth analysis (see Appendix A for listing).

A Description of the Work Simulations Collected

This section provides an informal description of the variety of simulations found without prejudging their suitability for school-to-work transition programs. Of the thirty-nine simulations, all were designed to be used by a single student or a small group using the same computer. Networked computer and coordinated software with students playing different roles are technologically possible, but did not occur among the thirty-nine simulations chosen for in-depth analysis. The simulations collected offered multiple (and in some cases, virtually innumerable) scenarios, games, or projects—each typically requiring fifteen to ninety minutes to complete. For example, *Great Ocean Rescue* provides four set missions; in contrast, *Project Challenge* provides innumerable projects for students to manage, each distinguished by their difficulty parameters and by randomly generated events. Scenarios allow teachers to use the same simulation repeatedly (e.g., once a week for several months), rather than limiting its use to one full-day experience; however, the content of simulations varies considerably.

In order to convey the diversity of the thirty-nine target simulations, we first informally established groups of those we considered to be quite similar. This yielded three groups, to be described shortly. As a check, we then rated each of the thirty-nine simulations along two dimensions and performed a cluster analysis. The cluster analysis confirmed our subjective categorization, and revealed some hidden substructure. Thus, it is worth a moment to discuss it.

Simulations were rated along two dimensions:

1. Amount of social discourse in the simulation. For instance, in some simulations, the student could "talk" to customers or co-workers, while in others, the portrayal of the workplace was so abstract that there were no opportunities for social interactions.
2. Task complexity required of the student. For instance, in one simulation the students managed a hot-dog stand, and their task was limited to ordering supplies based on the expected attendance and weather conditions at the next event. In other simulations, students managed a multinational corporation and were required to make many decisions, each more complicated and requiring more knowledge than any of the hot-dog stand decisions.

Although these dimensions are only two of the many important features that distinguish simulations, they were chosen because they captured much of the variation among the simulations.

Two coders independently rated each simulation along a 5-point scale. Interrater reliability between two independent judges was established at .89 ($r = 81$), using the correlational method developed by Rosenthal and Rosnow [9]. All disagreements were resolved by a discussion between the raters. A cluster analysis (centroid method) was conducted using SPSS (see Figure 1). There were three main clusters, which are discussed in subsequent sections.

Skill Simulations

In Figure 1, the simulations in the cluster at the bottom (simulations 34-39) have low scores on both complexity and sociability. That is, they are narrower in scope than the other simulations, where students employ a large variety of skills in

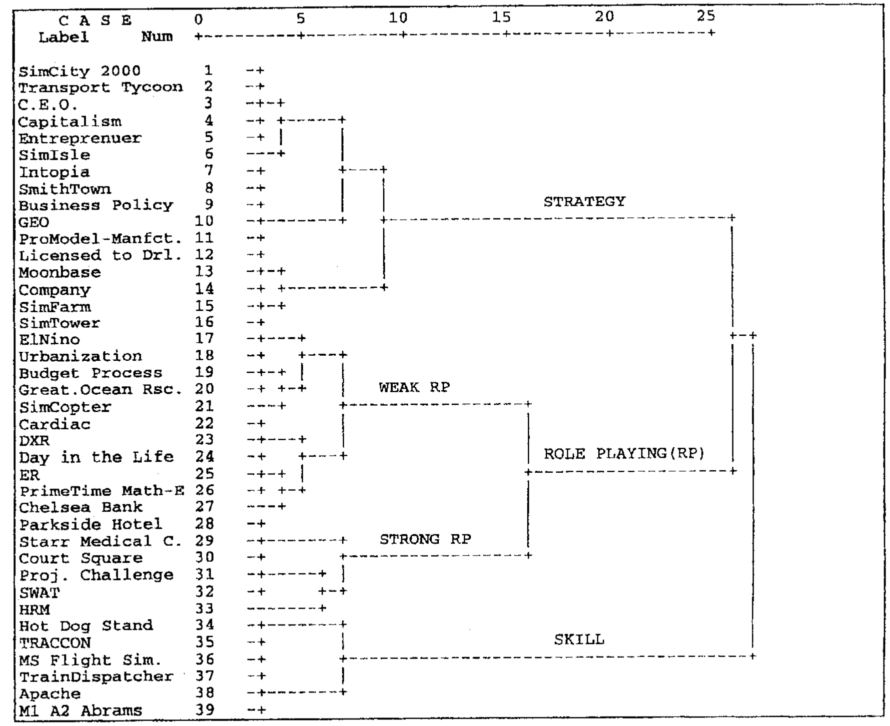

Figure 1. Hierarchical cluster analysis of the thirty-nine simulations collected.

getting a job done, and they seldom allow students to interact with simulated people. The main focus of these simulations was the training of specific job-related skills.

One good illustration of a skill simulation is the flight simulation, *Apache (38)*. Throughout this simulation, the student is in the cockpit of an Apache helicopter and uses the joystick to steer the helicopter while using the keyboard to control the weapons, radar, and other systems. The changing terrain outside the cockpit windows, and sounds from the engines and weapons, simulate the helicopter environment. The student has to acquire perceptual-motor skills as well as some cognitive skills such as understanding the radar and altimeter displays. However, there is limited social interactions and no coverage of a pilots' duties outside of flying combat missions. Thus, the simulation has a low social component and narrow scope.

The other simulations in this category are:

- *Hot Dog Stands: The works:* Managing a small stadium concession stand.
- *TRACON:* Controlling air traffic from an airport tower.
- *Microsoft Flight Simulator:* Flying a small plane.
- *Train Dispatcher:* Routing trains between Washington and Boston.
- *M1A2 Abrams Tank:* Driving an army tank.

Strategy Simulations

The cluster of simulations at the top of Figure 1 (simulations 1-16) have high complexity and low sociability. These simulations typically make students responsible for the long-term success of a business or other large organization. For instance, students may play the role of a CEO of a large corporation, a mayor of a city, or a high official in some other organization. As such, they make a wide variety of complex decisions that determine the fate of their organization. Thus, with strategy simulations, students perform a variety of the task that go well beyond those required in skill simulations.

On the other hand, these simulations do not portray the typical face to face social interactions of someone in such a leadership role. Typically, information is presented graphically (e.g., as tables, charts, or maps) rather than by a (simulated) person or team. Decisions are usually accomplished by issuing commands in the form of mouse clicks on buttons, rather than exercising social and political skills to convince a recalcitrant city council or management team. Thus, these simulations have a low social component. Although a variety of names would be appropriate, we named this class "strategy" simulations.

A good example of a strategy simulation is *Capitalism.* The goal of this simulation is to set up a profitable corporation by outwitting the competition and gaining a greater market share, while overcoming a number of realistic obstacles. The basic game is quite simple and involves setting up a department store that sells certain products obtained from either farms, local factories, or from overseas shipping. However, the level of difficulty can be varied to gradually increase complexity. At more complex levels of play, it can also involve setting up mines to supply raw materials for factories, and research and development centers to improve products. This simulation does not place students in any virtual office and one is only nominally in charge of workers. Instead, one must think strategically, in terms of business systems and how they operate. For example, one must consider the quality and price of one's product as compared to that of the competition, advertising strategies, brand-name strategies, etc.

The cluster analysis uncovered an interesting substructure to this broad class of simulations. The simulations (1-6) at the top of Figure 1 corresponds to simulations designed for the entertainment market. These are:

- *SimCity 2000:* Managing the growth of a city.
- *Transport Tycoon:* Developing a national transportation business.

- *C.E.O.:* Managing a large conglomerate.
- *Capitalism:* Develop and manage a multinational corporation.
- *Entrepreneur:* Developing a start-up company.
- *SimIsle:* Governing a small island.

The next group of simulations (7-10) in Figure 1 correspond to simulations designed for use in business schools. They are:

- *Intopia:* Managing a high technology company.
- *The Business Policy Game:* Managing a software company.
- *Smithtown:* Exploring supply and demand in a simulated town.
- *GEO:* Trading stock in international companies.

The third subgroup of strategy simulations (11-16) in Figure 1 is heterogeneous; it includes:

- *Pro Model:* Manufacturing: Designing a manufacturing plant and processes.
- *Licensed to Drill:* Developing a new oil site.
- *Moonbase:* Administrator of a small lunar colony.
- *Company:* Produce and market personal computers.
- *SimFarm:* Managing a farm.
- *SimTower:* Develop and manage a large office building.

Role-Playing Simulations

In Figure 1, the cluster of simulations in the middle (simulations 17-33) have high social content and moderate complexity. We identify these as "role playing" simulations because the student takes on all the social and problem solving tasks that occur in the daily experience of a person in that role. These are the only simulations that portray the social components of a job by having students interact with simulated people who become implicated in their decision making. Unlike the strategy simulations, where the screen typically shows a complex array of graphically presented business information, the screen in a work situation simulation typically shows an office or other workspace from the point of view of a person in that role. In order to read a report, one must "pick it up" off the desk by clicking on it. To go to a meeting, one must exit the office by clicking on the door. In this sense, the work simulation is more realistic than the strategy simulation. However, in order to get this realism, somewhat simpler organizations and roles are simulated than those of strategy simulations.

A good example of a role-playing simulation is *Court Square Community Bank.* Students are placed in a virtual office and play the role of bank vice-president. They report to the bank president and supervise a (simulated) staff with whom they frequently call meetings to discuss important business decisions. Students acquire information from their staff and clients via reports, phone calls, or faxes; in addition, they get information from manuals, newspapers, and television news. Students work with basic financial computer programs to evaluate decisions; major decisions require written justifications. When they make an unwise decision, they are reprimanded by the bank president and by the financial press. They also receive performance feedback (positive or negative) from employees and customers who are affected by their decisions.

Another good example of a role-playing simulation is *Project Challenge*, in which the student plays the role of project manager for a software company. The student must manage personnel and financial resources in order to produce a product on schedule and under budget. The student must also deal with clients who change their mind in the middle of the project, staff who get sick, quit, or are simply unqualified, and junior managers who can't manage. The setting is a virtual office with a desk, phone, computer, and file folders with important information. There are also organizational tools like GANT charts and budget projections which help students accomplish their goals. One is also encouraged to meet with team members and the client periodically, to hear first hand about the project status. *Project Challenge* provides a post-performance critique of key decisions, and scores the student on four key measures of project success: budget, schedule, team morale, and customer satisfaction.

Other simulations in this category are:

- *Parkside Hotel:* Manager of a hotel.
- *Starr Medical:* Nurse at a large hospital.
- *SWAT:* Rookie police officer on a SWAT team.
- *HRM:* Human Resources Manager for a large manufacturing company.

The cluster analysis revealed a substructure among the role-playing simulations. The role-playing simulations described so far are all members of what we call "strong role-playing simulations," which appear in Figure 1 as the lower half of the role-playing cluster (simulation 28-33). They provide the student with a strong sense of the typical "day in the life" of the job-holder, and include a considerable amount of social interaction.

The remaining simulations, which we call "weak role-playing simulations" (17-27) because they provide less sense of what it is like to work in the simulated role. For instance, in *DxR* (a clinical-medicine simulation), the student plays the role of a physician who is diagnosing a patient. The simulation first presents the patient's complaint, and then allows students to quiz them by choosing from a large menu of questions. Next, students can conduct a physical exam by selecting icons for medical tools (such as a stethoscope) and correctly applying them to the patient's body. The results are usually presented textually, although audio and video are sometimes used (e.g., for heart sounds or skin blemishes). The student then orders lab tests, presents a diagnosis, and prescribes treatment. Although the student has some social interaction with the simulated patient, there is none with co-workers or supervisors. Moreover, the student gets no sense of what a physician does besides diagnosing patients. Thus, *DxR* is typical of the "weak" role-playing simulations. Other simulations in this subcategory are:

- *A Day in the Life:* Laborer for assorted tasks (e.g., delivery, painting, clerical).
- *El Nino:* Scientist on an oceanographic research vessel.
- *Emergency Room:* Physician in an emergency room.
- *Urbanization:* Mayor of a small town.
- *Budget Process:* Congressional representative.
- *Prime Time Math: Emergency:* Solving emergency room problems.
- *Great Ocean Rescue:* Scientist solving international oceanographic problems.
- *Chelsea Bank:* Teller in a bank.
- *SimCopter:* Pilot of a rescue helicopter.
- *Cardiac:* Medical team member managing a heart attack in an emergency room setting.

Summary

Of the 142 simulations in our initial collection, thirty-nine were selected for further examination. These simulations fell into three main types:

- skills simulations (6)
- strategy simulations (16)
- role-playing simulations (17)

The preceding section described these simulations so as to give the reader a feel for the simulation experience. In the next section, we begin to address the harder issue, which is judging the appropriateness of these simulations for school-to-work transition programs.

COMMON PROBLEMS AND SOLUTIONS

In order for a simulation to teach something useful, four obvious criteria should be met:

- The students must find the simulation usable and engaging.
- The content of the simulation must be appropriate.
- The students must be able to learn that content.
- The content must be relevant to students' future work situations.

Within each of these major categories, many common problems have been observed in our analyses of the thirty-nine simulations. Table 2 provides an overview of the problem types and their frequency. The following sections provide more detail about each type of problem. All coding was done by two raters, with conflicts resolved by discussion between the raters.

Usability and Engagement

Here we discuss problems that would prevent a simulation from even being used as well as problems that decrease the chances that the students would be meaningfully engaged in the simulation.

Prior Knowledge

A common problem that can prevent a simulation from being used effectively in the classroom is that it assumes students already know a great deal about the work to be done and that that knowledge is accessible to them [10]. For example, *Cardiac* is designed to train emergency medical personnel in techniques for dealing with heart attacks. The student plays the role of the supervising physician who is surrounded by a team of helpers and equipment. The game is played in real time, with all the stress, ambient noise, and confusion of a real hospital emergency room. Simulated co-workers even speak aloud providing information in emergency room jargon. In many respects, it is an engaging introduction to a real workplace. Unfortunately, *Cardiac* assumes the student knows a lot about general medicine (what does adrenaline do? What is systolic pressure?) and the specific procedures for managing cardiac arrests. *Cardiac* requires so much prior knowledge that most high school students would be reduced to clicking randomly on buttons.

Table 2. Frequency of Problems among the Simulations Collected

Type of Problem	Frequency
Usability	
Requires extensive prior knowledge	5
Difficult user interface to learn	7
Low engagement	9
Content	
Atypical activity	11
Abstract or asocial job portrayal	16
Potentially inappropriate	3
Learnability	
Inadequate feedback	20
Confusing help	10
Single level of difficulty	26
Cannot be played as a team	5
Teacher Support	
No teacher manual	23
No workshops or consultants	30

Some simulations are accompanied by user manuals that present much of the job-specific knowledge required to play the simulations. Sometimes players are instructed to access the manual, because accessing information resources is often viewed as an essential part of the job [11].

Of the thirty-nine simulations, we judged five to require so much prior knowledge that they could not be meaningfully played by students in a school-to-work program. We estimated that two required so much background knowledge that a teacher would have to spend several hours of class time to prepare students to use the simulation. Another nine could be used given only the user manual, in principle; but teachers would probably prefer to devote some class time to preparation. The remaining twenty-two simulations could probably be used by students given only the user manual.

Difficult User Interface

Another problem, the usability of software, has been extensively studied in the field of Human-Computer Interaction and denotes both the ease of learning the user interface and the speed with which one can use it accurately once one has mastered it. In school-to-work programs, it is unlikely that students will spend more than a few dozen hours using the simulation, so the learnability of the user interface is far more important than the speed and accuracy that can be achieved by expert users. However, one must be careful to distinguish the learnability of the user interface, discussed here, from the learnability of the job-specific knowledge, discussed later.

The usability of the simulations we reviewed varied widely. For instance, some of the business simulations present the student with just a spreadsheet of numbers and they must consult the manual to discover its meaning. More accessible business simulations present the same kind of information with icons, graphs, maps, and pictures.

For thirteen of the thirty-nine simulations, we judged that students with little computer background could learn the user interface without referring to the manual. In another nineteen cases, we judged that an experienced computer user could learn the user interface without referring to the manual, but novices would require some instruction. In another seven cases, we judged the interface to be so complex that even experienced computer users would have to refer often to the manual in order to learn the user interface.

Engagement

To be used effectively in schools, students must become engaged in the simulations. If they fail to find a simulation engaging, they may just click randomly on the simulation's command buttons, without even thinking about their actions. This is almost always possible, and sometimes cannot be easily detected by the teacher.

Research suggests that software can be either intrinsically or extrinsically motivating [12, 13]. If students find the simulated job engaging in its own right, they will be intrinsically interested in it and need no enticement or rewards to play it. On the other hand, extrinsic motivation can be gained by adding appealing graphics or audio, exciting cover stories, competition with other students, or rewards such as grades.

It is hard to evaluate a simulation's potential for intrinsic motivation because that depends strongly on the individual student's interests. For instance, *Train Dispatcher,* whose advertisements urge users to "experience the thrill of dispatching trains," may seem dull to most students, but there are apparently enough people intrinsically interested in this task for at least multiple simulations to exist.

Although intrinsic motivation is hard to predict, extrinsic motivation can be estimated by evaluating the graphics, audio and cover stories that a simulation provide. Simulations designed for entertainment, such as the *Apache* flight simulator and the *SWAT* police game, came with arcade-quality graphics, audio, and cover stories. We judged fifteen simulations to be extrinsically motivating on this basis. On the other hand, some simulations had exceptionally simple cover stories, dull tasks, little or no graphics or audio. For instance, *A Day in the Life* has the student perform a long sequence of low-skill tasks, such as measuring a room, filling out one's address on a form, and shampooing a carpet. We judged nine simulations to be unengaging, unless one was intrinsically motivated by the task domain. The remaining fifteen simulations fell in between.

Even a dull simulation can still be used in classrooms when accompanied by extrinsic motivation. For instance, students can be organized into competitive teams, or their grades can be made partially dependent on the simulation outcome.

Content

A work simulation is only worth using if its content is worth learning. By "content," we mean the workplace appearance, activities, roles, principles, and all the other information that the simulation conveys about the job either explicitly or implicitly. For instance, in both *Project Challenge* and *Court Square Community Bank,* where the students play a managerial role, simulated employees and customers are frequently phoning them or barging into their office. From this, the student can infer many things about the work life of managers. Such inferences are part of the implicit content of the simulation, along with more explicit advice, such as "if an employee is not performing satisfactorily, consider training them."

Atypical Activity

A common problem, especially among Skill simulations, was that student activities represent only a small, non-representative portion of the activities normally encountered on that job. For instance, *Cardiac* portrays the life of emergency medical personnel during a heart attack, but these events are only a small portion of such a job. Similarly, unlike the simulation, military personnel who drive Abrams tanks actually spend very little of their time in them. Students exposed to only the most exciting activities of such a workplace may form an inaccurate image of what the world of work is really like.

Another problem is that some simulations present jobs that are so unusual that it becomes hard for students to generalize from them to the world of work as a whole. For example, *El Nino* puts students in the role of scientists exploring the effects of a particular climatic phenomenon. Although the simulation is intended to teach students some science, it portrays life aboard an oceanographic research vessel with engaging accuracy and is thus a workplace simulation. However, the job is hardly typical of the ones held by most scientists. Indeed, the whole point of *El Nino* and other simulations designed to teach academic topics is to use atypical, engaging jobs to motivate (and situate) learning. While admirable for academic instruction, this aspect makes them less appropriate for school-to-work transition programs.

Overall, we judged eleven of the thirty-nine simulations to have such atypical activities that it would be inappropriate to use them in a typical school-to-work transition program. However, as with all judgments about appropriateness of content, teachers or schools may find they disagree, and will find particular simulations useful for their specific purposes.

Abstract or Asocial Portrayal of the Job

Many of the simulations represent work at an abstract level. Both the information the student receives and the actions the student takes are at a high level and have less "real world" detail than those of the real jobholder. For instance, in *SimCity 2000,* the student directs the construction of a city. By clicking on icons, the student can raise taxes, bulldoze forests, build nuclear power plants, route freeways, and so on. In real life, city managers must go through a complex political process to accomplish these ends. One click of the mouse represents hundreds of phone calls, meetings, TV appearances, and so on. Needless to say, the students can get much more done in an afternoon than a real city manager, which allows them to rapidly see the consequences of their actions and perhaps come to understand the complex interrelationships that underlie the operation and growth of a city. On the other hand, they would not be able to appreciate what a day in the life of a city manager is really like from playing *SimCity 2000.*

As mentioned earlier, the sixteen strategy simulations portray their jobs at an abstract level, while the seventeen role playing simulations portray their jobs at a more concrete level. Moreover, it seems to us that role playing simulations are in most cases more appropriate for school-to-work transition programs because they can familiarize students with more of the "look and feel" of the workplace. Nonetheless, there is also significant value in appreciating the complex interrelationships that underlie large organizations, such as cities, businesses, and markets, so we would not want to rule out strategy simulations.

Inappropriateness

In some schools, military simulations may be considered inappropriate, which eliminates three of them, such as the *Abrams* tank simulation. We only included a few of the many available military simulations in our sample of thirty-nine because we expected that few schools would wish to adopt them. Similar comments apply to *SWAT,* which trains students, for instance, in hostage negotiations and in the use of police firearms.

A borderline case is HRM, which is intended to train human resource managers in large organizations. In one scenario, the only way to deal with a non-performing employee is to fire him because other measures, such as giving the employee training, transfers, or monetary incentives all fail. Moreover, students are reprimanded for even trying these other measures because they are expected to have noticed negative predictors in the employee's file. While perhaps an accurate representation of current resource management practices, many schools might find this content inappropriate for teaching students about the workplace.

Learnability

A simulation may have completely appropriate content, but if the student finds it difficult to learn that information, then there is little point in using that simulation. This section discusses some of the most common problems that make it difficult for students to learn from a simulation, and what can be done in order to increase learnability.

Constructive Feedback

Considerable research has shown that adding constructive feedback to educational software significantly increases student learning [e.g., 14]; in particular, critiquing student's actions immediately after they are made seems to provide the most efficient learning [15, 16]. However, it is sometimes difficult to provide feedback in the context of a simulation without harming the fidelity of that simulation.

Several (20) simulations gave such inadequate feedback that it would be difficult for the students to use it to improve their performance. For instance, in *SimCity 2000,* the student's city either grows or shrinks; students see this happen, but the simulation provides few specific clues as to why. In *Microsoft Flight Simulator,* students can crash their plane without understanding what could have been done to prevent it. In all these cases, the simulation designers emphasized fidelity over feedback. The kind of feedback given is roughly the kind that the real world would give. This leaves the students and teachers with a great deal of work to do in order to figure out what the students should have done differently.

In seven simulations, there is some feedback but not enough. For instance, in *Project Challenge,* the simulation prints a critique of the student's performance as project manager—including some explanations of what the student could do better. However, it fails to explain some of the critical events in the simulation (e.g., why was one team 2 weeks late in meeting their deadline despite the manager adding overtime, bonuses and even more people to the team); students may find this frustrating.

In only twelve cases did it seem that the simulation and the accompanying manuals provided enough constructive feedback. This typically occurred with simulations that severely limit the actions that students could take. For instance, in *Court Square Community Bank,* each episode leads up to a single decision, where students must choose between about five alternatives. For example, students playing the role of a bank vice-president must decide whether to keep a downtown branch of the bank open even though it is losing money. Depending on which alternative they choose, the simulation responds with congratulations or reprimands from the bank president, good or poor newspaper editorials, etc. Although such in-simulation feedback provides some explanation about the merits (or flaws) in students' choices, more is given in the teachers' manual. The quantity and constructive quality of the feedback probably increases the learnability of the content of this simulation. However, such decision are the only points at which the simulation provides feedback, and they only occur about once every hour.

The simulation itself is not the only source of feedback, teachers can give feedback as well. However, the teacher needs appropriate information about the student's performance in order to do so. In eight simulations, the teacher can probably tell enough about the student's performances to make constructive feedback possible. In a few cases (e.g., *Project Challenge*) the simulation provides a detailed record of the student's actions that teachers could analyze. In other cases (e.g., *SimCity 2000*), the final state of the simulation indicates some but not all of the students' mistakes, so a teacher could examine it and give the student at least some constructive feedback. In the remaining thirty-one simulations, the teacher would essentially have to continuously monitor student play in order to give useful feedback. For instance, in *Company* (which simulates managing a computer hardware company), the business may go bankrupt. But since no record is kept of the student's activities, without constant monitoring, the teacher cannot easily make suggestions for improving the student's performance.

Quality of the Job-Learning Help

Simulations provide varying degrees of help to students who have questions about the simulated occupation. This kind of help is not about the user interface, but concerns the job itself. As an example of easily used help, students playing *Court Square Community Bank* can click on simulated books that provide a glossary of banking terminology, an introduction to the banking business, and a manual of standard banking procedures. Students can also telephone their (simulated) predecessor in the position and ask them pertinent questions. Some simulations also provide tutorials, wherein students either watch the simulation do the job or receive significant scaffolding while they do the job. User manuals may also provide some help on learning the job.

Needless to say, if the quality of the help is low, students will need to ask the teacher for assistance. Thus, we can evaluate the quality of help by estimating how much time a teacher could expect to spend assisting students learning the job.

Of the thirty-nine simulations, we judge that seven had high enough quality help that students could learn the job without any supervision from the teacher. Another twenty-two simulations should require only a few minutes of help for each hour of play. The other ten simulations provided "help" that was so difficult to use that the teacher could expect to spend significant time interpreting it for the students. These figures are only for information that is actually provided in the simulations or manuals. Even more time would be required of teachers if playing the simulations required background information not present at all in the simulation or the manuals.

Graduated Difficulty

Research suggests that learning a task domain is more efficient if students start with a simple task then are gradually introduced to more complex tasks [17]. In order to expedite students' learning, simulations should have multiple levels of difficulty. Even if the instructional objective is only for students to experience the simulated workplace and not to become skilled workers, the experience can be less frustrating if students begin with easy tasks.

Some simulations adjust the difficulty level by manipulating contextual variables. For instance, the difficulty of completing a project on time and under budget in *Project Challenge* increases if the workers' training is not completely appropriate for the project or the budget is unrealistically low. Difficulty can also be adjusted by controlling the frequency of supposedly random events; for example, employees get sick or quit more often when the difficulty level is set higher. Simulations developed for the entertainment market often have "cheat codes" that make the simulation much easier to play. Of the thirty-nine simulations, thirteen either gave the user control of the level of difficulty or gave the user a progression of tasks, from easier to more difficult ones.

Playing as a Team

Another technique that seems to work well with educational software is to have pairs of students or small teams work on the same computer [18]. Research shows that team play is not always more beneficial than single student playing [19, 20]. For instance, it is almost always the case that one student controls the keyboard and mouse, so that if a student does not involve his or her teammates, then those teammates may learn very little. On the other hand, if student teams analyze their options and make group decisions on actions, then learning can be enhanced. For better or worse, team play of simulations is a necessity in many schools, where there are fewer computers in the classroom than there are students.

Some simulations require such rapid decision making that the player at the keyboard simply must make the decisions. For instance, in SWAT, one must act quickly during hostage negotiations in order to succeed at the task. This feature of simulations can reduce the learning of the other students on the team. Of the thirty-nine target simulations, five had this drawback.

There are ways to ameliorate this situation. Almost all real-time simulations provide a "pause" button, which will stop the game and allow students to trade roles. One simulation (*HRM*) provides a "rewind" button that would allow a new player to go back and replay a period of time.

Teacher Support

In order for use of educational software to be optimally effective, one needs teacher support for both class activities and innovative assessment [21, 22]. The most common form of teacher support for workplace simulations was the teacher's manual, which included suggestions for discussion topics, off-computer exercises, media resources, classroom organization, etc. Simulations designed for the education and training markets often came with extensive teacher's manuals whereas simulations designed for entertainment or research did not.

Of the thirty-nine simulations, sixteen came with teacher's manuals. In addition, nine simulation suppliers also offered training workshops and telephone support for teachers. Although many simulations offered telephone or e-mail support for technical questions, we only counted those that specifically helped teachers design and implement instructional interventions.

Summary

Table 2, presented earlier, summarizes our findings. As Table 2 shows, most of the simulations had few problems with usability. Problems with content were a bit more common. However, the most common problems with work simulations are that they provided few aids to students (in the form of feedback) and few aids to teachers (through teacher support) to allow them to be easily used in classrooms. This deficit reflects the fact that many simulations were designed for entertainment and not instruction; or they were designed as components of training programs that differ from school-to-work transition in that they typically presuppose that learners have extensive prior knowledge about the simulated domain.

simulation-specific or redundant propositions were eliminated. The final list of propositions was then coded for content and learnability as described above.

The results of the analysis are shown in Tables 3 and 4. With respect to the content of the simulations, it is clear that roughly two-thirds of the propositions were specific to the type of industry simulated. For instance, most of the propositions from *Court Square Community Bank* were about banking—they addressed concepts such as mortgage rates and automated teller machines, which would not be relevant in other industrial sectors. About one-third of the propositions addressed general topics, such as risk in decision making, staff morale and community relations, which would be of concern in just about any business. The ratio of general to specific propositions was approximately the same for both simulations. Later we will discuss the implications of these results for school-to-work transition.

With respect to the learnability of the propositions, more variability was found across the two simulations. *Court Square Community Bank* had proportionally more mandatory explicit propositions, and *Project Challenge* had proportionally more implicit propositions. However, the largest category for both simulations was optional explicit propositions (45%). This was mostly due to the larger user manuals which were available with both simulations. The manuals contained much pertinent information about banking and project management, but a student could still navigate the simulation without reading it, although their performance would probably suffer.

Table 3. Propositional Analysis: Project Challenge

	Explicit: Mandatory	Explicit: Optional	Implicit	Total
General	23 (14%)	8 (5%)	27 (17%)	58 (36%)
Industry Specific	22 (14%)	64 (40%)	16 (10%)	102 (64%)
Total	45 (28%)	72 (45%)	43 (27%)	160 (100%)

Table 4. Propositional Analysis: Court Square Community Bank

	Explicit: Mandatory	Explicit: Optional	Implicit	Total
General	109 (16%)	56 (8%)	86 (13%)	251 (38%)
Industry Specific	144 (22%)	246 (37%)	27 (4%)	417 (62%)
Total	253 (38%)	302 (45%)	113 (17%)	668 (100%)

Both simulations contained some implicit information (27% for *Project Challenge;* 17% for *Court Square Community Bank*). This quantifies the observation that experiential instruction, as opposed to didactic instruction, often contains a great deal of valuable information in an implicit form.

There was a strong association between general and implicit propositions. Most of the implicit propositions involved general work knowledge, as opposed to industry-specific knowledge. In *Project Challenge,* 63 percent of the implicit information was general, and in *Court Square Community Bank,* 76 percent of the implicit information was general. This reverses the trend in the explicit propositions, where 79 percent (*Project Challenge*) and 65 percent (*Court Square Community Bank*) of the information was industry-specific. Conversely, much of the general information in these simulations was implicit (47% for *Project Challenge,* 34% for *Court Square Community Bank*). In short, most of the implicit information was general and most of the explicit information was industry-specific.

Lastly, *Court Square Community Bank* contained four times as many propositions as *Project Challenge.* This is due to the different purposes of the simulations. *Court Square Community Bank* is designed for school-to-work transition, so it exposes students to a wide variety of activities that engage the vice president of a small bank. *Project Challenge* is designed to train software project leaders in managing projects by obliging them to do the same activity many times. On each iteration, the student manages a different project which runs into different problems, but much of the work is the same each time. This redundancy may be needed to bring students up to a high level of skill. In contrast, achieving such levels of skills was not an objective for *Court Square Community Bank.* Thus, *Project Challenge* tended to expose students to the same information many times (albeit with different project-specific data each time), whereas *Court Square Community Bank* exposed students to a much wider variety of information. The implication of this finding and the ones preceding it are discussed in the next section.

CONCLUSION

We began this survey with the naïve belief that there were dozens of simulations available for school-to-work transition programs, and hundreds more designed for other purposes, such as industrial and military training. Moreover we thought (again naïvely) that it might be fairly simple to use existing industrial training simulations in a school-to-work program. The results of our survey leave us still optimistic, but less naïve. We discovered that there were many fewer simulations in use than expected, and fewer still were specifically designed for school-to-work transition. Of the 142 simulations we found, only nine were specifically designed for school-to-work programs. Most of the simulations were designed for job-specific training (83), entertainment (25), learning basic academic skills (14), or research (11). Nevertheless, these simulations may still be useful for familiarizing students with workplaces even if that wasn't their original purpose.

Working with a reduced set of simulations that avoided impractical or redundant ones, we classified thirty-nine simulations into three groups, namely:

- *Role playing simulations:* A high fidelity portrayal of the information and activities that a real jobholder would experience in a typical day on the job.
- *Strategy simulations:* The information and actions of the student are more abstract and powerful than the real occupation so that the student can implement long-range strategies and see their results.
- *Skill simulations:* Student practices a specific skill or task that is one component, albeit often an important one, of the occupation.

Our intention in making this classification was to succinctly describe the wide variety of simulations that are currently available. Thus, we described some members of each category in order to give a richly textured description of the main types of simulation available.

The next step after locating the simulations was to play them in order to determine what problems might reduce their effectiveness if they were used for school-to-work classes. The problems we found were loosely organized into the taxonomy shown in Table 2. The first set of potential problems, labeled "usability," concerned how much students would have to learn before they could begin to play the simulation, and whether the simulation was engaging enough to keep them playing it once they had started. Perhaps the most significant problem here was that many simulations require students to learn a great deal about the occupation before they can begin to meaningful play the simulation.

The second set of problems, labeled "content," concerned the occupational content of the simulation. Some occupations either focussed on only one particular task of the many done by jobholders (e.g., the flight simulations) or portrayed the occupation at such a high level of abstraction that students could not get a feel for what a real day in the life of a person holding that job would be like. The Skill and Strategy simulations most frequently had this property; however, they might still be useful in a school-to-work situation if accompanied by other material that completed the picture of the occupation.

The third set of problems, label "learnability," concerned the ease with which students could learn the occupational content of the simulation. The most common problem was that the simulations sometimes sacrificed learnability for fidelity. That is, they preferred to portray the occupation in realistic terms instead of offering feedback, help, and other aides that would make the occupation easy to learn. This is somewhat ironic, since one of the main advantage of simulations over the real world is that such aids to learning are possible in simulations and impossible in the real world. However, for some school-to-work transition programs, fidelity might be more important than learnability, especially if the goal of the program is to give students a "feel" for the occupation, rather than their becoming competent at it.

Lastly, there is the important issue of teacher support. Some simulations came with extensive teacher's manuals. A few companies even offered workshops or pedagogical consultation.

Overall, only a few of the thirty-nine target simulations had insurmountable problems. For instance, a simulation that required far too much prior knowledge or had inappropriate content is simply not worth using; there were relatively few simulations of this kind. On the other hand, there were many simulations whose problems required extra class time or teacher attention to fix. Many simulations, for example, did not provide adequate constructive feedback. On the whole, though, these figures bring surprisingly good news given that only seven of the thirty-nine simulations were designed for use in school-to-work settings.

Of special concern is the job-specificity of simulations. In a propositional analysis of two simulations, it was found that about two-thirds of the information available for students to learn was specific to the particular type of industry simulated (i.e., banking and software development). On the one hand, this suggests that the simulations are doing a good job of portraying their industries. On the other, only one-third of the information available to learn was general work knowledge in that it dealt with issues such as decision making, information management or interpersonal relations that occur in many jobs. Yet it is these general, industry-independent issues that are often seen as the instructional objectives of school-to-work transition programs. For instance, the SCANS competencies would all be classified as general work related issues. If these are in fact the "right" instructional objectives, then simulations may be an inefficient means for achieving them, because this information is embedded in supposedly irrelevant industry-specific information about collateral for loans, back office computers for banks, change orders from project clients, and so on. However, if our simulations are faithful portrayals of jobs and the propositional analysis is not too far off in measuring the information required for performing the job adequately, then only one-third of what job-holders need to know is general work knowledge. Thus, a school-to-work program that concentrated only on general competencies, such as those mentioned in SCANS, would still leave students with much to learn.

The propositional analysis of learnability distinguished explicit from implicit propositions. About half the information in both simulations was explicit, in that it appeared in user manuals or similar sources, but students did not have to attend to it in order to play the simulation. This suggests that unmotivated students could get only half the benefit they should get. Fortunately, studies of students using such simulations found very high levels of engagement [22, 24]. The propositional analysis showed that much of the general information in simulations is implicit. This means that teachers may have to scaffold the extraction of general, SCANS-level, knowledge from the experience of playing a simulation.

Lastly, the major differences between the two simulations studied in-depth was the simulation designed for school-to-work transition had four times as many propositions as the simulation designed for training managers. Although both simulations were classified as role-playing simulations, it was clear that the management training simulation was focussing on only one of the activities of the manager—the most common and important activity. The other simulation, which also had the student play the role of a manager, emphasized the diverse activities of the position. It is not clear which simulation is more appropriate for school-to-work transition programs: one that emphasizes the breadth of a position or one that emphasizes the depth and complexity of its major activity.

Somewhat surprisingly, the two simulations did not differ in the amount of job-specific versus general content. One might have expected *Project Challenge* to have a higher proportion of job-specific information because it was designed for training. However, this did not occur. In both cases, about two-thirds of the simulations' content was job specific.

The major conclusion of this survey and these analyses is that existing work simulations, even when originally designed for entertainment or industry, can be one important component of a school-to-work transition program. But potential problems with narrow content or with sacrificing learnability for realism suggest that students will require considerable teacher support while using such workplace simulations. A new generation of work simulations might cover a wider range of occupations and incorporate intelligent tutoring to increase learnability, thus freeing teachers to provide more quality, individualized instruction.

APPENDIX A
List of Thirty-Nine Simulations Surveyed in Detail

A DAY IN THE LIFE. (1994). Curriculum Associates. Penn State University.
APACHE. (1995-96). Interactive Magic. Research Triangle Park, NC.
BUDGET PROCESS: Balancing the Budget (1991). Tom Snyder Productions.
BUSINESS POLICY GAME (4th ed.) (1995). R. V. Cotter & D. J. Fritsche. Englewood Cliffs, NJ: Prentice Hall.
C.E.O. (1995). I-Motion Interactive. Santa Monica, CA
CAPITALISM. (1996). Interactive Magic. Research Triangle Park, NC.
CARDIAC. (1996). B. Wolf. U. Mass.
CHELSEA BANK. (1994). Classroom Inc., NY.
COMPANY. (1985-96). IC USA, Inc. Tokyo, Japan.
COURT SQUARE. (1995-97). Classroom Inc., NY
DxR. (1992-95). DxR Development Group. Carbondilla, IL.
EL NINO. (1997). Tom Snyder Productions. Watertown, MA.
EMERGENCY ROOM. (1995). IBM.
ENTREPRENEUR. (1997). Stardock Systems. Livonia, MI.
GEO. (1994-95). P. Thavikulwat. Dept. of Management. Towson State University.
GREAT OCEAN RESCUE. (1996). Tom Snyder Productions. Watertown, MA.
HOT DOG STAND: The Works. (1996). Sunburst Communications, Inc. Pleasantville, NY.

HUMAN RESOURCE MANAGER (HRM) [Part of the Business Practices Course]. (1996). ILS (Institute for the Learning Sciences). Northwestern University, IL.
INTOPIA. (1995). Thorelli, H. B., Graves, R. L., Lopez, J. C. (1995). International Operations Simulation: Executive Guide. Englewood Cliffs, NJ: Prentice-Hall.
LICENSED TO DRILL. (1985). Henry Ellington, Educational Development Unit, The Robert Gordon University, Aberdeen, & Phillips Petroleum Co.
M1A2 ABRAMS. (1996). Interactive Magic. Research Triangle Park, NC.
MICROSOFT FLIGHT SIMULATOR. (1983-98). Microsoft Corporation. Redmond, WA.
MOONBASE. (1990). Wesson International. Austin, TX.
PARKSIDE HOTEL. (1992-93). Classroom, Inc., NY.
PRIME TIME MATH: Emergency. (1997). Tom Snyder Productions.
PROMODEL. Manufacturing model (1996). Promodel Corp., Orem, UT.
PROJECT CHALLENGE. (1995-96). Thinking Tools, Inc. & SHL Systemhouse Inc.
SIMCITY 2000: Network. (1996). Maxis. Orinda, CA.
SIMCOPTER. (1996). Maxis. Orinda, CA.
SIMFARM. (1993). In SimClassics. Maxis. Orinda, CA.
SIMISLE. (1995-96). Maxis. Orinda, CA.
SIMTOWER. (1994-95). Maxis. Orinda, CA.
SMITHTOWN. (1991). Learning Research and Development Center, University of Pittsburgh.
STARR MEDICAL CENTER. (1995-97). Classroom, Inc., NY.
SWAT. (1995). Sierra. Bellevue, WA.
TRACON. (1991-92). Wesson International. Austin, TX.
TRAINDISPATCHER. (1996). Signal Computer Consultants. Pittsburgh, PA.
TRANSPORT TYCOON. (1994). Microprose. Hunt Valley, MD.
URBANIZATION: The growth of cities. (1991). Tom Snyder Productions. Watertown, MA.

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