KM QUEST: A collaborative Internet-based simulation game

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In this article, the development of a collaborative Internet-based simulation game for learning to solve knowledge management problems is described. The simulation game builds on two starting points: first, on psychological and pedagogical developments in learning and instruction, which are based on a shift from instructivistic toward constructivistic approaches; and second, on a perceived need for better training of people working in the emerging field of knowledge management. After having described these starting points in the introduction, the choice for using a simulation game is clarified and a set of assumptions that have been used to develop a simulation game are described. The resulting simulation game is described in the second part of this article together with the elements that have been implemented to support communication and collaboration at a distance, as well as those to support the learning process. The article ends with a summary of the results of the formative evaluation of the first prototype. The issue of collaboration via the Internet is a particular focus of discussion.

KEYWORDS: *collaborative learning; constructivism; functional business game; instructional design; knowledge management; simulation game; situated learning*

During the past decade, there has been a shift from instructivistic approaches toward constructivist approaches in the field of instructional design (van Merriënboer, 1997). Instructivistic theories assume that formal concepts and systems can be transmitted to students by giving them formal descriptions in combination with the presentation of examples. Constructivistic approaches emphasize the idea of an active, experiencing student in a situation where knowledge is not transmitted to the student but constructed through activity or social interaction. Well-designed instruction should offer experiences to learners that enable them to construct useful cognitive schemata

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and allow them to understand a new domain. For instance, situated cognition (Brown, Collins, & Duguid, 1989) stresses the importance of learning in context, because the context becomes an important part of the knowledge associated with that learning. In the related cognitive apprenticeship approach (Collins, Brown, & Newman, 1989), it is argued that instruction should focus on realistic real-world problem solving rather than the transmission of prestructured pieces of knowledge. The role of an instructor or instructional materials is then to coach and support the learner while these problems are solved.

van Merriënboer (1997) stated that constructivistic and instructivistic approaches need not be seen as distinct alternatives but merely as two aspects of instruction that can and often should complement each other. Ultimately, the chosen mix is a function of the desired exit behavior of the learners and thus is also a function of the context in which this behavior will occur.

As stated above, problem solving is seen as the main activity for acquisition of knowledge and skills. In the most general sense, a problem is an unknown that results from any situation in which a person seeks to fulfill a need or accomplish a goal. The kinds of problems that humans solve vary dramatically, as do the nature of the problem situations, solutions, and processes. On one hand, the domain, goal, and processes entailed by a problem may be very well structured, and on the other hand, they may be very ill-structured. Jonassen (1997) stated that these problem types do not represent well-defined dichotomies but rather represent a continuum from decontextualized problems with convergent solutions to very contextualized problems with multiple solutions.

Knowledge management (KM) is a domain that has recently received increasing attention. This is partly due to the awareness that advanced economies will rely increasingly on their ability to create and deploy knowledge for competitive advantage. KM can be defined as the achievement of the organization's goals by making the factor knowledge productive (Beijerse, 2000). Knowledge as a factor of production has some properties unlike other resources in organizations. Wiig, de Hoog, and van der Spek (1997) listed some of the most important characteristics that set knowledge apart from other resources such as raw materials, goods, and so forth. They stated that knowledge

- is intangible and difficult to measure;
- is volatile, that is, it can "disappear" overnight;
- is most of the time embodied in agents with wills;
- is not consumed in a process and sometimes increases through use;
- has wide-ranging effects in organizations (e.g., "knowledge is power");
- cannot be bought on the market at any time and often has long lead times; and
- is nonrival, meaning it can be used by different processes at the same time.

The authors concluded that "knowledge management should focus on these unique properties of knowledge and come up with a set of methods, tools and techniques that helps in tackling problems that arise from these and other properties" (Wiig et al., 1997, p. 16).

However, this is easier said than done. Especially at the level of individual companies, the systematic and effective management of knowledge assets is still far from perfect. Effective KM is related to the development of new knowledge, consolidation of knowledge already acquired, distribution of knowledge in the organization, combining the knowledge available, and ensuring that the best knowledge is being used (Wiig et al., 1997).

Typical problems in the domain are the following: What knowledge is crucial to reach the organization's goals? Is the knowledge that is necessary in certain processes available at the right moment, at the right place, in the right format? If not, should knowledge be acquired or developed, or should knowledge transfer and sharing between departments be supported? and How can people be motivated to share knowledge and use new or already existing knowledge? People faced with these kinds of KM problems often do not handle them in a systematic way and therefore often do not choose the right activities and solutions (Christoph, van der Tang, & de Hoog, 2001). Many KM activities are guided more by available (information technology) solutions than by a thorough understanding of the nature of the relations between initial problem (or opportunity) statement and the most suitable organizational solution or measure. This seems to be partly due to the fact that a coherent and well-supported methodology for KM is lacking (Wiig et al., 1997) and that problems in this area are multifaceted, complex, and without univocal outcomes.

Many problems in this domain can be categorized as ill-structured. Several authors have claimed that training to solve those kinds of ill-structured problems requires different instructional settings than training to solve well-structured problems (e.g., Jonassen, 1997). Instructional designs for well-structured problems are rooted in information-processing theory, whereas instructional designs for ill-structured problems necessarily share assumptions with constructivism and situated cognition. Important elements of instructional design for ill-structured problems, according to Jonassen (1997), are the use of cases, which are placed in a context and have problem constraints instead of clear or obvious solutions; the support of knowledge base and argument construction; and assessment based on process and product criteria. These elements are characteristic for learning situations in which games and simulations are used and in which learners collaboratively solve problems, as will be explained below.

From a constructivistic perspective, collaborative learning can be seen as one method to promote knowledge base and argument construction. Collaboration with other students provokes activity, makes learning more realistic, and stimulates motivation (Veerman & Veldhuis-Diermanse, 2001). In collaborative learning settings, learners are "forced" to share perspectives, experiences, insights, and understandings. This can help learners to come up with new ideas, debug their ideas, and notice the complexities of concepts and skills. Barrows (cited in Kolodner & Nagel, 1999) pointed to the fact that if collaborative learning is done well, learners can solve much more complex problems and come to far more sophisticated understandings than they could on their own.

Collaborative learning needs to be distinguished from cooperative learning. Examples of cooperative learning groups are those in which students help each other while still maintaining their own worksheet and groups in which each student does a different part of the group task. In contrast, in collaborative peer workgroups, students try to reach a common goal and share tools and activities (van Boxtel, 2000).

Use of simulations and games to teach problem solving

Games, simulations, and case studies have an important role in education and training in putting learning into a context. Furthermore, they are constructivistic environments in which students are invited to actively solve problems. Games and simulations provide students with a framework of rules and roles through which they can learn interactively through a live experience. They can tackle situations they might not be prepared to risk in reality, and they can experiment with new ideas and strategies. They involve individual and group interpretations of given information, the capacity to suspend disbelief, and a willingness to play with the components of a situation in making new patterns and generating new problems (Jacques, 1995).

Games have played a role in instructional situations for quite some time. The first field in which such applications took place was military training (see Hays & Singer, 1989). The next field in which important developments took place was business management training, where the use of games, simulations, and case studies as vehicles for developing decision-making skills was introduced in the mid-1950s (Ellington & Earl, 1998, p. 5).

Carson (1969) stated that these games generally fall into two classifications, general management (total enterprise) or functional games:

> General management games are designed to teach decision making at the top management level where all major functional areas of the total enterprise are involved in achieving fundamental organizational objectives, such as maximum profit, return on investment, or attainment of certain sales levels or a certain share of the market. Generalized games of this type are designed to teach objective decision making through experimentation, evaluation, and modification.
>
> Functional games are intended to teach specific skills in a particular management area such as marketing, production, inventory control, finance or some other. They are aimed at teaching better decision making at the middle and lower levels of management.
>
> In these games, instead of trying to maximize attainment of some organizational goal, the players are usually working to minimize costs through efficient operation. Teams normally do not compete with one another in a market, but try to get the highest possible score relative to a perfect operation. (p. 40)

Although a wide variety of management games have been developed, they share several general features. Hays and Singer (1989) mentioned the following features:

- They allow the presentation of feedback of the results of players' actions.
- The environment represented in management games is expressed in logical or mathematical relations. Some of these relations are known to the players as rules, whereas others are only vaguely qualified and become known during play.

- They allow interaction between the players (sometimes representing different functional areas within a company) and the environment.
- They provide a simplified view of reality. These simplifications are due to the desire to make the games manageable and because at times our understanding of the world is lacking.

In our research project (Knowledge management Interactive Training System), we use the following general description of games: Games are (competitive) situated (learning) environments based on a set of rules and/or an underlying model in which, under certain constraints, some goal state must be reached. Games are situated in a specific context that makes them (more or less) realistic, appealing, and motivating for the players. Important elements, which are related to the situatedness of games, are validity/fidelity, complexity, risk, uncertainty, surprise, unexpected events, role-play, access to information, and the representation form of the game (Leemkuil, de Jong, & Ootes, 2000).

Simulations

A type of (learning) environment, which is very close to games, is simulation. Simulations resemble games in that both contain a model of some kind of system and learners can provide input (changes to variable values or specific actions) and observe the consequences of their actions.

Jacobs and Dempsey (1993) stated that the distinction between simulation and games is often blurred and that many recent articles in this area refer to a single simulation game entity:

> After all a game and a simulation generally may be assumed to have goals, activities, constraints and consequences. A distinction could be made between simulations and games in the following way. Where the task-irrelevant elements of a task are removed from reality to create a simulation, other elements are emphasized to create a game. These elements include competition and externally imposed rules, and may include other elements such as fantasy and surprise. (p. 201)

Jacobs and Dempsey (1993), as well as Gredler (1996), emphasized resemblances and differences between simulations and games. Games and simulations have some kind of underlying model, allowable actions to be taken by the learner, and constraints under which these actions should take place. Games add to this some kind of winning or losing characteristics, participants need to reach a kind of goal state, and they quite often have to do so with a limited set of resources. The latter means that participants in a game have to think about the trade-off between costs and profits of actions.

Instructional support

Much of the work on the evaluation of games has been anecdotal, descriptive, or judgmental, but there are some indications that they are effective and superior to case studies in producing knowledge gains, especially in the area of strategic management (Wolfe, 1997). However, there is general consensus that learning with interactive environments such as games, simulations, and adventures is not effective when no instructional measures or support are added. Miller, Lehman, and Koedinger (1999), for example, stated that "the learning outcomes achieved through micro world interaction depends largely on the surrounding instructional activities that structure the way students use and interact with micro worlds" (p. 306). Some years before, Knotts and Keys (1997), in the context of learning from games, asserted that

> early research in business gaming and experiential learning destroyed the notion that games were self teaching. Instructor guidance is critical and must be applied during crucial states in the game development to insure that learning closure takes place. Students must be guided, prompted, motivated, and sometimes forced to learn from experiences. (p. 387)

Also, de Jong and van Joolingen (1998), after reviewing a large number of studies on learning from simulations, concluded,

> The general conclusion that emerges from these studies is that there is no clear and univocal outcome in favor of simulations. An explanation why simulation based learning does not improve learning results can be found in the intrinsic problems that learners may have with discovery learning. (p. 181)

These problems are related to processes such as hypothesis generation, design of experiments, interpretation of data, and regulation of learning. After analyzing a large number of studies, de Jong and van Joolingen (1998) concluded that adding instructional support to simulations might help to improve the situation.

Instructional supports include the following elements that are listed by Alessi (2000): explaining or demonstrating the phenomenon or procedure; giving hints and prompts before student actions; giving feedback following student actions; providing a coach, advice, or help system; providing dictionaries and glossaries; providing user controls not needed in a noninstructional simulation; and giving summary feedback or a debriefing.

> All of these types of support may be increased or faded across time, or they may be based on user performance, user choice, or instructor choice. The amount and design of instructional support will be a function of the instructional philosophy (discovery or expository) and the degree of model transparency that is dictated by that philosophy. (Alessi, 2000, p. 191)

Assumptions

The information presented in the previous section leads to a set of assumptions that is the basis for the development of the simulation game that will be described:

- Learning is an active process in which knowledge is gained and constructed and in which problem solving takes a central position.
- Knowledge is context based (situated).
- Games, simulations, and case studies have an important role in education and training in putting learning in a context.
- Learning with interactive environments such as games, simulations, and adventures is not effective when no instructional measures or support are added.
- Problems in the domain of KM are not clear-cut, complex, and without univocal outcomes. Therefore, the problems in this domain can be categorized as ill-structured problems.
- Explication, reflection, and argumentation are important processes when solving ill-structured problems.
- Collaborating with others can enhance the processes mentioned above because learners in a collaborative learning situation are forced to explicate and formalize knowledge that otherwise would stay implicit and intuitive.

The simulation game

The learning environment that is described in this article is based on a case-based learning situation in which teams of players had to react to unexpected events related to a company description given to the learners (de Hoog et al., 1999). In this situation, no feedback mechanism was incorporated and no instructional support was given to the learners.

To transform the case description into a collaborative and constructive Internet-based learning environment, the case description was enriched with several tools and components that will be briefly described below.

A business model is implemented to simulate the behavior of a large set of business and knowledge (process) indicators of the company and to enable new situations to arise as a consequence of decisions taken by the learners. In principle, the business model should be seen as a learning-relevant representation of an organization and its environment and not as a necessarily valid representation of an actual organization. The business model consists of a set of variables representing the crucial features of an organization that are relevant for learning KM. The set of variables is divided into four layers, of which two reflect general business concerns and two are focused on knowledge domains and knowledge processes. These last two generally are not incorporated in general business simulations.

- Organizational effectiveness variables reflect the competitive characteristics of the company such as market share, profit, level of sales, and so forth.
- Business process–related variables reflect the quality of internal processes and how well work is done within the company. Examples are production level and average time it takes to bring a new product to the market.
- Knowledge-related variables reflect the level of competence in the relevant knowledge domains (marketing, research and development, and production).
- Knowledge process–related variables reflect the properties of processes involving knowledge in relevant domains, like speed of knowledge gaining or effectiveness of knowledge transfer.

Elements of games are introduced to make the environment more appealing and give it some validity. This was done by implementing constraints (limited resources), roles and goals, and uncertainty and surprise (unexpected events; see description given below).

It was decided to use an Internet-based environment for several reasons, the main one being that the primary target group of the simulation game consists of managers given responsibility for implementing KM in their companies. These managers, in most cases, have a very tight schedule and do not have many colleagues with the same task in their own company. By using an Internet-based environment, the opportunity of remote participation is offered (Dasgupta & Garson, 1999). This means that players can collaborate with people outside their company without having to be available at the same place and time. The only thing players need is an Internet connection and a Web browser.

To support collaboration and communication at a distance, tools are implemented such as a chat box, monitoring facilities, a voting tool, shared worksheets, and embedded forums. These tools support synchronous as well as asynchronous communication between team members.

To support the players in solving KM problems, several elements were implemented that should enhance the learning process. The main element is the introduction of a KM model that describes a systematic approach to solving KM problems. This approach is based on a prescriptive view of how KM should be done. It consists of four distinct phases (focus, organize, implement, and monitor), which are subdivided into smaller steps. These steps indicate the activities and actions a knowledge manager should complete to come up with the best-fitting KM solution for problems in an organization. Although the model consists of a limited set of steps, there are choice points, each leading to different pathways in the model. These pathways are based on different types of KM problems that one can encounter.

Learning goals and target group

The simulation game is made for senior managers who are keen to learn more about KM because they think it might solve existing and/or future problems for their organization, or other managers given responsibility for implementing KM in their companies. A second target group consists of students at universities and business schools that want to know more about KM.

The learning goals can be subdivided into goals that have to do with the procedure to follow when performing KM (KM strategic knowledge) and knowledge that is used in the procedure (KM conceptual knowledge). After having completed all phases in the learning scenario (see below), learners

- are able to recognize a KM problem or opportunity;
- are able to specify which phases can be distinguished in solving KM problems;
- can perform the different phases in the KM model;
- are aware that KM problems, opportunities, and solutions can be highly situational;

- are able to relate KM work to business output through established performance indicators;
- are able to assess the KM situation and advise/implement appropriate interventions; and
- are able to monitor and evaluate the consequences of interventions.

Short description of the core of the simulation game (KM QUEST)

The combination of a task-relevant business simulation model and game elements characterizes the learning environment as a simulation game. The simulation game (KM QUEST) is situated in the context of a fictitious (large) product leadership organization, Coltec, a manufacturer of adhesives, coatings, and so forth. The starting point is a (case) description of that company. In this case, a description of static information about Coltec is given. This contains information about its mission, the history of the company, products they make, the market they operate in, and the structure of the organization.

What players can do. When entering the simulation game, the players get a description of their role in Coltec:

> The board of directors of the company has recognized that knowledge is a key asset. To develop a better understanding of the role of knowledge in the organization, and the ways it should be managed, a special knowledge management task force has been put together. Your team is this special task force.
>
> Your task is to initiate specific activities that improve the efficacy of the knowledge household of the company. You are expected to propose both proactive and reactive actions.

Roles and goals. The simulation game is played by three players who all have the same role of knowledge manager and who collaboratively have the task to improve the efficacy of the company's knowledge household. This is not an aim in itself as it is related to objectives for the (management of the) company in general. The general goal of the simulation game is to optimize the level of a set of general organizational effectiveness variables: market share, profit, and the customer satisfaction index. These variables are at the top level of the business model (that is used to simulate the behavior of the company). Players play their role for 3 consecutive years in the life span of the company.

As already mentioned in the section on business games, in functional management games, teams normally do not compete with one another in a market but try to get the highest possible score relative to a perfect operation (Carson, 1969). This is also the case in the simulation game described here.

What players can do. Basically, in the simulation game, players can inspect the status of business process indicators and knowledge process indicators (in three general domains), ask for additional information, and choose KM interventions to (try to) change the behavior of the business simulation. Most of the indicators are characterized by a decay factor. This means that the value of the indicators decreases over time when no interventions are implemented. The interventions can be chosen from a predefined pool of 60 interventions. At some moments in time, certain interventions will not be available. This depends on the past actions of the players.

Changes in the status of the business indicators will be computed only at the end of each quarter. There is no time limit to playing the simulation game. Teams set their own pace. When players think they know enough to solve the problem, they indicate that they agree with the proposed interventions (by using a voting tool). After they have reached agreement, the simulation game proceeds to the end of the quarter and the business simulation will calculate new values for each of the business indicators. The game ends after the players have indicated that they have implemented the last intervention(s) in the fourth quarter of the 3rd year in the life span of the company.

Unexpected events. To trigger activities from the players and make sure that players are confronted with different types of KM problems, at the beginning of each quarter players are confronted with an (unexpected) event that could affect the knowledge household of the company. Players have to decide if and how they want to react to these events. Events are generated from a pool of 50 events. Different types of events can be distinguished based on two dimensions: the locus of the event (internal or external) and the effect of the event (direct, delayed, or no effect). Effects can be positive or negative.

Which event is selected can depend on several elements: the events presented in the previous quarters, the interventions taken by the players, and/or the value of certain business indicators. When the triggering conditions of more than one event are met, one event from this set will be randomly generated.

Players can interact with the environment and with each other by using tools and resources that are presented in an Internet environment based on a virtual office metaphor (see Figure 1). Clicking on a specific element in the office will open a window with additional resources or tools. For instance, clicking on the newspaper will display the description of the event that has occurred. The simplified organization chart at the right side of the whiteboard gives access to static information about Coltec (mission, history, products, market, and organizational structure). The icons next to the chart give access to a measurement system, which can display the (current and old) values of a set of 65 indicators in the business model (using different types of visualizations). The books on the lower bookshelf give access to additional information about KM, the indicators in the business model, and the interventions that can be implemented. The books at the top shelves contain historic data about the player’s own behavior in the 12 quarters of the game. Clicking on the phone gives access to a chat facility. The computer gives access to process worksheets related to the steps in the four phases of the KM model.

Constraints. The implementation of interventions involves costs, as well as several other activities the players can perform. Players receive a limited budget that they can use to implement interventions and buy information.

FIGURE 1: Virtual Office Interface

Other constraints to the actions of the players are the following: It is not possible to reorganize the structure of Coltec or to inspect indicators at the level of specific departments, products, or persons, nor is it possible to implement interventions at these levels.

These constraints are introduced for practical reasons. Reorganizing the company would mean that the relations between variables within the business model would have to be changed, which is very difficult. Furthermore, the static information about the company would be outdated. The business model comprises about 200 variables (of which 65 are visible for the players). Adding additional variables at the levels of specific departments, products, or persons would make the model even more complex than it already is. In the current version, it is possible to inspect only the status of general business indicators and knowledge process indicators in three global domains: research and development, marketing and sales, and production.

Overall instructional strategy used with the simulation game

In this section, the elements that were implemented to enhance the learning process and support the players in playing the simulation game and solving KM problems are described.

As stated in the introduction, one of the dimensions on which instructional strategies differ from each other is the dimension instructivistic-constructivistic. An instructivistic approach is characterized by the explicit presentation of nonarbitrary relationships between pieces of information to the learners (expository strategy). In a constructivistic approach, one expects the learners to produce or construct this information from either their concrete experiences or from what they already know (an inquiry or discovery approach). The latter is the basic instructional strategy used in simulations and games.

As we have stated before, however, these two approaches need not be seen as distinct alternatives but merely as two aspects of instruction that can and often should complement each other. To make the training process more efficient, it is sometimes necessary to provide the learners with prespecified, general knowledge that may be helpful and offer guidance to solve the problems in a particular domain.

The chosen mix of inquiry and expository elements in the learning environment should be based on several factors, such as the learning goals, the types of problems students have to solve, prior knowledge of the students, and the context in which learning takes place.

Looking at the general setup of the learning environment, the following elements are important when deciding on the instructional strategy:

- The players/learners probably have very limited conceptual KM knowledge and no well-specified, high-level, strategic KM knowledge.
- The business model (the internal relationships between the business variables) is invisible: Learners can see the status of only certain indicators at a certain point (and compare this with former status reports).
- The (decay) behavior of the variables in the business model is not known.
- The relationship between KM interventions (which can be implemented) and the behavior of indicators in the business model is not known.
- The problems the players are confronted with are not well defined.

This means that the situation the players are confronted with at the beginning of the simulation game is very complex. If no support is given, this probably will lead to very inefficient learning behavior because students have problems with regulating their own (learning) behavior in the simulation game and lack experience and conceptual knowledge. Therefore, we decided to use a combination of an expository and discovery strategy.

Additional instructional measures are based on general principles that play an important role in the cognitive apprenticeship approach (Collins et al., 1989) to teach complex cognitive skills. These principles are the following:

Modeling. This involves an expert carrying out a task so that students can observe and build a conceptual model of the processes that are required to accomplish the task. In cognitive domains, this requires the externalization of usually internal (cognitive) processes and activities, specifically, the heuristics and control processes by which experts make use of basic conceptual and procedural knowledge.

Coaching. Coaching consists of observing/monitoring students while they carry out a task and offering hints, scaffolding, feedback, modeling, reminders, and new tasks aimed at bringing their performance closer to expert performance.

Scaffolding and fading. This is problem-solving support that is integrated with practice and decreases as the learner gains more experience. The intention is to force the student to assume as much of the task on his or her own, as soon as possible.

Articulation. This includes any method of getting students to articulate their knowledge, reasoning, or problem-solving processes in a domain.

Reflection. Reflection enables students to compare their own problem-solving processes with those of an expert, another student, and, ultimately, an internal cognitive model of expertise. Reflection is enhanced by the use of various techniques for reproducing or replaying the performances of expert and novice for comparison.

Exploration. This involves pushing students into a mode of problem solving on their own. Forcing them to do exploration is critical if they are to learn how to frame questions or problems that are interesting and that they can solve. Exploration is the natural culmination of the fading of supports. It involves not only fading in problem solving but fading in problem setting as well.

In the learning environment, a shift will be made from an environment that is initially based on modeling, coaching, and scaffolding (and fading) to an environment where these processes are less important and where the learners collaborate without guidance. In the latter phase, the main instructional measures are articulation, reflection, and exploration.

Four-phased learning scenario

It was decided to embed the actual playing of the simulation game into a learning scenario that comprises four phases: introduction, instruction, playing, and reflection/debriefing. By including these phases, the simulation game should be a self-contained teaching module that could replace elements of a KM course.

Introduction

In the introduction, the main elements of the learning environment and simulation game are introduced, as well as some basic information about KM and collaboration.

Instruction

The instruction phase is used to develop (shared) knowledge that forms the basic knowledge base needed to play the simulation game and collaborate with other team members. To develop this knowledge, an expository approach is used. This means that information is presented to the learners and, at certain points in time, tools or assignments are introduced. People can go through this phase individually.

Modeling in this phase is done by presenting the main phases and the choice points and substeps in the different pathways in the KM model to the players step-by-step and by giving them examples. Stark, Graf, Renkl, Gruber, and Mandl (1995) showed that this approach could be beneficial. They guided students while managing a business simulation (jeans manufacturing) by using a multistaged problem-solving scheme. Students were guided to explain decisions, predict action results, and draw final conclusions. Stark et al. showed that the intensity of the learners' exploration of the simulation could be increased when the learners operate according to the problem-solving scheme. Furthermore, the construction of mental models was fostered.

Coaching and scaffolding is done by structuring the environment and limiting the freedom of choice of the players and by giving them immediate feedback on their behavior. Furthermore, by giving them process worksheets (see below) that are based on the KM model and by presenting prompts and hints about what to do and how to do it, freedom of choice gradually is increased.

Assignments in the instruction phase have to do with using process worksheets related to each of the steps in the KM model.

Playing

In the playing phase, the players actually play the simulation game collaboratively for 3 years in the life span of the company, using all the resources and tools that are available. Players have the freedom to choose their own way of problem solving and collaboration.

Information and tools should be easily accessible at the time players need them. Just-in-time information presentation (Kester, Kirschner, van Merriënboer, & Baumer, 2001) is an important principle that is used in the environment. This means that several resources are available in the virtual office that can give the players information about several topics, such as KM, interventions, the company, business indicators, and so forth (see Figure 1). Furthermore, tools are implemented to support articulation and explication of knowledge and the monitoring and reflection of one's own behavior.

At the beginning of this phase, the indicators in the business model are reset to the initial level and the players start again at Day 1 in the first quarter of the 1st year. Freedom of choice is at its maximum. Feedback will be given to the players only indirectly by means of the values of the indicators in the business model.

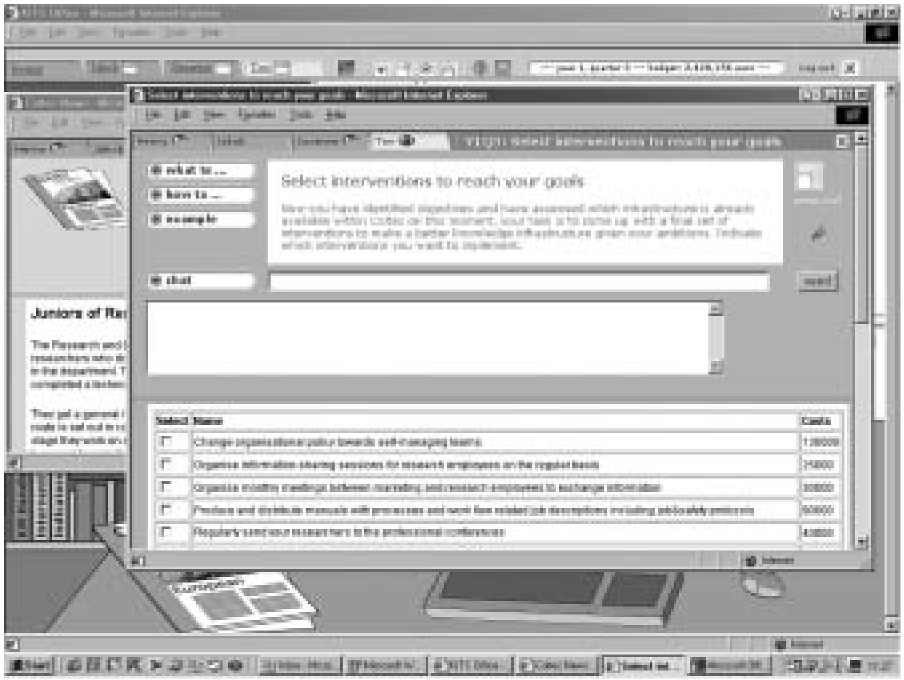

FIGURE 2: Screen Dump Showing Different Types of Resources in Several Windows: The Status Bar, an Event Description (Coltec News), and a Process Worksheet

Process worksheets. The process worksheets that were introduced in the instruction phase and that are related to the different steps in the KM model are available by request in the playing phase (by clicking on the icon of the laptop). Players are free to use them or not. Using them can serve different functions: They give a clue on how to solve problems by means of their content and additional information (what to do and how to do it) and examples, which can be accessed by clicking on a certain icon in the worksheet (see Figure 2).

Each worksheet contains a text field, checkboxes, and/or drop-down menus, which can be edited by all team members (one member at a time). These fields and boxes can be used to articulate and discuss ideas with team members about a specific element in the problem-solving process.

Each worksheet also contains a topic-related chat facility that can be used to discuss ideas with team members.

The content of the worksheet and the related discussion are saved together and are always available for inspection. In this way, team members that were not present at a certain point in time can still see what the others have done and even make changes to the content of the worksheet.

Every quarter the team gets a new set of worksheets. The content of the old ones is saved in files (which refer to the different quarters) and a worksheets file that are in the virtual office (see Figure 1). This means that players can always monitor their behavior during the game and have the opportunity to reflect on it.

The only process worksheet that is obligatory every quarter is the implementation document. This has to be filled in and approved by all team members; otherwise, the simulation game will not proceed to the next quarter.

The content of the information available by means of the process worksheets overlaps with the different sources of information, which are directly accessible by clicking on icons in the virtual office. This means that several texts, answers to questions, and overviews of indicator values are available by means of several links in the environment. This is a means to give the players freedom to choose their own way of playing and working.

Reflection and debriefing

A problem related to simulation games is its gamelike character. Students are very easily inclined to play it only as a game. During the simulation, "intuitive knowledge" (see Swaak & de Jong, 1996) is acquired about the rules of the game and the strategies players have used. By having students reflect on what they do and experience, they can make this knowledge more explicit.

Petranek (2000) stated that several authors in the simulation and gaming field stress the value of oral debriefing. Written debriefing is, however, rarely used: "The major hurdle is the time needed to write and evaluate the writing. However, the benefits far outweigh the costs. With written debriefing, participants can reflect about their behavior, facilitators can assess individual learning, and students can privately communicate with their professor" (Petranek, 2000, p. 108).

In the learning environment described in this article, players are triggered to reflect on their actions. At the end of each year, the KM team has to write a report to the general management team. In that document, they indicate which problems they faced in the year before, which actions they performed, which interventions they implemented (with which objectives), and which results were accomplished (until that moment) or are foreseen in the coming period. And, not the least important, why certain assumptions and interventions were (not) right and what lessons they learned from it. A worksheet for this document is available. After they have completed this obligatory report, the simulation game will go on to the first quarter of a new year.

After the players have finished the simulation game, a debriefing session will be planned in which they can look back at the three reflection reports they made. Players can discuss choices and actions in relationship to their final score and to the goals they set for themselves during the game. An external tutor or adviser is appointed to each team. This person is a kind of nonplaying group member that can observe the behavior of the players, inspect the worksheets they have filled, and participate in chats. The adviser will be invited to the debriefing session.

Collaboration over the Internet. In principle, it is possible for team members to play the game completely asynchronously. This means that they never are logged on at the same moment in time. In practice, it is often handy to build in synchronous playing moments to speed up the gaming process.

When players have logged on to the server and enter the virtual office, they can see whether one or more team members are present (logged on) by looking at the icons behind the names in the status bar (that is always visible at the top of the screen; see Figure 1).

If none of the other players are present, a player might like to know if others have logged in before and have done something. To get a quick impression, the player opens the chatbox to see if someone has left a message. To use the chat facility to exchange information with players who are not logged in on a certain moment in time, the content of the chatbox is not cleared after each session (as is mostly the case in chat systems, e.g., in MS NetMeeting) but only after a quarter has finished. If players want to see what activities other players have performed, they open the file of the current quarter at the bookshelf (see Figure 1). In the asynchronous mode, players can do almost anything. They can gather (buy) information, fill in and/or change the content of process worksheets, set objectives, propose interventions, and so forth. However, to actually implement interventions, they need the approval of the other team members. Players can give their approval by using a voting tool that is added to the implementation worksheet.

If the other players have not agreed (yet) with the proposed interventions, the simulation game will not proceed to the next quarter and changes in the business indicators will not be computed. If the third player has voted "yes," the interventions automatically will be implemented, new values will be calculated by the business model, and a new quarter will start (with a new event).

If two or three players from a team are logged on to the environment, they can use the chat facility to communicate. When a player types in a message and presses Send, it will be displayed in the chat window of the other players.

While playing synchronously, players do not necessarily have to open the same tools and resources and therefore may be looking at different windows. For instance, one player may be looking at the status of certain business indicators, whereas another is analyzing the event. To keep track of each other's position in the environment, in the top of each window, icons are displayed to indicate which of the players has opened the same window (see Figure 2). If a player is looking at a certain window and notices that the others have not opened it, the player can press a Group call icon. Pressing this icon will send a message to the other players saying, "You are invited to join [name of player] in the window [name of the window]. Do you accept?" together with two buttons, OK and Cancel. When a player presses the OK button, the target window will be opened automatically.

When a window contains editable text fields, checkboxes, or other elements where input is needed, only one player can edit these at a time. Players have to take control over the editing process by pressing a pencil icon in the top of the specific window. When one player is in control, the others cannot interfere in the editing process. The others can see who is in control by looking at the icon that indicates the presence of team members (this icon will change). Furthermore, they can see directly (with a small time delay) what the editor is doing. And when they want to make comments, they can type these in using a topic-related chat facility, which is part of all of the process worksheets, or they can use the general chat facility. When the first player releases control over the window, the others can take over.

Evaluation of the prototype

The first prototype, which did not contain the full functionality envisioned, was formatively evaluated with participants of the primary target group (18 managers of different companies in the area of consultancy, training and education, and research) and a group of 23 students from the University of Amsterdam. The evaluation of the simulation game was performed along three lines: usability of the environment, behavior of players and models, and acceptability of the environment. Evaluation of the learning effects was not performed because some elements in the environment were still missing. Learning effects will be the main issues of the evaluation of the next version.

Usability is conceived as the detection of mistakes and errors and problems in the interaction between the user and the application. The usability of the simulation game was measured by using an electronic questionnaire that consists of several dimensions (e.g., ease of use, navigation, and consistency). On each dimension, the players rated the different aspects of the simulation game on a 10-point scale. In addition, interviews were performed to gain more insight in how the participants perceived game play.

The behavior of the players and models is captured by the system in several log files, which give insight to what events were played, what activities players performed in terms of the instructional envelope, what activities players performed in terms of the KM model, what interventions were chosen, the performance of the business model, and what players discussed.

The third topic of interest in this evaluation was the acceptability and validity of the simulation game (Peters, Visser, & Heijne, 1998). The degree of reality and validity of the context of a simulation game is an important element that could facilitate learning or hinder learning and learning transfer. So it is important that the elements of the learning environment are valid and acceptable for the users. The acceptability and validity of several elements is important:

- The situatedness of the learning environment. Important elements are the case description, the indicators that are incorporated in the business model (and complexity of the model), the events that are introduced, and the interventions that can be implemented.
- The KM model that is introduced.
- The additional support that is given to the players to play the game in a meaningful way and to learn something about KM.
- The tools the players can use while playing the game.
- The gaming aspects.

If one or more of these elements is not acceptable to the players, the game could be less attractive and realistic and therefore less motivating to play. Furthermore, they could obstruct the learning process. After working with the environment, participants were asked to fill in an electronic questionnaire about the elements indicated above. In the questionnaire, the participants were asked to indicate whether they agreed with statements that expressed a judgment about validity and acceptability of the different elements of the learning environment on a 6-point rating scale that ranged from 1 (*strongly disagree*), 2 (*disagree*), 3 (*slightly disagree*), 4 (*slightly agree*), 5 (*agree*), to 6 (*strongly agree*). Furthermore, some open questions were included in which the respondents could give additional comments in open text fields.

Results

The results of the evaluation are summarized below. In general, the data indicate that the four-phased scenario is a good idea. However, several points concerning situatedness of the game, the models used, and the communication and collaboration aspect need further attention and revision in the next version of the simulation game.

Situatedness

The case description and business model is tailored to a large product leadership type of organization. Respondents indicated that they found it difficult to match the type of organization and interventions they can apply (to change the behavior of the organization as simulated by the business model) to their own organization. Furthermore, they had problems with assessing the effects of the events and interventions based on the large set of business indicators in the business model. They wanted more explicit feedback based on the events that were presented, the interventions that were chosen, and suggestions about the indicators that are important to assess important changes. The users also wanted other types of visualizations of the values of the indicators over time (that were displayed in tables), and these will be implemented.

In general, these findings indicate that it is important to have reflection and debriefing phases in which attention is given to the general principles and ideas behind the situations encountered in the game and to transfer of knowledge to other types of organizations. An external adviser/tutor should be involved in this. A reflection and debriefing phase should not be limited to debriefing after the game is finished but should also be possible during the game.

KM model and process worksheets

The respondents were slightly positive about using process worksheets and giving additional information by means of examples and “What to do?” and “How to do it?” links.

However, they also indicated that too many worksheets were available. They were disappointed that the support given by the worksheets was mainly in structuring the process and that there were no situations in which actions taken in a specific worksheet have an effect on the content of other worksheets.

Although players see the value of having a KM model to help them solve KM problems, they also indicated that the model comprises too many steps (working through the model every cycle takes too much time). Furthermore, the value of some of the steps was questioned.

A critical review of the KM model will be performed to try to make it more concise and remove steps that have no clear meaning in the context of the simulation game.

Communication and collaboration

One of the results from the evaluation study is that the communication and collaboration is not optimal. One of the reasons was that not all intended functionality was available at the time of playing.

The main result found was that the central chat facility should be visible at all times so that players can instantly see new contributions. It should not be possible for players to miss messages because they have not opened the chat facility or because it is covered by other layers/windows.

Furthermore, players experience problems in the collaboration process in the sense that they do not know where other players are and what they are doing. Gutwin and Greenberg (1997) called this “workspace awareness.” Players of the simulation game mentioned that they did not have an overview of the presence and activities of their peers when all were online. Workspace awareness can be improved by installing a kind of observation unit. This observation unit should inform players of the presence, location, and activities of fellow team members.

Another issue that players indicated was the difficulty in assessing the tasks they had done so far and the tasks still to be performed (workflow), that is, having a progress report when logging into the game again. One of the reasons for this is that the history function was not available yet in the game. History information should be available for each quarter the team has played. Moreover, a facility that distributes e-mail messages containing the latest changes in the environment (every night) should be incorporated to inform the players of the status in the game (e.g., latest activities/contributions) so they are informed about changes and activities without having to log on to the environment. This could also attract their attention and get the players more into the game.

Gaming aspects and team features

In general, users indicated the game could be more challenging and competitive. Some thought it was too complex and that playing it took too much time (approximately 24 hours divided over several days).

Players agreed that having three players in a team was enough, and they found it motivating to play the game with a team. However, they did not directly see how playing the game in a team improved learning.

Conclusion

This article described the development of a collaborative, Internet-based simulation game for learning to solve KM problems. The formative evaluation of a first prototype of this simulation game showed that to facilitate collaboration using the Internet, a central chat facility that is always visible is important, as well as a tool for workspace awareness and workflow (what has been done/has to be done). The data indicated that process worksheets (based on a KM model) with related background information can be useful to structure the problem-solving process. Furthermore, players would like explicit feedback based on the unexpected events that are presented and the interventions that were chosen, and they also would like suggestions about the indicators that are important to assess changes in the business model that drives the simulation. In general, the findings indicated that before playing the simulation game, it is important to have an instruction phase in which the model for problem solving (in the KM domain) is introduced. Afterward, reflection and debriefing phases are necessary in which attention is given to the general principles and ideas behind the situations encountered in the game and to transfer of knowledge to other types of organizations.

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