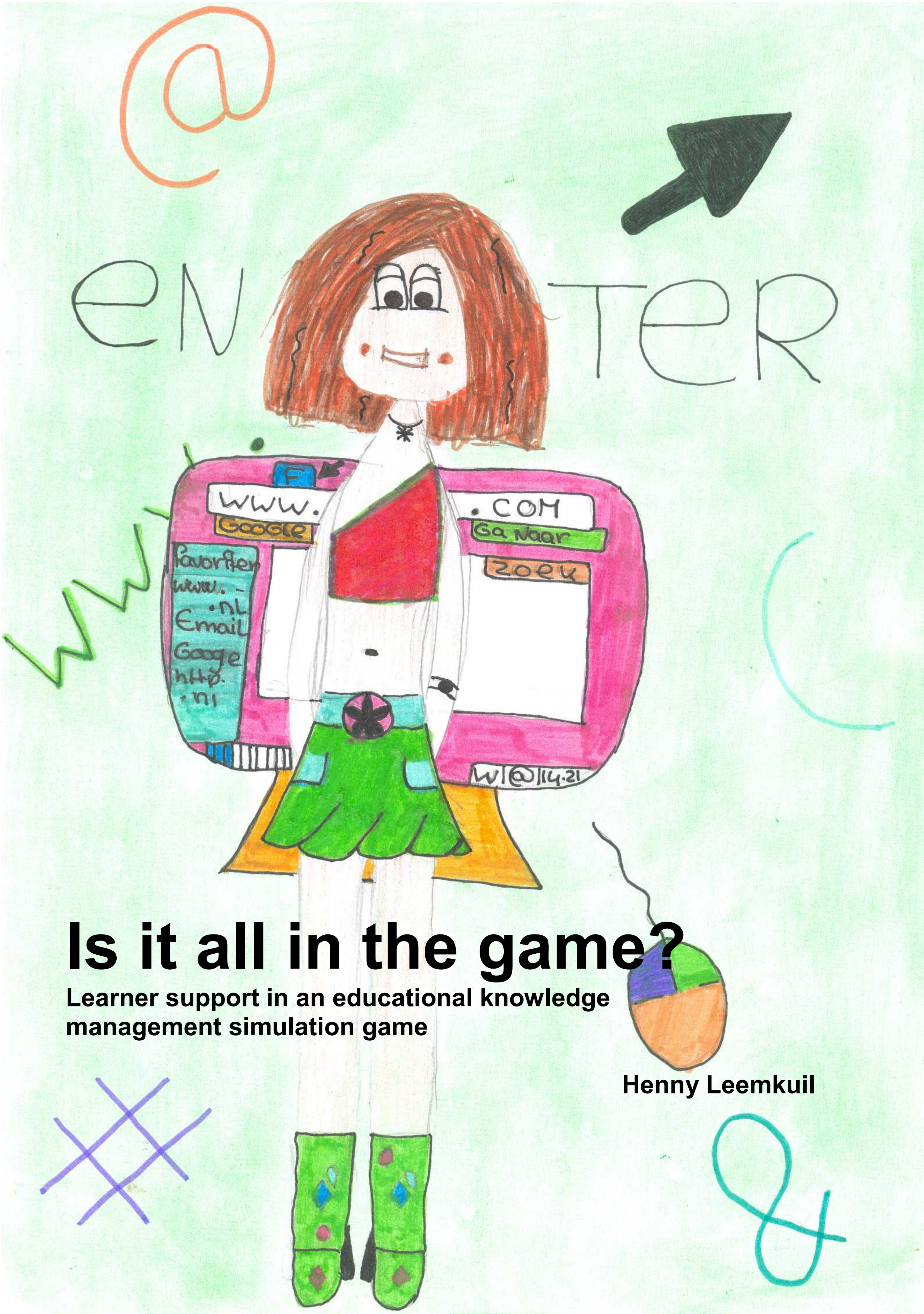

Is it all in the game?

Learner support in an educational knowledge management simulation game

Henny Leemkuil

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University of Twente

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IS IT ALL IN THE GAME?

LEARNER SUPPORT IN AN EDUCATIONAL KNOWLEDGE MANAGEMENT SIMULATION GAME

PROEFSCHRIFT

ter verkrijging van
de graad van doctor aan de Universiteit Twente,
op gezag van de rector magnificus,
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volgens besluit van het College voor Promoties
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door

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geboren op 9 april 1959
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Dit proefschrift is goedgekeurd door de promotoren:

Prof. dr. A.J.M. de Jong
Prof. dr. R. de Hoog

Game on

Imagine you just graduated at the University of Utrecht and have a degree in psychology and learning. A friend calls and says there is an opportunity for a job at the University of Twente, but it is still unclear whether this job will actually be available because the funding is not certain.

Then the adventure begins. You start searching for information and write a letter of application. Then you wait for a reaction …… After some time a call comes in. It appears that the grand for the research position was not rewarded. Game over.

You start again and begin by exploring the environment, looking for new possibilities. Suddenly an unexpected event happens: Sanne Dijkstra calls and says that he has written a research proposal and received funding, but still needs somebody to do the job. Your name was mentioned. The funding is only for one year. After that your position is unclear. What to do……?

You take up the challenge. You move to Enschede and meet your new partners in the adventure who will help you to accomplish your task. First of all, there is Erik Ranzijn (who is doing a Ph D research on the use of examples in learning natural concepts), and his white dog that often accompanies him, and that sleeps in the drawer in your room. Then there is Jakob Sikken who has developed an authoring language for the Apple Macintosh computer. The first goal is to develop two versions of an instructional computer program for primary school pupils to learn the difference between insect flowers and windflowers. In one of the two versions the computer will have to start a VHS video recorder to show the appropriate video fragment from a specific flower after the student pushes a button on the computer screen. The mission was accomplished. And after some strange adventures during a conference in Leuven the resources were ending. End of the first episode. Level up!

Episode 2: A new mission is presented to you. This time it has to do with learner control and adaptive control in computer based instruction. New resources are found and new people enter the scene: Jules Pieters and Ellen Hasselerharm who has a comparable mission to accomplish. New tools are provided; this time it is TAIGA that has to be used.

After this episode a new one follows, and yet another one and……. When does this game end? How many levels are there? Then in 2000 a new mission starts (with codename KITS), a very complicated one. This must be the last level. New resources are provided by the European Community under the Information Society Technology (IST) RTD program, contract IST-1999-13078. The overall goal is to build an interactive training system to learn about knowledge management. A very complicated task that contains many subtasks. Many new characters play a role in this mission: Ton de Jong, Robert de Hoog, Rianto Purbojo, Irina Shostak, Noor Christoph, Susanne Ootes, Jakob Sikken (yes, the same one), Anjo Anjewierden, Bruno Ressa, Anne Monceaux, Eelco Kruizinga, Gerjan van Heijst, Noam Shalgi, Rogier van Koetsveld, Andrew Haldane and Bob Wielinga. Some played only a minor role, while others were there till the end of the mission in 2003. At the end of this episode KM Quest: a simulation game in the domain of knowledge management (see Chapter 4) was ready for use, and the final mission could begin.

The goal of this last mission was to do research and write a PhD thesis. The story of this final mission is in this book. The mission is completed. The game is over!

I would like to thank those who have stimulated me during all these years and especially in the final phase. First of all, Wilma who was always there, in good and in bad times. Maaike and Dorien who, as modern ICT kids, in some ways, inspired me to look at game play and learning, and who contributed to this book by designing the cover (a task they took very seriously and that took far more time and effort to complete than all of there other drawings). Thanks!

Second, of course Ton and Robert, who gave me the opportunity to take part in the KITS project and to finalise this thesis. They were inspiring, but also critical while playing their role of supervisor. Furthermore, all of those who participated in the KITS project, the students form the Communication department of the University of Twente who participated in the first two experiments, and Paul Hendriks and the students of the Radboud University in Nijmegen who participated in the third experiment.

Last but not least, Annie and Dini, the rest of the family, and Birgit, who facilitated this research by taking care of the kids while Wilma and I had to go to work, and by helping out by doing all kinds of things in and around the house which take a lot of time, and which still would not have been completed if there was no help from you all. It is a pity that Bertus and Teun did not get the time to be able to see this final result. I know for certain they would have been proud.

Henny Leemkuil

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1 Introduction

This thesis is about the educational use of computer games. The fast growth of the use of digital games (on game consoles, personal computers and the Internet) in the last two decades has led to renewed attention to the role of game play in education (see for example Dawes and Dumbleton, 2001, McFarlane, Sparrowhawk, and Heald, 2002; Kirriemuir and McFarlane, 2003; Gee, 2003; Squire, 2004 and Egenfield-Nielsen, 2005) and to scientific research that could be used to design effective educational games.

In the second chapter a definition of games will be given and important features are introduced. A comparison will be made between games and two tools that are used in educational settings already more often than games are: simulations and case studies. In the third chapter the use of games in educational settings will be dealt with. It will be concluded that games can be powerful educational tools but that instructional support often is needed to ensure that learning is taking place. In the remainder of this thesis experiments will be described that try to discover which support elements contribute to learning with a simulation game about knowledge management. A distinction will be made between two types of learning or information processing in games: an experiential unselective mode (search and apply) and a selective reflective mode. These modes lead to different types of learning results. The experiential mode seems to be a ”natural” way to process knowledge in rich dynamic environments like games, especially when the players have little task relevant knowledge. This leads to learning but it is mostly in the form of facts (like names, the colour of certain things etc.), procedures, instances, examples, and sequences of actions that are applicable in the context of the game. When new abstractions, rules or insights are learned this is mostly implicit, intuitive and context specific knowledge that is difficult to verbalise and transfer to other situations.

The players will keep using this strategy as long as useful cues are available in the environment and/or useful event-action instances are available in memory. When players get into an impasse because these cues and instances are not available or when the actions taken so far were not successful (the goals of the game did not come closer) players might change to a reflective strategy in which they look back at their own (or others) past behaviour in the game or in similar situations and try to abstract new rules, procedures or insights. This strategy requires more mental effort, structure and selective reasoning than the search strategy and could be supported by systematic procedures and methods and the aid of additional tools or other people (for example other players or a teacher). When this reflective strategy is successful players will develop new explicit insights and strategies that they can apply during the rest of the game or in situations that are comparable to the game situation.

The largest knowledge gain from an educational game is to be expected when users use both an experiential mode of information processing and a reflective mode. This will lead to new intuitive and explicit knowledge. Since the experiential mode seems to be the natural way to proceed in rich dynamic games, elements should be added that can support a reflective strategy. The use of tools (inside or outside the game environment) or the help of other people (other players or a tutor/supervisor) can facilitate the use of a reflective strategy. A review of games research revealed that several tools could be effective in supporting a reflective mode: cooperation and collaboration, debriefing and group discussions, feedback, monitoring facilities, additional assignments, and guidance by means of hints and prompts, a help or advice system.

This thesis focuses on two of the support elements that can be incorporated in the game itself (guidance and additional assignments) whose role is still not clear based on research reported so far. Additional assignments in simulations were reported to be effective (Jong & Joolingen, 1998) but these mostly led to a gain of intuitive knowledge and thus seemed not to support a reflective strategy. It is hypothesised that this could be due to the type of assignments that were used and therefore further research should focus on a different type of assignments. Until now there is only one study (Leutner, 1993) in which guidance in the form of advice warnings, led to a gain in explicit knowledge. Further research is needed to clarify the importance of advice.

This leads to the following central question that is the basis of the research reported in this thesis “Do additional elements in the game, like assignments or advice, support the use of a reflective mode of information processing and thereby the acquisition of explicit knowledge?” So elements that could be added to the learning scenario or the didactical situation, in which the game is used, like debriefing and collaboration, are not taken into account.

Colleagues that were also involved in the KITS (Knowledge management Interactive Training System) project that resulted in the KM Quest learning environment (see Chapter 4) performed additional research that amongst other issues focused on the role of hints by means of a systematic problem solving approach (Christoph, 2006), feedback by means of visualisations or tables (Purbojo, 2005) and collaboration (Shostak and De Hoog, 2004). Their data supplement the findings reported in this thesis and together these give an impression which elements are important for learning with the KM Quest environment.

In the second chapter the concept of games will be defined and its characteristics elaborated. The third chapter focuses on learning with games. The fourth chapter is about knowledge management and the KM Quest simulation game that is used in the current research is described. In the next three chapters data from experiments with this simulation game are presented. In the final chapter the central question will be discussed in a broader perspective. The discussion will focus on the effectiveness of support tools in the game and on the issue whether all support should be in the game environment or whether critical support could also be provided by elements that are outside the actual game but are part of the educational setting in which the game is used.

2 Games

2.1 Introduction

Since ages playing games is an important activity for enjoyment. Already in 1283 a rich illustrated hand written book was published (“Libro de Juegos”) in which a number of games were described like Chess, Go, Backgammon, Mill, Alquerque, and Wari. The book was written on the initiative of Alfonso X, king of Castile. It was part of a series of books that were devoted to the most important themes of that time: history, law, religion, astronomy and magic. That play was an important theme (in that time) is clear from a quote from the introduction: “God has intended men to enjoy themselves with many games (Games)…bring them comfort and dispel their boredom” (http://gamesmuseum.uwaterloo.ca/Alfonso/).

However, games were not only used for enjoyment, but also as a tool to stimulate and train important motor, social and cognitive skills. Oerter (2004) states that play is a crucial activity in childhood which serves mental hygiene: “Children do not only play for fun but express their needs, unresolved problems, and traumatic experience in play. Play serves as a medium for coping with actual and diachronic problems and developmental tasks” (Oerter, 2004, p. 217).

In former ages the main types of play were role playing games, board or card games, or games of skill that could be played inside or outside with a limited set of resources. Currently more and more games are played by means of electronic devices, like personal computers or game computers (Playstation, Gameboy, Gamecube, X-box, N-Gage). The fast growth of the Internet has offered new playing possibilities (online game play). By using an Internet based environment the opportunity of remote participation is offered (Dasgupta & Garson, 1999). This means that players can play and collaborate with people outside their own home without having to be present at the same place at the same time. The only thing that players need is an Internet connection and a web browser. In some cases this could mean that large groups of players are involved in a game. In that case one talks about Massively Multiplayer Online Games (MMOG) or Massively Multiplayer Online Role Playing Games (MMORPG).

The Dutch Institute for Classification of Audiovisual Media (NICAM), that is responsible for the classification of films, videos and games to determine for which age group these products are suited (http://www.kijkwijzer.nl), in 2003 reported about research into the role of electronic games in the Dutch society (Nikken, 2003). This showed that almost all parents stated their children play computer games. Only 1% said their children never play these games.

The fast growth of the use of digital games has led to renewed attention to the role of game play in education and to scientific research that could be used to design games. According to Kirriemuir and McFarlane (2004) there are two key themes common to the development of games for education, namely: ”the desire to harness the motivational power of games in order to ‘making learning fun’ and a belief that ‘learning through doing’ in games such as simulations, offers a powerful learning tool” (p.10).

This renewed attention has led to several new initiatives. In 2003 the Digital Games Research Association (DIGRA: http://www.digra.org) was founded. This is a non-profit, international association of academics and practitioners whose work focuses on digital games and associated activities. In the beginning of November 2003 this association organised the first Digital games research conference (Level-up) that was held at the University of Utrecht in the Netherlands.

At the same time the Serious Games Initiative (http://www.seriousgames.org) was founded at the Woodrow Wilson Center for International Scholars in Washington, D.C.. This is focused on the use of games in exploring management and leadership challenges in the public sector. A related initiative is “Social Impact games” (http://www.socialimpactgames.com) whose goal it is to catalogue the growing number of video and computer games whose primary purpose is something other than to entertain.

In March 2004 the Special Interest Group for Game-based Learning for Universities and lifElong Learning (SIG-GLUE: http://www.sig-glue.net) started with financial support of the European Commission’s eLearning initiative. This group aims to promote more and better use of better learning games.

These initiatives, as well as the “Games to teach” project of the Massachusetts Institute of Technology (http://www.educationarcade.org/gtt), and the “Computer games in education” project from the British Educational Communications and Technology Agency (http://www.becta.org.uk) have focused the attention of teachers and researchers on the role (digital) games could play in education.

Before the role of game play in educational settings will be elaborated a definition of the concept of games will be given.

2.2 A definition and important features

When trying to give a definition of games a complicating factor has to be taken into account. Holsbrink-Engels (1998) noticed that non-English languages tend to have just one term for what the English call ‘play’ and ‘game’. In Dutch, for instance ‘spel’ is used for both play and game, and so are ‘jeu’ in French, ‘Spiel’ in German, ‘gioco’ in Italian and ‘juego’ in Spanish. The English word ‘play’ is related to the experience of pleasure. The word ‘game’ is related to the notion of competition. Games are contests among adversaries (players) operating under constraints (rules) for an objective (winning, victory or pay-off). The Dutch philosopher Huizinga already recognized this problem in his famous work “The play element of culture” in 1938, titled “Homo ludens”. Huizinga (1955) stated however, that a contest is also play. He distinguished the following crucial elements of a game (“spel”):

- an informal act or activity,
- occurring within certain temporal and spatial boundaries,
- developing according to freely chosen, but afterwards committing rules,
- the goal is the activity itself,
- the activity is accompanied by a feeling of tension and/or enjoyment and the consciousness that the activity is different from real life.

So according to Huizinga the concept “game” can be seen as a subset of the concept “play”. Salen and Zimmerman (2003) however, state that “play” also can be seen as a subset of the concept “game”. In a competitive setting of a game one can enjoy discovering and exploring the rules of the game.

Dempsey, Rasmussen and Lucassen (1996) define gaming in a basic sense as "any overt instructional or learning format that involves competition and is rule guided” (p. 4). This definition however, is very broad. In a more recent publication Dempsey, Haynes, Lucassen and Casey (2002) gave a more precise description: “A game is a set of activities involving one or more players. It has goals, constraints, payoffs, and consequences. A game is rule guided and artificial in some respects. Finally a game involves some aspect of competition, even if that competition is with oneself” (p. 159). The features of games that are presented in this definition resemble the ones that are mentioned by Prensky (2001). He lists the following six basic elements of computer games: rules, goals and objectives, outcomes and feedback, conflict/competition/challenge/opposition, interaction, and representation or story. In this report a definition will be used that is based on the one given by

Dempsey, Haynes, Lucassen and Casey (2002) and that contains most of the elements mentioned by Prensky.

> "Games are competitive, situated, interactive (learning-) environments based upon a set of rules and/or an underlying model, in which, under certain constraints and uncertain circumstances a challenging goal has to be reached".

Below the characteristic game features will be elaborated and important aspects of these features will be introduced. Later in this chapter based on these features a comparison will be made with simulations and case studies. The features are: a challenging goal, rules, an underlying model and constraints, a type of competition, interactivity (actions and feedback), uncertainty, and situatedness (representation and story).

2.2.1 A challenging goal

An important feature of games is that there is some kind of goal that has to be reached. Goals are closely linked to the element of competition (see section 2.2.3). There is a large variety in the types of goals that have to be reached. In general three types of goals can be distinguished (which often are used in combination). The goal can be:

- To solve a particular problem or a series of problems. Such goals are typically used in puzzle games or adventure games (see Section 2.3). In the last type of games players usually are faced with an overarching problem that can be solved by solving a large variety of sub problems. For instance in a game for primary school children, the overarching problem is that all the goods that are needed for a holiday camp have disappeared and new campers will arrive soon. The player is asked to help to find the goods (sleeping bags, tents etc.) before the campers arrive. To locate these goods the player has to solve different types of math and language problems. When they have solved a series of problems of the same type, a particular instance that is missing is "back" and can be scratched from the list of items to be found. When all missing items are found the overarching goal is reached and the player is rewarded by additional features in the game environment.
- To reach the highest level of proficiency and/or efficiency (a maximisation goal). An example of a traditional game in which these types of goals are used is the pinball machine. In that game the players try to outperform themselves (or other players) each time the game is played. Other examples are business simulation games in which players try to reach the highest market share and/or profit while they are managing a company.
- To be the best amongst the competitors. In this case the goal is related to the actions of the other players who play synchronously or asynchronously. Examples are board games like "Colonists of Catan" in which players try to reach a certain goal before the other players do.

Goals can be the same every time the game is played, or they can change every time the game starts, or even during the game. In the well-known game "Risk" at the beginning of the game every player draws a mission card from a pile of 14 cards that all have different assignments. So the goals for the individual players are different and the goals can de different each time the game is played.

In some games the (sub) goals can change during game-play because the player has reached a certain proficiency level and advances to a higher "playing" level. At this level new or more complex goals may be introduced

The goals can be preset or left open, so players can set their own goals. For instance in “Virtual U” a computer simulation game for university administrators and others interested in managing a university, players can set their own goals as long as they stay within certain boundaries (in this case the game can continue as long as the institution remains financially viable), or they can select certain scenarios with preset goals (see: http://www.virtual-u.org/educause.html).

The goals have an important influence on the motivation to keep playing. Therefore, it is important that the goals and the way by which they can be reached are clear, specific, meaningful, and challenging (Malone, 1981). Clear specific goals allow the individual to perceive goal-feedback discrepancies, which are seen as crucial in triggering greater attention and motivation. When feedback indicates that current performance does not meet the established goals, individuals attempt to reduce this discrepancy. Under conditions of high goal commitment this discrepancy leads to an increase in effort and performance (Garris, Ahlers, and Driskell, 2002).

Goals should not be too simple because in that case players are not challenged and will lose their motivation to play. However, the goals should not be too complex, because players might get frustrated and tempted to stop playing. To keep players involved often different proficiency levels are used in a game. At a higher-level new (more difficult) goals are introduced as well as new constraints (see next section).

2.2.2 Rules, constraints and an underlying model

Each game consists of a basic set of procedural rules that define which actions are allowed and which are not, and that define the setting and goals of the game. On the one hand these rules limit the actions the players can perform. On the other hand they must allow for a wide range of permissible actions to keep players motivated to keep playing. Players should have the feeling that they have a certain amount of freedom to choose their own strategy. Otherwise they will lose interest.

To keep players motivated additional constraints may be introduced by implementing resources/incentives that can be used (lost/won or acquired) for instance money, armies, and “lives”. Cooper (1978) states "A well designed (business) game has to be surrounded by constraints such as production costs, market trends, seasonal factors, availability of finance, industrial relations, stock holding costs and so on” (p. 80). Some business games, for instance, enable teams to obtain information (like market research information) at a price. Cooper (1978) also thinks this is an important constraint. He advises that relatively little information should be fed back automatically to the participants and that relatively large opportunities should be given to them to buy information.

When resources and incentives are used in games, in most cases there is a kind of trade-off involved: every action a person takes uses some resources and resources are limited. Successful actions may lead to new resources. So the question for the players is when to use their resources. In certain cases they will have to take risks to accomplish their intermediate or final goals.

The use of resources and incentives in those games is based on a predefined set of (decision) rules, or in more complex cases, on an underlying model that computes the number of resources available (for every player or team) at a certain point in time. For instance, a relatively simple decision rule is used in “Risk” where players have to conquer specific continents or a specific number of countries on the world map. When a player succeeds in conquering and keeping an entire continent (s)he will get extra resources (armies).

Models may not only be used to compute the amount of resources available, but also to compute new game states or the values of certain indicators that are available in the game environment. Such models will always be part of games in which certain processes are simulated. In “Roller coaster tycoon” players have to build their own amusement park. An underlying model is used to compute how many visitors will come to the park based on indicators like the number of attractions, their diversity, safety, the tidiness of the park, the costs of a ticket, etcetera.

2.2.3 A type of competition

Games require a sense of “winning” or “losing”. This can be accomplished by:

- beating the system,
- outperforming yourself (by improving your performance in a next round of game play),
- beating other players/teams in a direct “confrontation”,
- outperforming the other players/teams (by achieving higher scores than the others did in a previous round of game play).

This element is closely related to the achievement of the goals of the game.

There can be different forms of competition in a game: one in which the actions taken by one player/team directly influence the general state of affairs (the market) for all the others; and one in which the teams act in their “own world” and after a certain time period the performances of the different players/teams are compared to each other and a “winner” is indicated (for that round, or over-all).

For instance, in most general business games several teams try to outperform the others 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. However, in strategic 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).

2.2.4 Interactivity: Actions and feedback

In games, an action taken by a player generally leads directly to changes in the game environment/status, followed by an action from one of the other players/teams, or from the system.

Taking the consequences of their own actions and the reactions from the other players or system into account the players get feedback, that enables them to determine whether the goals of the game have been reached or have come closer, and thereby to value their actions. In the game “Roller coaster tycoon” players can build new attractions in an amusement park. When none of the visitors of the park uses the new attraction players might discover that there is something wrong with getting access to the new attraction because the entrance is blocked or not situated on a walking lane.

2.2.5 Uncertainty

An important element of games is that, although the goals are clear, while playing it is stays uncertain whether these goals actually can be reached. This uncertainty can be caused by

- Unpredictability of the actions of the other players/teams or the system,
- Unexpected events that are introduced in the game environment,
- Chance (for instance when using a dice),
- The fact that not the entire environment, or the underlying model, and or all essential information is available from the beginning.

This uncertainty urges players to explore the environment, to experiment with strategies and to take certain risks.

In the above-mentioned game “Roller coaster tycoon” the weather might change suddenly. For instance, it starts raining and players see that visitors are leaving the park and that the number of new visitors drops. This could lead to the insight that the players should also build indoor attractions in their park.

2.2.6 Situatedness (representation and story)

Games often are based on a fictitious situation that triggers the fantasy of players. In most cases the players are expected to play a certain role or they have to identify themselves with a certain character or instance in the game context.

The appealing aspect of games is that these could be situations and roles that one rarely encounters in real life. Whether the situated context is fictitious or based on reality, a key characteristic of games is that the game context will stay separate from reality. This means that actions taken by the players in the game environment do not have consequences outside this environment (Thomas and Macredie, 1994).

Rieber (1996) points to the role of fantasy. According to him fantasy is used to encourage players to imagine that they are completing the activity in a context in which they are not really present. He noted that the fantasy context in educational games can be exogenous or endogenous to the game content. An exogenous fantasy is overlaid on some learning content as a kind of sugar coating. For instance, in the games that are related to the math books developed by the Dutch publisher Malmberg all kind of fantasies are used with the only goal to make children practice basic math skills. For instance the children of a school go on a trip to a castle. One of them has overslept and missed the trip. When he is still in bed he gets a SMS message of one of the pupils stating that they are trapped in the castle and that they need help. During the game the players have to solve all kinds of math problems to free all the scholars in the castle. The problems are not a real part of the fantasy. The fantasy is just used to make solving the problems more interesting/fun.

An endogenous fantasy is related to the learning content. Content and game aspects are interwoven. One cannot tell where the game stops and the content begins. According to Rieber, the advantage of an endogenous fantasy is that if the learner is interested in the fantasy, he or she will consequently be interested in the content. A good endogenous fantasy is an important first step towards intrinsic motivation to play and to learn.

2.3 Categories of (digital) games

In the sections above the defining features of games have been summarised. But although all games have these features to some extent, many different types of games can be distinguished in which certain features are more salient than others and in which players have to use different types of cognitive or motor skills. Looking at computer games or “digital” games a distinction is often made between: action games, adventure games, fighting games, puzzle games, role playing games, simulation games, sports games, and strategy games (Prensky, 2001, Herz, 1997). One could say that fighting games and sports games are instances of action games. This leaves six main categories of games. Below a short description of these genres will be given and some examples will be given (more information about specific games can be found on http://www.gamespot.com).

- *Action games* are situated in a context in which speed and skills play an important role. Fast reflexes and good eye-hand coordination are important to be successful in these games. Examples are PacMan, Tetris, Space Invaders, Super Mario, (and more recently) Super monkey ball, Call of Duty, and all kinds of fighting and sports games.
- *Puzzle games* are games in which a particular problem or set of problems has to be solved. The context often is not very rich. Examples are “Minesweeper” in which players have to detect the mines in a field, or Donky Kong Coconut Crackers. In this puzzle game players must manipulate a rotating platform to create color shapes and earn points.

- According to the Oxford English Dictionary, *a role-playing game* (RPG) is “a game in which players take on the roles of imaginary characters, usually in a setting created by a referee, and thereby vicariously experience the imagined adventures of these characters". In these games the context is very important and in many cases there is no competition. Despite this generally non-competitive nature, RPGs usually have rules, or "game mechanics", which enable the players to determine the success or failure of their characters in their endeavours. Examples are Dungeons and dragons, and Everquest.
- In *adventures* (like Freddi Fish, Reader Rabbit, Junior Detectives, Harry Potter and the Prisoner of Azkaban, or Myst III) at the beginning players, by means of a video, are introduced in a certain context and a storyline. After that they can freely explore the game environment. While doing this, they regularly are faced with problems that they have to solve. For this players often have to use cues or objects that can be found elsewhere in the environment. When the problem is solved one gets a bonus (for instance new powers) or one can proceed to new parts of the environment.
- In *strategy games* the player is in charge of an entity like an amusement park (Roller Coaster Tycoon) a university (Virtual U), a family (The Sims), a city (SimCity), a nation (Rise of Nations), or even an entire civilisation (Civilisation). Players are expected to take decisions about how the entity will develop in the future. While doing this, they have to face all kinds of events and constraints. In these games different kinds of strategies can be used to be successful. There is no situation of winning or losing, but the competitive aspect is in doing better than a certain standard, or than oneself or another person that is using the same environment.
- In *simulation games* responsible tasks or processes are being simulated. For instance, the player is a pilot of an airplane (Flight simulator), or a doctor who has to learn to identify infective diseases to prevent epidemical disasters (Biohazard). While playing players can practice all kinds of skills and/or can try to discover the underlying principles.

From the descriptions given, it is clear that the differences between the categories are not unequivocal. For instance, strategy games and simulation games appear to be very similar. Furthermore, the distinction between certain types of games and “pure” simulations or “advanced” case studies is not always clear. This issue will be elaborated in the next section.

2.4 Relationship between games, simulations and cases

The last type of game described above is “simulation games”. This already indicates that there is a close relation between games and simulations. A third concept that is closely related to these two is that of “case studies”. Case studies and simulations are already often used in educational settings, while the use of games is still limited. In this section the (dis)similarities between these concepts/tools will be clarified. In the next chapter it will be elaborated what kind of educational goals may be achieved by using these tools.

Jacobs and Dempsey in 1993 already pointed to the fact that the distinction between simulations and games is often blurred, and that many articles in this area refer to a single “simulation game” entity. They state “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 emphasised to create a game. These elements include competition and externally imposed rules, and may include other elements such as fantasy and surprise” (Jacobs and Dempsey, 1993, p. 201).

Besides the concept of "simulation games" the term "game simulations" (in Dutch: "spelsimulaties") is used with a slightly different connotation (see below).

Greenblat (1981) sees games as a particular type of simulations: "The term game is applied to those simulations which work wholly or partly on the basis of players' decisions, because the environment and activities of participants have the characteristics of games: players have goals, sets of activities to perform; constraints on what can be done; and payoffs (good and bad) as consequences of the actions" (Greenblat 1981, p. 23).

So, games and simulations both 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 in the game environment and quite often have to do so with a limited set of resources. The latter means that in games participants have to think about the trade-off between costs and profits of actions.

In this respect it is important to make a distinction between two kinds of simulations. De Jong and Van Joolingen (1998) divide computer simulations into two types: simulations containing conceptual models and those based on operational models:

- *Conceptual* models hold principles, concepts and facts related to the (class of) system(s) being simulated.
- *Operational* models include sequences of cognitive and non-cognitive operations (procedures) that can be applied to the (class of) simulated system(s).

In a similar vein, Gredler (1996) distinguishes experiential simulations and symbolic simulations. Experiential simulations establish a particular psychological reality and put participants in defined roles within that reality. Participants, in the context of their roles, execute their responsibilities in an evolving situation. Experiential, simulations, in other words, are dynamic case studies with the participants at the inside.

De Caluwé, Geurts, Buis and Stoppelenburg (1996) call this kind of simulations: game simulations (in Dutch "spelsimulaties"). In game simulations the participants play different roles in a predefined scenario in order to experience the (new) structure and the dynamics of the situation. In a game simulation often a new situation/scenario is used that is the result of new structures or new policy in an organization. By means of the game simulation the players can get used to the new situation/structure or can experiment with new strategies to experience the consequences of their actions. This type of simulation is closely related to role play.

In a symbolic simulation the behaviour that is simulated is usually the interaction of two or more variables over time, and the learner can manipulate these variables in order to discover scientific relationships, explain or predict events, or confront misconceptions (Harper, Squire, and McDougall, 2000). In contrast to the experiential simulation, in a symbolic simulation the learner is not a functional element of the situation. The student acts, but stays external to the evolving events, so the reinforcement on the actions is different. Operational or experiential simulations are closer to games than are conceptual or symbolic simulations. In operational simulations (for example a flight simulator) the participant has to reach specific goals (for example take off the plane, keep it in the air for a while, and land it safely) under specific constraints (e.g., a specific quantity of fuel). For conceptual or symbolic simulations these elements often are not present. Here, learners interact with a simulation to understand the underlying model (e.g., collisions in physics, see de Jong et al., 1999), they do not need to reach a certain goal state in the simulation environment but have to reach a state of learning. There are also no specific constraints in the form of resources the learner has to take into account. Conceptual simulations can be changed into more game like environments by adding specific goals, like optimization tasks. For example Miller, Lehman, and Koedinger (1999) designed a simulation in which the topic is electricity, more specifically electrically charged particles. In the simulation that is called “Electric field hockey”, students are expected to gain an intuitive feel for the qualitative interactions of electrically charged particles by playing a game in which they have to place charged particles in such a way on a hockey field that another particle that is given an initial speed and direction from a certain point hits a hockey goal.

Wilensky (2003) introduces another type of simulation: participatory simulations. These are activities where learners act out the roles of individual elements of a system and then see how the behaviour of the system as a whole can emerge from these individual behaviours.

Environments, like the above mentioned “Electric field hockey”, are often labelled ‘microworlds’. They are mainly used in the field of physics. A microworld is an idealized world that represents ideas/models in a theoretically ideal form (White, 1984). White used such an idealized world to let students develop a basic understanding of Newton’s laws of motion (see also diSessa, 1979). The real world is confusingly complex. It includes friction and gravity and has non rigid bodies that do not correspond to the point masses of formal physics. In the microworld she used, there is just Newtonian motion in a pure and simplified form. There are no extraneous complications, such as friction, to distract and confuse the learner. This should provide students with the kind of experience, which would permit the induction of the correct beliefs about force and motion. Within the context of a microworld one could either set the learners free to explore as they choose, or one could give them some activities to pursue. Setting a goal, such as hitting a target or navigating a maze creates a game-like challenge (White, 1984).

This way of creating ‘microworlds’ or ‘games’ with conceptual simulations still misses one essential aspect of games, namely that the participant is an integral part of the environment and that there is a sense of involvement, as for example, in a simulation such as a flight simulator. In games, participants do get a certain ‘role’ that they have to play. In conceptual simulations or microworlds the participant is still ‘external’ to the simulated domain.

As stated above experiential simulations can be characterised as dynamic case studies. This indicates that a third related concept to simulations and games is “case studies”. Van Merriënboer (1997) gives the following description of case studies: “Examples that exemplify supportive knowledge and require learners to actively participate in actual or hypothetical problem situations in the real world” (Van Merriënboer, 1997, p. 311). Often, such a case study will describe a spectacular event in order to arouse the learners’ interest: an accident, a success story, a disputed decision that turned out all right, and so on. He distinguishes three different kinds of case studies, which may be distinguished on the basis of the type of knowledge they illustrate.

- Case studies that illustrate conceptual models will typically describe a concrete object, event or situation that exemplifies the conceptual model. For instance, a conceptual model of the concept “Computer game” might link the features that are described in section 2.2. A case study for this model might require the learners to study a typical game.
- Case studies that illustrate goal-plan hierarchies will typically be artificially designed objects (or be descriptions of those objects) that have to reach particular functions or goals. For instance a case study might describe a hierarchy of functions that must be fulfilled in the process of building a new computer game.
- Case studies that illustrate causal or functional models will describe real-life processes that illustrate a number of principles or a causal or functional

model. For instance a case study that illustrates a particular fault tree may provide a detailed description of the sequence of events that led to a particular disaster.

The last two forms of case studies may take the form of computer based design simulations or process simulations, according to Van Merriënboer.

In summary, games are closely related to simulations and cases. Often these concepts are used for the same kind of (learning) environments, and many combinations of these concepts can be found in the literature, like simulation games or game simulations. The main distinction between games and pure simulations are that games contain elements of competition, chance, surprise and fantasy that are not found in simulations. Furthermore, the goal is different. In simulations the goal is to discover the underlying principles of the simulation model, while in a game one tries to win the game or beat the system, the highest score or other players. In a simulation the learner has more freedom to act and experiment and in most cases does not have to cope with limited resources and mostly it is relatively easy to recover from wrong choices. In a game it is not possible to “undo” the actions. One has to face the consequences of one’s actions, while in a simulation it is easy to restart and experiment in the same situation. Pure cases also lack the element of competition and chance.

2.5 Summary

In this chapter a definition was given of games: Games are competitive, situated, interactive (learning-) environments based upon a set of rules and/or an underlying model, in which, under certain constraints and uncertain circumstances a challenging goal has to be reached. The elements of competition and uncertainty because of chance and/or unexpected events distinguish games from related concepts like simulations and cases. Furthermore, the goal of games is different. In simulations and case studies the goal is to discover the underlying principles, while in a game one tries to win the game or beat the system, the highest score or other players.

In the next chapter the use of games in educational settings will be dealt with. It will be concluded that games can be powerful educational tools but that instructional support often is needed to ensure that explicit learning is taking place. In the remainder of this thesis experiments will be described that try to discover which elements contribute to learning with a simulation game about knowledge management.

3 Learning with games

3.1 Introduction

Games are in potential interesting educational tools because players (sometimes in cooperation with others) are actively solving challenging situated problems. In that sense they have aspects that are in line with learning theories like constructivistic learning, situated learning and collaborative learning. In these theories it is stressed that learning is an active social process in which meaning is given to experiences while solving situated realistic problems.

An important advantage of games in comparison with more traditional educational settings is that students within these environments are strongly involved and motivated and focus on long-term goals (Garris, Ahlers, and Driskell, 2002). Games on the one hand can motivate students to learn and practice something. On the other hand they can keep the students motivated in case they are well designed. Motivation is enhanced by several elements. By the appealing context and interface, and by the fact that players have a feeling of control over the (learning) process, because they can make their own decisions and by means of these can influence the outcomes of the activities, even if the actions are not instructionally relevant. Druckman (1995) describes a number of features of games that should facilitate learning: involving students in an active learning situation, enhancing their control over the learning environment, focusing on learning principles and referents for concepts, rapid feedback and the learning of strategies, enhancing the motivation to learn, and providing an opportunity to encounter problems in ways analogous to the way they are encountered in real world contexts. This last aspect refers to the advantage that situations can be implemented into a game in which one normally does not have the possibility to apply and experiment with new ideas and strategies, because this would lead to drastic or costly changes and because the risks and costs of failure are too high.

Furthermore, gaming is an appealing setting to practice all kinds of basic skills (for instance in math and writing). Children often do not like to practice multiplication tables or spelling. However, when these are part of a challenging adventure their appreciation changes dramatically. In this case the term “stealth learning” is used (see for instance Kirriemuir and McFarlane, 2004).

Action games in general are not interesting from an educational point of view. In some cases these could be implemented to train motor and visual skills like eye-hand coordination. Adventures, strategy games and simulation games are more suited as is shown by some small studies using of the shelf commercial games in an educational setting (Dawes and Dumbleton, 2001, McFarlane, Sparrowhawk, and Heald, 2002; Kirriemuir and McFarlane, 2003).

In this chapter a description will be given of the role(s) games have played and can play in educational settings. Furthermore, results about the effectiveness of games as learning environments will be summarized. In the last part of this chapter a model is presented of how people (could) learn by means of games, and features that could support learning in these environments are described.

3.2 Games used in educational settings: a brief history

As was stated in the previous chapter, games have been played for ages for pleasure but also to train certain motor or mental skills or to transfer knowledge.

Chess and Go were used to develop analytical and strategic skills. Other games were used to practice motor skills (like the predecessor of the current "Darts", a game to practice the throwing of arms at certain targets). Some games that were initially meant for pleasure, over time got a more pedagogical goal because the content was changed. All kinds of alternatives of the Goose Game were developed that were meant to transfer knowledge about historical or geographical subjects or to make children aware of certain values and rules.

According to Shefrin (1999), one of the first examples is "Le Jeu du Monde" which was developed for Louis XIV in 1645 by the geographer Piere du Val. In this game small geographical maps replaced the 64 squares on the board of the Goose game. Additional to each square there was a description that summarized important events from the past in that particular region. Based on this game, new games were developed, like "The new game of human life" that was published in 1790. In this game all kinds of moral issues were presented based on the life of George III. This game still is available as a learning tool on an American historical website: http://www.history.org/history/teaching/objects_sale.cfm. At the end of the 18th century the number of educational games was growing fast, especially because commercial publishers were becoming interested. For example, in 1792 "A complete course of geography, by means of instructive games", edited by Gauttier was brought to the market. When developing this material Gauttier was inspired by the works of Plato, Locke and Montaigne.

One of the first educational settings in which games were used regularly was in military training. The first military games were card games. For example, French cadets in the 17th century learned combat techniques or the building of fortresses by means of card games. Other games in these times were based on board games like Chess or Go. Later more emphasis was put on simulating and replaying of battles to train tactical skills.

One of the oldest and most famous military games is the "Kriegspiel" that was developed at the beginning of the 19th century by Baron von Reisswitz (Leeson, 2002). In 1824 King Friedrich Wilhelm from Prussia gave instructions that a copy of the game should be supplied to every regiment in the army.

> The Kriegspiel is being played by two teams that are not in direct contact with each other and who exchange information by means of a third party (a game leader). The game leaders chooses a scenario in which all kinds of things have been described, like the number and strength of the forces, the pace at which they can be moved through the battle area, the efficiency of the arms etc. The game leader monitors game play by moving army forces of both teams on a board the strongly resembles a realistic landscape. The game leader reports to both parties about changes in the situation. To make these reports he uses tables to compute the effect of the action plans that are send in by the teams. Furthermore, he introduces unexpected events like a sudden change in weather conditions or unexpected manoeuvres.
>
> (Source: http://myweb.tiscali.co.uk/kriegsspiel/).

Up to this moment games are regularly being used in the military. On the "Game developers community" website of the American army (www.dodgamecommunity.com) in mid 2005 more than sixty computer games were described that were used in training by the different forces of the army with titles like: Full spectrum command, Anti-Terrorism Force Protection or Soldier of Fortune.

The next field in which important developments took place was business management training, where the use of games, simulations and case studies as vehicle for developing decision making skills was introduced in the mid-1950s. Here, there was a need to find a teaching method that could bridge the gap between formal, academic instruction (which often lacked direct job relevance) and on-the-job training (which could be slow, and was generally restricted to a limited domain). Around 1955, it was recognised that gaming and simulation methods could help provide a solution, and, in 1956 the American Management Association produced the first business game. This was a decision-making simulation exercise for potential executives. Led by the Harvard Business School, which made the 'case-study-method' one of the mainstays of its teaching, the use of such exercises soon spread to business schools throughout the world (Ellington and Earl, 1998).

> "AMA Top Management Decision Simulation provides an environment in which two teams of players could represent officers of firms and make business decisions. Each of up to five teams with three to five persons each produced a single product which they sold in competition with other teams (Hays and Singer, 1987, p. 197)".

Apart from military and management courses, at the end of the 20th century only limited use is being made of games in educational settings. This seems to be changing as was stated in the introduction of this thesis. For instance, in the Netherlands several commercial publishers like Malmberg (www.rekenspel.nl) and Bekadidact Educatieve Software (www.despeelsethuisschool.nl) have started to develop games that are closely linked to the curriculum of primary schools. These games primarily are meant to be used at home. Their goal is to practice basic skills in math, reading and writing within enjoyable and challenging contexts. Most of these games are adventures in which the players have to solve a large number of problems to reach the general goal of the game, meanwhile practicing the basic skills that were introduced in school. Other Dutch publishers, like Wolters-Noordhoff and Thieme Meulenhoff, have put some games on their websites that are additional to the printed materials that are used in classes.

Furthermore, the Koninklijke Bibliotheek (Royal library) initiated the development of some educational online games in a project called "Het geheugen van Nederland (The memory of the Netherlands)" that aims at digitalising important sources of the Dutch heritage (http://www.geheugenvannederland.nl). These games can be used by primary and secondary schools in historical or cultural courses.

3.3 Educational use and effects

Several authors (De Caluwé, Geurts, Buis, and Stoppelenburg, 1996; Ellington and Earl, 1998; Prensky, 2001; Mitchell and Savall-Smith, 2004) state that games can act as a powerful motivating force for the trainee and can maintain that motivation by being interesting, involving and fun. Apart from being a tool to motivate students, games may serve many other functions in educational settings, such as helping to explore new skills, promoting self esteem, practicing existing skills, drilling existing skills, automating or seeking to change an attitude, and sometimes tutoring or amusing is part of their function (Dempsey, Rasmussen, and Lucassen, 1996). Furthermore, games can be used to achieve affective objectives of all types and to develop communication- and interpersonal skills. Dempsey et al. (1996) reviewed 99 articles that reported about games and they conclude that practising existing skills and learning new skills were the functions that were reported the most (21 examples of each).

Hays and Singer (1989) give an overview of the way games can be used to train cognitive skills. They state "games can be used *in* training to: assess entry level behaviour; measure criterion performance; aid in formative and summative evaluations; provide instruction in specific knowledge and skills; and to teach attitudes. Games can be used *before* traditional instruction to provide advanced organizational information to trainees so that they are better prepared for traditional instruction. Games can be used *in place of* traditional instruction to transmit facts, teach skills, and provide insights. Games can also be used interspersed with or *after* traditional instruction for drill and practice, to integrate and maintain skills, or to illustrate the dynamics or abstract principles of a task (p. 194)".

Apart from tools to transmit information and to train cognitive skills, games can also be used as environments for discovery learning. By exploration and experimentation within the environment students can become aware of interactions and interdependencies between various elements or actors and can discover new rules or insights.

Gaming is considered to produce a wide range of learning benefits. Jacobs and Dempsey (1993) talk about improvement of practical reasoning skills, higher levels of continuing motivation, and reduction of training time and instructor load. Hogle (1996, p.11) states that simulations and games may improve several types of cognitive learning strategies like "organizational strategies (paying attention, self-evaluating, and self-monitoring), affective strategies (anxiety reduction and self-encouragement), memory strategies (grouping, imagery, and structured review), and compensatory strategies (guessing meaning intelligently)." Several authors however, have questioned some claims because of a lack of sufficient empirical support (Bredemeier and Greenblatt, 1981; Druckman, 1995). Much of the work on the evaluation of games has been anecdotal, descriptive or judgmental.

There are a few studies, however, that give more insight in the effectiveness of games/simulations compared to other forms of instruction. Below results will be described from studies looking at different types of learning effects.

3.3.1 Knowledge

Randel, Morris, Wetzel, and Whitehill (1992) examined 68 studies directly or indirectly (review studies over the period of 1963 - 1984, and separate articles published between 1984 and 1991) on the difference between simulations/games and conventional instruction in student performance. Business games were *not* included because, according to the authors, "they do not cover traditional academic subjects and because of the difficulty of specifying exactly what subject matter was taught, especially in management games (p. 264)".

Of the studies reviewed 56% found no difference, 32% found differences favouring simulations/games, 7% favoured simulations/games, but their controls were questionable, and 5% found differences favouring conventional instruction

Most of the studies that found no difference were in the area of social sciences and did not use a computer. Seven out of eight studies involving math found that the use of (computer) games is superior to traditional classroom instruction for improving math achievement. Subject matter areas where very specific content can be targeted and objectives precisely defined are more likely to show beneficial effects of gaming.

Furthermore, they conclude that simulations/games show greater retention over time than conventional classroom instruction, and that in 12 of 14 studies, students reported more interest in simulation and game activities than in more conventional activities (p. 269).

Wolfe (1997), in contrast to Randel et al., reviewed only studies in which a computer based general management game was used to teach predefined strategic management learning outcomes. The studies had to be comparative in nature with at least one treatment and one control group. He found evidence for the effectiveness of business games. In every study cited in the article, the particular gaming application that was used produced significant knowledge-level increases. When the business game approach was pitted against the case study approach, which is the major alternative teaching strategy in strategic management courses, the game approach was superior to cases in producing knowledge gains.

Klawe (1999) summarises the results of the Electronic Games for Education in Math and Science (EGEMS) project at the University of British Columbia. E-GEMS started in late 1992 to explore the potential of specially designed electronic games to increase learning and appreciation of mathematics and science by children in grades 4-8. Based on several experiments with two games that were developed in the project (Super Tangrams and Phoenix Quest) she concludes: ”Over the past six years we have found that it is possible to design computer games that students aged 9 to 13 greatly enjoy playing, and that are very effective in helping students understand mathematical concepts. Relatively small changes in design, however, can strongly influence the extent of the effectiveness”

3.3.2 Learning strategies

Oyen and Bebko (1996) have studied how different contexts for learning affect the development of memory enhancing strategies in young children (7-9 years). In particular, the effect of embedding a memory task in a computer game context was compared to a more formal “lesson” context. Furthermore, two types of fantasies were used: one endogenous and one exogenous (see also Section 2.2.6) in each context. Oyen and Bebko found that the game contexts stimulated much greater observed rehearsal. But when covert rehearsal was also taken into account (based on self reports) the differences between groups were only small. Rehearsers recalled more items than non-rehearsers in both contexts, but recall in the games was less than for the lessons. The authors assume that the game conditions, while more enjoyable and interesting for children, were also more difficult. “The added complexity and the distracting features inherent in the games may have combined to make the task more difficult, resulting in the decreased recall performance of the non-rehearsers” (Oyen and Bebko, 1996, p. 187). In the game context children that played the game with the exogenous fantasy had higher recall scores than the ones who played the endogenous game. This was contrary to the expectations.

3.3.3 Attitude

According to Bredemeier and Greenblat (1981) simulation games are believed to have great potential in the area of affective learning. They are assumed to be more effective than traditional teaching methods for increasing empathy and might lead to changed perspectives and orientations. The results they report, however, are not conclusive. "The available evidence suggests that, under certain circumstances and for some students simulation-gaming can be more effective than traditional methods of instruction in facilitating positive attitude change toward subject and its purposes (p. 324)”.

The data from Bredemeier and Greenblat are from the pre-digital area. A more recent study in this area is performed by Dandereau and Baldwin (2004). They have shown that people with low self-esteem have an attentional bias for rejection and people with high self-esteem do not. Dandereau and Baldwin developed the EyeSpy game to help change people’s attentional bias for rejection, more specifically to teach people with low self-esteem to ignore rejection information. EyeSpy teaches people to look for the smiling/approving person in a crowd of 15 frowning faces. By doing this repeatedly and as quickly as possible, this teaches people to look for acceptance and ignoring rejection. In order to successfully and accurately identify the smiling/approving face, one must get in the mind frame “Look for acceptance, and ignore rejection because it slows me down”. They have found that the EyeSpy game reduces the attentional bias for rejection in people who have an attentional bias for rejection, that is, people with low self-esteem. Results showed that after game playing, people with low chronic self-esteem experienced significantly less interference on rejection words in a task in which they had to name the word colour than their counterparts in the control condition. People with high self-esteem on the other hand, did not exhibit different amounts of interference on rejection or acceptance words between conditions. The findings suggest that it is possible to measure people's attention bias to rejection and to teach people skills that help them deal with negative social information. In this case a relatively simple game was successfully used to change players' attitude.

3.3.4 Motivation

Bredemeier and Greenblat (1981) also report that numerous studies support the idea that simulation gaming leads to higher levels of motivation and interest than more traditional forms of instruction. However, little is reported about the "whys" of this effect. In relation to this question, the work of Malone (1984) is often cited to give more insight. Malone states that games have three characteristics that enhance trainee motivation. Games offer a *challenge* with goals and uncertain outcomes. They enhance trainees' *curiosity* through audio-visual techniques, humour, and new information content, and they allow trainees to *fantasize* by providing an imaginative context and adventure scenarios. However, as the author pointed out, his studies focused on what made games fun, not what made them educational.

3.3.5 Perceptual and motor skills,

Egenfeldt-Nielsen (2003), based on a review of 12 studies focusing on eye-hand coordination, concludes that there do not seem to be any differences between non-players and game players in respect to proficiency in eye-hand coordination. However, one must be cautious with drawing conclusions based on these data, because most of the studies were "old", they were performed in the eighties of the previous century, and because in some cases there were some methodological problems. For instance, the test of spatial skills was performed on a computer screen. This might favour the video-games group.

A recent study is reported by Green and Bavelier (2003). They showed that action video game playing is capable of altering a range of visual skills. Four experiments establish changes in different aspects of visual attention in habitual video-game players (these played action video games on at least 4 days per week for a minimum of 1 hour per day for the previous 6 months) as compared with non-video-game players (these had little, and preferably no, video-game usage in the previous 6 months). The games included were *Grand Theft Auto3*, *Half-Life*, *Counter-Strike*, *Crazy Taxi*, *Team Fortress Classic*, *007*, *Spider-Man*, *Halo*, *Marvel vs Capcom*, *Roguespeare* and *Super Mario Cart*. Subjects were aged between 18 and 23 years.

Green and Bavelier demonstrated that the growth of visual skills is not a result of self-selection (i.e., not because subjects with superior visual abilities tend to prefer playing video games). Subjects with little or no video gaming experience showed significant improvement on the benchmark tasks after playing just ten hours of a first-person-shooter video game.

3.3.6 Behaviour

Brown et. al. (1997) found that the game *Packy and Marlon*, which aims to improve diabetes self-care among children, was quite effective. The player in the game controls an avatar with diabetes and must monitor level of blood glucose, take insulin injections, and choose foods. This is done within the overall narrative of saving the diabetes summer camp from evil rats and mice that have stolen the diabetes provisions. Participants in the experiment were between 8 and 16 years old. Each participant received a video game system at an initial clinic visit and was randomly assigned to receive either Packy and Marlon (treatment group, N = 31) or an entertainment video game containing no diabetes-related content (control group, N = 28). They could play their video game at home as much or as little as they wished, as long as they followed their family's rules about video game playing. Participants were interviewed in person, and a parent filled out a questionnaire, at baseline, three months, and six months. Participants in both the treatment group and the control group played their game for an average of about 34 hours over six months.

Children in the treatment group improved on self-efficacy, communication with parents about diabetes, self-care behaviours, and the number of urgent doctor visits decreased. The post-test showed a 77-percent drop in visits to urgent care and medical visits in experimental group compared to control group (Brown et. al., 1997). Interestingly the players did not improve their knowledge on diabetes significantly.

3.3.7 Conclusion

Games in education until now mainly aim at practising and learning skills. The effectiveness of games in developing new skills and knowledge has been shown in a few studies especially in the areas of mathematics and management. There are some indications that games could lead to changes in learning strategies, attitudes and certain practical behaviours for instance in the area of diabetes self care. An important finding of the last study that was presented is that students did not improve their knowledge measured by a test, but by means of their behaviour gave indications that they learned something. This seems to indicate that they could not make explicit what they learned, but nonetheless could apply new insights or skills. This is an example of implicit learning. The distinction between explicit and implicit knowledge/learning will be dealt with in the next section.

3.4 Learning in games: Different modes of information processing

As shown above there are indications that games can be effective in teaching in certain areas, but still little is known about the way students learn while playing a game and about game features that support learning. In next sections an attempt is made to clarify these issues and a model is presented of game based learning. Central in this model is the distinction between two modes of information processing and learning that take place while playing a game. This distinction is based on research by Berry and Broadbent (1984), Norman (1993) and Taatgen (1999).

Berry and Broadbent (1984) used a dynamic system, the Sugar Factory computer simulation, in which participants had to reach a certain level of sugar production by changing the number of employees. The behaviour of the simulation is based on a rule that is non-linear and contains a random component. Berry and Broadbent noticed that participants could achieve a good level of control of the system even though they remain unable to describe precisely the rules of the system in post-experimental structured questionnaires. They concluded that a task like this under certain conditions might be performed in some implicit manner. Berry and Broadbent observed a similar finding in 1988 using a different task. On the basis of these results they suggested that two modes of learning could be distinguished, an implicit unselective mode (U-mode) and an explicit or selective one (that is effortful and reportable). U-mode learning is probable in situations in which there is much information in the learning environment and the key variables and their interrelationships are not salient. Especially in “rich” low transparent, interactive discovery simulations this leads to intuitive knowledge that is difficult to verbalize. Berry (1993) states that these two modes of learning should be seen as the two extremes on a continuum, while Swaak and De Jong (1996) assume that these two types of learning can be seen as two parallel, at least partly independent learning systems.

Taatgen (1999) however, has a slightly different view. In his view implicit and explicit learning are a result of two competing modes/strategies: a search mode and a reflective mode. When using a search strategy, implicit learning is a “by-product” of normal information processing (Taatgen, 1999, p. 95). People are actively performing a task and while doing that unintentionally learn certain things (facts, procedures, instances, examples, sequences of actions). When using a reflective mode, learning is based on information processing based on learning strategies aimed at explicitly learning, comprehending or memorizing something.

These are two competing strategies whose use depends on the expected outcomes of the strategies. The expected outcome is determined by three elements: the estimated probability of reaching the goal using a specific strategy, the expected value of the goal, and the estimated cost of reaching the goal using the strategy. These estimates change over time due to increasing knowledge and the successes and failures of applying the strategy. In most cases people will start with a search strategy because reflective reasoning has a high cost, and it is not evident that the search strategy will be unsuccessful. Especially when one has little task relevant basic knowledge, the costs of a reflective strategy will be even higher. If the search strategy is not effective, and the estimated likelihood of reaching the goal becomes lower, people might consider changing to a reflective strategy.

The distinction made by Taatgen resembles the one made by Norman (1993). Norman describes two modes of cognition: an experiential mode and a reflective mode. “These two modes do not capture all of thought, nor are they completely independent (p.16)”. The experiential mode is one of perceptual processing, it is a pattern or event driven activity. It requires some thought but the information processing is data driven and reactive. According to Norman this mode leads to an accumulation of facts, it reactivates information that is already present in the memory system and it leads to a tuning and shaping of knowledge structures already available.

“The reflective mode is that of comparison and contrast, of thought, of decision making (p. 16)”. It is slow and laborious. “Reflective thought requires the ability to store temporary results, to make inferences from stored knowledge and to follow chains of reasoning backward and forward, sometimes backtracking when a promising line of thought proves to be unfruitful……The use of external aids facilitates the reflective process by acting as external memory storage, allowing deeper chains of reasoning over longer periods of time than possible without the aids (p. 25)”. Effective reflection requires some structure and organization and is greatly aided by systematic procedures and methods and the aid of other people.

Norman points to the fact that much of the technology we use seems to force us toward one or the other mode of cognition. “Rich, dynamic, continually present environments can interfere with reflection: The environments lead one toward the experiential mode, driving cognition by the perceptions of event driven processing, thereby not leaving sufficient mental resources for the concentration required for reflection” (Norman, 1993, p. 25). This line of reasoning seems to be applicable especially to modern computer games. So, the richness of the environment and complexity of the domain are important aspects that influence the way information is processed.

3.5 Supports that facilitate a reflective selective strategy

In rich dynamic, low transparent environments in which the key variables and their interrelationships are not salient (like in a lot of games) students often use a (low cost) unselective, experiential mode of information processing that is perceptual and event driven. This leads to learning but it is mostly in the form of facts (like the names of people or things), procedures, instances, examples, and sequences of actions that are applicable in the game context. When new abstractions, rules or insights are learned this is mostly implicit, intuitive and context specific knowledge that is difficult to verbalise and transfer to other situations.

Students keep using this mode of processing as long as it is successful in reaching certain goals in a game. If this mode is not successful anymore and they get into an impasse (VanLehn, 1988) students might change to a (more costly) reflective mode of processing in which they, based on their experiences (in this game and in other games or similar situations) and on resources that are available (in the game environment), try to induce new explicit rules, procedures or insights. A reflective mode is more costly in terms of cognitive effort that has to be put in because comparisons between problems have to be made, possibly relevant knowledge has to be retrieved from memory, and new hypotheses have to be formulated.

The use of tools (inside or outside the environment) or the help of other people can facilitate the reflective process. These tools could make that students use a reflective mode of information processing and not only an experiential mode, or they could support the use of this mode in the sense that it is more effective. Garris, Ahlers and Driskell (2002) confirm this: "simulation games may be ineffective stand-alone training tools because people do not learn from simple exposure or experience alone to understand complex relationships …… Although our goal is to achieve self-directed, self-motivated learners, we must provide support for knowledge construction. The role of the instructor in debriefing learners is critical (if somewhat overlooked) component in the use of instructional games, as are other learner support strategies such as online help, cues/prompts, and other activities" (p. 460). Below several of these supports will be elaborated and research will be reported that illustrates their importance.

3.5.1 Feedback

All games have some kind of feedback system that shows directly or indirectly whether players get more near to their goal or not. For instance in a flight simulator game players can see directly whether the plane they were flying had a safe landing or not (outcome feedback). By doing a lot of such landings and getting outcome feedback (crash or safe landing) players in some cases will be able to get an intuitive notion how to perform a safe landing. However, to be able get into a reflective mode of information processing that could lead to new explicit insights into performing such landings additional feedback information (process feedback) is needed (for instance about the velocity of the airplane, the direction and speed of the wind, steepness of the descent etc.). By comparing the information from different landings, players could induce new rules about how to proceed in certain situations. In many cases however, providing such information is not enough because players are not able to decide which information is important and are not able to discover what the essential relationships are between all the data available (see next section). In those cases also information is needed that offers the opportunity to compare the player's actions with good or bad courses of action (reference data) together with the underlying rationale. Feedback should help the recipient to generate hypotheses and to reject erroneous hypotheses. If it does not contain these kinds of cues (when it is mere outcome feedback), the players probably will not turn to a reflective and selective mode of information processing. When they still get into this mode the lack of process and reference feedback data may cause the recipient to generate a multitude of hypotheses that can reduce consistency and hence decrease performance. However, even when feedback contains useful cues, it does not necessarily lead to a reflective mode (as is illustrated below).

Halttunen and Sormunen (2000) report data from a setting in which they used an information retrieval game. In this game students received a search task for retrieving documents from a database. Goal was to formulate the optimal query. After they entered the query they received (numerical and graphical) performance feedback based on a comparison between the list of retrieved documents, and the list of relevant documents. Although the game aspects of the task were limited, there are some interesting findings concerning feedback. A large group of students indicated that the query effectiveness feedback they got, improved learning. Half of them stated that graphical data were more informative than the numerical data. However, there were also students who stated that the type of feedback that was given inhibited learning. These students stressed that their attention was fixed on the results and that they tried to improve their behaviour without analysis and reflection of their preceding queries and results. They were focused on developing new queries and on high query performance (game goal) and not on browsing documents to find new information from their content. The fact that performance feedback was presented directly after the query was entered and before the actual query results were shown, could have reinforced this behaviour.

This last remark indicates that not only the content of feedback is important but also the moment at which it is given. Jacobs and Dempsey (1993) suggest that feedback in a simulation should not be given immediately after an action, but should be provided after the simulation is completed, or at least be postponed until there is a logical break in the scenario, because than it is less intrusive. They base this suggestion on a study from Munro, Fehling and Towne (1985). In this study students worked with a simulation involving an air intercept controller task. Half of the students received computer generated error messages whenever the computer recognised and error. The other half could have a look at such messages only after they pressed a certain button. This last group made significantly less errors.

Not every type of feedback leads to learning of intuitive or explicit knowledge. Kluger and DeNisi, (1996) report the results of a meta-analysis of the effects of feedback. They state that feedback interventions on the average improved performance, but that over 1/3 of the feedback interventions decreased performance. The latter could indicate that no learning is taken place or that the wrong type of knowledge is acquired and/or used.

Looking at these data it appears that the type of feedback and the moment at which it is given have an influence on the information processing strategy that students will use. To support a reflective strategy feedback should not be goal or outcome directed, but should help the recipient to evaluate hypotheses by giving process data.

3.5.2 Guidance

As stated above, in some cases feedback is not enough to support a reflective strategy. Especially when actions lead to a large number of changes in the environment, when there is a lot of information or when there are many cues/stimuli available, players need some additional guidance to be able to use a reflective strategy. Hints and prompts can be given, or a coach or advice system may be provided to support players in organising the available information/cues/stimuli, in selecting the relevant elements and on focusing on the relevant relationships between elements. The use of prompts has been explored as a means to improve training effectiveness. Prompts may take a number of forms (Jacobs and Dempsey, 1993). "For example prompts may be given to help the learner respond to a question and take the form of an answer or partial answer (see next section about assignments). Prompts may be used in a less directive manner, such as providing a rule or mathematical formula. Prompts can also be used to promote the learners' self awareness or self-monitoring."

Stark, Graf, Renkl, Gruber, and Mandl (1995) guided students while managing a business simulation game (Jeans manufacturing) by using a multi-staged problem-solving scheme. Students were guided to explain decisions, to predict action results and to 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. It is unclear from this study however, whether the development of mental models was the result of a reflective mode of information processing that was supported by the problem solving scheme. The quality of the mental models was measured by a performance task in the game environment and by prediction performance in novel problem situations on a paper and pencil test. Both indicators could also have been improved as a result of a gain in intuitive knowledge that is acquired in an unselective mode while playing the game.

So, the study presented above does not give a clear picture whether guidance (by means of a problem solving scheme) supports a reflective mode. A study performed by Leutner (1993) focused on two other types of guidance in three experiments: (1) system-initiated adaptive advice and (2) learner-requested non-adaptive background information. He used the simulation game Sahel Zone in which students play the role of a farmer, making general decisions in the course of the year and determining the use of different types of land. Decisions are affected by unchangeable climate and ecological factors. In the advice groups, during the game, the players are provided with warnings if their decisions are likely to lead to problems. Results of the experiments (with 7th grade students and with university students) showed that advice increased verbal domain knowledge, but decreased game performance. Furthermore, the data indicated that system-initiated adaptive advice had short-term effects (measured directly after game play), while learner requested non-adaptive background information had long-term effects (measured by a test that was administered a week after game play). Leutner assumes that the difference in effects could be due to the fact that advice is only given when certain conditions are met while background information is always available. Since both types of guidance led to increases in verbal knowledge this seems to indicate that these supported a selective mode of information processing.

3.5.3 Additional assignments

Additional assignments could be introduced into the learning environment. These assignments can elicit reflective behaviour by making the task more problematic and by focusing attention on aspects that might have been overlooked or taken for granted without mindful processing of information. This may create short-term costs, preventing students from rushing through their work on a problem without being mindful of the subject matter issues that are the goal of the instruction (Reiser, 2002, p. 258).

An example of this phenomenon is described by Klawe and Philips (1995). They report research with a game "Garden", made in the E-GEMS project (Electronic Games for Education in Math and Science). In the game, players move their pieces around in a two dimensional coordinate system. The educational objective of the game is to encourage exploration of negative numbers and coordinate systems. A turn in the game goes as follows. After rolling a dice, the player is presented with a number of possible moves represented by 2-dimensional vectors. Thus a player might be offered the vector (1,0), which represents moving one unit to the right, and also the vector (-1,2), which represents a knight-move upwards and to the left. When the player chooses one of the vectors the piece is moved accordingly.

In order to help players develop their intuition of the coordinate system and how vectors correspond to moves, they designed the game in such a way that players could tentatively select a vector, and the location that would result from the selected vector would flash. The player could then either confirm the choice, or try one of the other possible vectors. Though this interface worked reasonably well in terms of game play (students simply cycled through the vectors until they found a move they liked), they found that for the most part the players completely ignored the numerical values of the vector coordinates and the coordinate system itself.

Klawe and Philips tried to improve this by adding bonus moves in which the player selected a location in which a special effect will occur. By requiring the player to type in the coordinates of the desired location, they were able to markedly increase the attention paid to the coordinate system. Although students found entering the coordinates cumbersome and difficult, they did not complain because the bonus moves were valuable and only occurred sporadically.

Another example is reported by Klawe (1998). She used a single-player game, Phoenix Quest, an adventure aimed at making mathematics more appealing to girls 9 to 14 years old. It integrates math with language arts activities. The story takes place in a mythical island group called the Phoenix Archipelago. The player has to solve 15 mathematics puzzles, each with many levels of difficulty.

When used with supporting classroom activities such as related pencil and paper worksheet activities, large and small group discussions, and journal writing, significant increases in interest, enjoyment and achievement in learning the mathematics concepts in the puzzles were found. On the other hand, without these supporting activities, despite enthusiastic game playing the increases were much more modest.

Van Joolingen and De Jong (2003) describe different types of *assignments* that can be used in combination with simulations. They distinguish investigation assignments that prompt students to find the relation between two or more variables, specification assignments that ask students to predict a value of a certain variable, explicitation assignments that ask the student to explain a certain phenomenon in the simulation environment, optimisation assignments that ask students to reach a specified optimal situation, and operation assignments in which a certain procedure is applied. De Jong et al. (1995) using a simulation on collisions, Swaak et al. (1998) using a simulation on harmonic oscillation, and De Jong, Härtel, Swaak, and Van Joolingen (1996) using a simulation on the physics topic of transmission lines found that students (who were free to choose) used assignments very frequently, and that using assignments had a positive effect on gaining what they call “intuitive” knowledge. This latter seems to indicate that the assignments that were used did not support a reflective mode because in most cases there was only a small difference in explicit knowledge between groups who could use assignments and those who could not, and furthermore, the gain of explicit knowledge was small for all groups. The reason for this could be that the assignments that were used were too directive. They tell students what to do, help to discern important variables and to set goals and in that sense they make the task easier to perform. This could reduce the need to use a selective reflective mode. As stated in the beginning of this section Reiser (2002) suggests that assignments can elicit reflective behaviour by making the task more problematic and by focusing attention on aspects that might have been overlooked or taken for granted without mindful processing of information. This would imply that not every type of assignment supports a reflective mode of information processing.

3.5.4 Cooperation and collaboration

Collaboration with other students provokes activity, makes learning more realistic and stimulates motivation (Veerman and 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, to debug their ideas, and to notice the complexities of concepts and skills. Barrows (in Kolodner and Nagel, 1999) points 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 do on their own.

Collaborative learning needs to be distinguished from co-operative learning. Examples of co-operative 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 with co-operative learning groups, in collaborative peer workgroup students try to reach a common goal and share both tools and activities (van Boxtel, 2000).

Inkpen et al. (1995) report a study in which they used *The Incredible Machine*, a problem solving game in which players have to assemble Rube Goldberg[1] style machines out of a collection of parts. The factors investigated in this study were achievement in the game, measured by the total number of puzzles completed by each student, and motivation to play the game, measured by whether or not the children played the game for the full thirty minute period allowed. Students were randomly chosen to play either alone (solo play) or with a partner cooperatively using one computer (integrated play) or using two different computers (parallel play). The students in the integrated play condition solved significantly more puzzles. Inkpen et al. hypothesize that this result is caused by the verbal interaction (elaborating, discussing and expanding on ideas) between the players that play cooperatively. The study also demonstrated that the playing configuration has a significant effect on motivation as measured by the number of children who stayed and played for the full thirty-minute session. A higher percentage of children left during the Solo Play condition than for the Parallel and Integrated Play condition. This result could be explained by two factors: success in the game and whether or not the child played with a partner.

Klawe and Philips (1995) report similar findings: "Like many others we have observed positive benefits from having two students work together at a single computer. These include:

a) Sharing the computer stimulated discourse about what was being done. We believe this enhances learning.
b) The discourse and the presence of the other learner made the learners remain more aware of and connected to the usual classroom environment. We believe this enhances transfer.
c) While one learner operated the input device, the other learner frequently took that time as an opportunity for reflection and for using non-computer tools such as pencil and paper, and calculators.
d) Learners found sharing a computer more enjoyable than playing alone" (Klawe and Philips, 1995, p.3)

To summarise it seems that collaboration has positive effects on learning because it triggers discourse and reflection about the actions that are taken in the game environment.

3.5.5 Debriefing and group discussions

In 1992 a special issue was published of "Simulation and Gaming" which was dedicated to debriefing. In this issue it was stated that debriefing is perhaps the most important part of a simulation game for learning. According to Lederman (1992) debriefing aims at "using the information generated during the experimental activity to facilitate learning for those who have been through the process (p. 147)". Peters and Vissers (2004) point to the importance of debriefing because not all participants of a simulation game will be equally able to reflect on the experiences acquired during the game and to draw conclusions and apply these to a real life situation. Furthermore, especially in a multi player game, participants may have a limited picture of what happened. While playing they usually observe only those parts of the simulation game their position allows them. "From a learning perspective, then it is useful to

[1] Rube Goldberg (1883-1970) was a Pulitzer Prize winning cartoonist, sculptor, and author. His drawings depict absurdly-connected machines functioning in extremely complex and roundabout ways to produce a simple end result. More info at: http://www.rubegoldberg.com/html/bio.htm.

revisit the scene with all participants after playing has stopped, compare different pictures, and encourage participants to make a joint analysis of what happened (Peters and Vissers, 2004, p. 70)". According to Stolovitch (1990) a debriefing session should contain six elements: (1) decompression from the activity, (2) delineating factual information from the activities, (3) generating inferences: focusing on judgements and seeking for causes, (4) transfer: drawing parallels between the events, characters, circumstances of the activity and the real world situations of the participants, (5) creating generalizations, rules, and principles to improve the understanding of the real world, and (6) specifying applications of the generalisations.

Petranek (2000) states that several authors in the simulation and gaming field stress the value of oral debriefing. Written debriefing, however, is 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 behaviour, facilitators can assess individual learning, and students can privately communicate with their professor (Petranek, 2000, p.108)".

Klawe and Philips (1995) did research in four fourth grade classes that used a number of commercial electronic games. One of the most effective strategies they have found is the holding of regular entire class debriefing/sharing discussions. In one of the classrooms the initiation of these meetings marked a significant change in student attitudes. Once regular recording and sharing of ideas was expected, the students started to really listen to each other, to write more detailed comments about their findings, and to think not only about what they were doing, but also about what they were learning.

In general researchers agree that debriefing supports reflection. By its nature however, debriefing is not taking place during, but after (a period of) game play. So it is not part of the game but of the learning scenario in which the game has been played.

3.5.6 Monitoring facilities

In games, especially in complex situations, a reflective mode of information processing is supported by the opportunity to inspect the history of the interaction. Such monitoring facilities enable players to look back at their own (and others') actions and on system reactions. This enables comparison of lines of actions and thought and the formulation of hypotheses. In the area of simulations, several monitoring facilities have been offered. In the area of games little is published about this kind of support. Therefore some examples from their use with simulations will be given.

Support for *monitoring* one's own discovery process can be given by overviews of what has been done in the simulation environment. Reimann (1991) provided learners in Refract with a notebook facility for storing numerical and nominal data from experiments. Data in the notebook could be manipulated so that experiments could be sorted on values for a specific variable, experiments could be selected in which a specific variable has a specified value, and an equation could be calculated over experiments. Also the student could replay experiments from the notebook. Schauble, Raghavan, and Glaser (1993) presented monitoring support that not only provided an overview of students' actions, but also offered the opportunity to group actions under goals, and to ask for an "expert view" that gives the relevance of the student's actions in the context of a specific goal (e.g. to find the relation between two variables).

De Jong and Van Joolingen (1998), however state that the evidence for the effectiveness of monitoring tools in scientific discovery learning with computer simulations is not substantial enough to warrant general conclusions. Although this might be the case, monitoring facilities in some kind of form seem to be crucial for a reflective mode of information processing. When no data are available about past experiences (except for those stored in the mind of the player) it is difficult to test hypotheses and to develop new insights.

3.6 Conclusion

In the beginning of this chapter it was stated that little is known about the way that students learn while playing a game and about game features that support learning. In this chapter the research that was available was summarised. This leads to the following model of learning in games.

When players enter a game environment and have little task relevant basic knowledge they will use an experiential strategy in which they explore the game environment looking for clues that give indications which actions they could take to come closer to the game goals. When the environment enforces them to act they will use these cues and the information from past experiences in similar situations, to select an appropriate action or action sequence. Based on the feedback from the game environment (after the action has been processed) they will store this action (sequence) as an instance of a good or poor action. This strategy requires some thought but the information processing is data driven and reactive. Players apply the information that they have almost directly. This strategy leads to the acquisition of knowledge about the interface, about procedures that have to be used and to the acquisition of concepts and event-action instances that are used within the game environment. Furthermore, it leads to implicit knowledge about principles and strategies that are applicable in the game environment. This knowledge however is intuitive and hard to verbalize, and transfer to other contexts is difficult.

The players will keep using this strategy as long as useful cues are available in the environment and/or useful event-action instances are available in memory. When players get into an impasse because these cues and instances are not available or when the actions taken so far were not successful (the goals of the game did not come closer) players might change to a reflective strategy in which they look back at their own (or others) past behaviour in the game or in similar situations and try to abstract new rules, procedures or insights. This strategy requires more mental effort, structure and selective reasoning than the search strategy and could be supported by systematic procedures and methods and the aid of additional tools or other people. When this reflective strategy is successful, players will develop new explicit insights and strategies that they can apply during the rest of the game or in situations that are comparable to the game situation.

A combination of an experiential mode of information processing and a reflective mode is expected to lead to the largest knowledge gains. This will lead to new intuitive and explicit knowledge. Since the experiential mode seems to be the natural way to proceed in rich dynamic game environments, elements should be added to that environment that can support a reflective strategy and the switching of strategies.

The use of tools (inside or outside the game environment) or the help of other people can facilitate the reflective process. Monitoring facilities support a reflective strategy because they provide data about previous actions and reactions (from the system or from others) and by doing this they enable the comparison of (sequences of) actions and states and enable the formation and testing of hypotheses (new insights or principles). Feedback that gives process information and that helps the recipient to evaluate hypotheses also could support such a strategy.

Cooperation and collaboration with other players could support the use of a reflective selective strategy because players who work together have to make implicit knowledge explicit, have to discuss lines of action and reasoning before they make choices. The same line of thought can be applied to the role that debriefing could be playing. In a debriefing session players (and an external tutor) look back at their behaviour, discuss and value alternatives and try to transfer knowledge to other contexts.

To support the use of a reflective strategy in situations where players would not consider doing this based on the cues and information available and on the effect of their actions so far, elements could be added that induce a feeling that one is lacking information or insights to be able to perform/choose the right actions. This could be done by focusing players' attention on information that is not in line with their current way of reasoning by means of feedback, certain types of guidance and/or assignments, or by focusing attention on abstractions and transfer of knowledge to other situations by means of discussion or additional assignments.

In this thesis research focuses on two of these support elements that can be incorporated in the game itself. Elements that could be added to the learning scenario or the didactical situation, in which the game is used, like debriefing and collaboration, are not taken into account. The role of some supports that could be implemented in a game (like feedback and monitoring facilities) seems obvious although there still is not much research that grounds this. If no proper process feedback is given and no data are available from previous actions and game states, it will be difficult for players to use a reflective strategy. The role of two other elements (guidance and additional assignments) still is not clear. Additional assignments in simulations were effective but mostly led to a gain of intuitive knowledge and thus seemed not to support a reflective strategy. It is hypothesised that this could be due to the type of assignments that were used and therefore further research should focus on a different type of assignments. Until now, there is only one study (Leutner, 1993) in which guidance in the form of advice warnings, led to a gain in explicit knowledge. Further research is needed to clarify the importance of advice.

This leads to the following central question that is the basis of the research reported in this thesis "Do additional elements in the game, like assignments or advice, support the use of a reflective mode of information processing and thereby the acquisition of explicit knowledge?"

In the next chapter the learning environment that was used in answering this question is introduced. In the following chapters experiments with this environment will be described.

4 Knowledge management and the KM Quest™ simulation game

4.1 Introduction

Knowledge management (KM) is a domain that recently has 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. Knowledge management can be defined as the achievement of the organisation's goals by making the factor knowledge productive (Beijerse, 2000). Knowledge as a factor of production has some properties unlike other resources in organisations. Wiig, de Hoog and van der Spek (1997) listed some of the most important characteristics that set knowledge apart from other resources like for instance raw materials, goods etcetera: 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, it sometimes increases through use;
- has wide ranging impacts in organisations (e.g. 'knowledge is power');
- cannot be bought on the market at any time, if often has long lead times;
- is 'non-rival', it can be used by different processes at the same time.

So Wiig, de Hoog and van der Spek (1997) conclude 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 (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 Knowledge Management is related to the development of new knowledge, consolidation of knowledge already acquired, distribution of knowledge in the organisation, combining the knowledge available and ensuring that the best knowledge is being used (Wiig, de Hoog, and van der Spek, 1997).

Typical problems in the domain are: What knowledge is crucial to reach the organisation'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? How can people be motivated to share knowledge, and use new or already existing knowledge? People faced with these kinds of knowledge management problems often do not handle these problems in a systematic way and therefore often do not choose the right activities and solutions (Christoph, van der Tang, and de Hoog, 2001). Many knowledge management activities are more guided by available (IT) solutions than a thorough understanding of nature of the relations between initial problem (or opportunity) statement and the organisational solution or measure that serves its purpose well. This seems to be partly due to the fact that a coherent and well-supported methodology for knowledge management is lacking (Wiig, de Hoog, and van der Spek, 1997), and partly due to the fact the problems in this area are multi-faceted, complex, and without univocal outcomes.

In this chapter a distinction will be made between learning to solve well and ill structured problems (or tame and wicked problems as other people name them). It is argued that problems in the knowledge management domain often are 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. Based on this, it will be argued that simulations or games could be powerful devices to learn about ill structured problems, and some examples of KM games are presented.

In the second part of this chapter a knowledge management game that was developed in the KITS project[2] (Knowledge management interactive training system) is described. A description is given of the static case that was the starting point of the simulation game, as well as the business simulation model that was added to the static case to generate dynamic information based on the players' and systems' actions. Furthermore, a description is given of the elements of the instructional envelope that was added to the simulation game environment to support collaborative work and a reflective and selective mode of information processing in an Internet based learning environment.

4.2 Well and ill structured problems

The kinds of problems that humans solve vary dramatically, as do the nature of the problem situations, solutions and processes. On the 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) states that these problem types do not represent well-defined classifications, but rather represent a continuum from decontextualized problems with convergent solutions to very contextualized problems with multiple solutions. This distinction between well- and ill-structured problems resembles the distinction that Buckingham Shum (1998) makes between *"tame" and "wicked"* problems. "Tame problems are not necessarily trivial problems, but by virtue of the maturity of certain fields, can be tackled with more confidence. Tame problems are understood sufficiently so that they can be analysed using established methods, and it is clear when a solution has been reached. Tame problems may even be amenable to automated analysis, such as computer configuration design or medical diagnosis by an expert system (Buckingham Shum, 1998)". Wicked problems display a number of distinctive properties that violate the assumptions that must be made to use tame problem solving methods.

4.2.1 Properties of well- and ill-structured problems

Well-structured problems (also referred to as application or transformation problems) consist of a well-defined initial state, a known goal state, and a constrained set of logical operators. These problems:

- Present all elements of the problem.
- Are presented to learners as well-defined problems with a probable solution.
- Engage the application of a limited number of rules and principles that are organized in a predictive and prescriptive arrangement with well-defined, constrained parameters.
- Involve concepts and rules that appear regular and well-structured in a domain of knowledge that also appears well-structured and predictable.
- Possess correct convergent answers.

[2] Work partially supported by European Community under the Information Society Technology (IST) RTD program, contract IST-1999-13078. The author is solely responsible for the content of this report. It does not represent the opinion of the European Community, and the European Community is not responsible for any use that might be made of data appearing therein. For more details about KM Quest please see: http://www.kmquest.net.

- Possess knowable, comprehensible solutions where the relationship between decision choices and all problem states is known or probabilistic.
- Have a preferred, prescribed solution process.

Ill structured problems, on the other hand:

- Appear ill defined because one or more of the problem elements are unknown or not known with any degree of confidence.
- Have vaguely defined or unclear goals and unstated constraints.
- Possess multiple solutions, solution paths, or no solution at all, that is, no consensual agreement on the appropriate solution.
- Possess multiple criteria for evaluating solutions.
- Possess less manipulable parameters.
- Have no prototypic cases because case elements are differentially important in different contexts and because they interact.
- Present uncertainty about which concepts, rules and principles are necessary for the solution or how they are organized.
- Possess relationships between concepts, rules, and principles that are inconsistent between cases.
- Offer no general rules or principles for describing or predicting most of the cases.
- Have no explicit means for determining appropriate action.
- Require learners to express personal opinions or beliefs about the problem, and are therefore uniquely human interpersonal activities.
- Require learners to make judgements about the problem and defend them.

Many problems in the knowledge management domain can be categorised as ill-structured problems for several reasons. First, because there is no well-supported methodology for knowledge management (Wiig, de Hoog, & van der Spek, 1997), and second, because problems often are vague and complex as knowledge often is implicit and therefore difficult to locate and to measure. Third, because problems are contextual and multi-faceted, and have multiple solutions. Finally because they have no univocal outcomes: outcomes are difficult to measure, outcomes often have a delay and outcomes are context specific (depending on other elements like organisational strategies, structure, culture and the motivation of employees).

4.2.2 Instructional model for ill-structured problems

Several authors have claimed that training to solve ill-structured problems requires different instructional settings than training to solve well-structured problems (e.g. Jonassen, 1997; Smith & Ragan, 1999). Hong, Jonassen and McGee (2002) found that solving ill-structured problems in a simulation called on different skills than well-structured problems, including metacognition and argumentation. Jonassen and Kwon (2001) showed that communication patterns in teams differed when solving well-structured and ill-structured problems.

Instructional designs for well-structured problems are rooted in information-processing theory while instructional designs for ill-structured problems necessarily share assumptions with constructivism and situated cognition. Jonassen (1997) presents separate instructional design models for well- and ill-structured problems. The model for ill-structured problems that is proposed by Jonassen consists of six steps:

1. **Articulate problem context.**
   Ill-structured problems are more context dependent than well structured ones. Therefore a context analysis is necessary. Another reason for articulating the problem domain is that well developed domain knowledge is essential to problem solving.

2. **Introduce problem constraints.**
   Instruction for well-defined problems would articulate the goals and solutions for the problem at this point. However, ill-structured problems seldom, if ever, have clear or obvious solutions or solution alternatives. What ill-structured problems do have are problem constraints or requirements (that are imposed by a client and/or the situation).
3. **Locate, select and develop cases for learners.**
   Having identified the skills needed by a practitioner, the next step is to select cases that necessarily engage those skills.
4. **Support knowledge base construction.**
   In order to construct useful knowledge structures learners need to compare and contrast the similarities and differences between cases.
5. **Support argument construction.**
   Getting learners to make reflective judgements about what can be known and what cannot, is important to support in problem solving instruction. That support may take the form of modelling the arguments for the solution to a related problem or coaching or prompting learners to reflect on what is known.
6. **Assess problem solutions.**
   Solutions to ill-structured problems are divergent and probabilistic. Evaluating learners' solutions must consider both process and product criteria.

Smith and Ragan (1999) state the there are a number of strategies for teaching problem solving most of which are based on a "guided discovery" approach in which the learners must discover how principles and knowledge can be combined to solve problems, but in which occasionally direct instruction and hints are given to introduce important aspects and prevent students from getting lost or missing important facts and information.

Smith and Ragan give eight strategies that all are good candidates for assisting the learning of well-structured problem solving, but that vary when it comes to assist the learning of ill-structured problem solving. The strategies are presented below in a rough, hypothetical sequence, with the least applicable to ill-structured problem solving first an the most applicable last: Socratic dialogue, expert systems, elaboration model, simulations, microworlds, anchored instruction, case studies and case problems, problem based learning and cognitive apprenticeships.

The strategy of the Socratic dialogue is based on interaction between a expert/mentor and a student in which the role of the mentor is to provide instances and guiding questions.

Expert systems originally were developed to (help people to) solve problems in a specific domain based on the expertise of people in the field. Such a system contains a knowledge base and an inference engine. Expert systems can be used in learning to solve problems by using them as a query system. While solving the problems students query the system and the system displays the principles that are used to find the answer. Expert systems can also be used as part of an intelligent tutoring system. In that case a third component is added to the system: a learner model that keeps track of the principles and knowledge that the student has already mastered. ITS programs in principle are self-contained and sufficient in teaching learners a particular content. A third strategy for using expert systems to teach problem solving is to give learners the task to develop an expert system that can solve problems in a specific domain.

Simulations, microworlds and cases studies already were described in Chapter 2. Anchored instruction is based on the idea that learning and teaching activities should be designed around an "anchor" which is based on a contextualized case study or problem situation. Curriculum materials should allow exploration by the learner (e.g., interactive sites) to allow active manipulation, questioning, and involvement in the situation.

Problem based learning is an approach that structures courses and entire curricula on problems rather than on subject content. In this approach students collaborate in small groups working on fundamental problems that might be encountered in professional practice. The most common areas in which this approach is used are medical, law or business schools.

Cognitive Apprenticeship is a method of teaching aimed primarily at teaching the processes that experts use to handle complex tasks. The focus of this learning-through-guided-experience is on cognitive and metacognitive skills, rather than on the physical skills and processes of traditional apprenticeships. Applying apprenticeship methods to largely cognitive skills requires the externalisation of processes that are usually carried out internally. Observing the processes by which an expert listener or reader thinks and practices these skills can teach students to learn on their own more skilfully (Collins, Brown, & Newman, 1989, p. 457-548). Collins et. al. describe six primary elements of this approach:

- *Modelling*. This involves an expert carrying out a task so students can observe and build a conceptual model of the processes that are required to accomplish the task. In cognitive domains, this requires the externalisation 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* consists of observing/monitoring students while they carry out a task and offering hints, scaffolding, feedback, modelling, reminders, and new tasks aimed at bringing their performance closer to expert performance. Coaching may serve to direct students' attention to a previously unnoticed aspect of the task or simply remind the student of some aspect of the task that is known but has been temporarily overlooked. Coaching focuses on the enactment and integration of skills in the service of a well-understood goal, through highly interactive and highly situated feedback and suggestions. That is, the content of the coaching interaction is immediately related to specific events or problems that arise as the student attempts to carry out the target task.
- *Scaffolding and fading.* 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 own, as soon as possible.
- *Articulation* includes any method of getting students to articulate their knowledge, reasoning, or problem solving processes in a domain.
- *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 both expert and novice for comparison.
- *Exploration* 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.

Common to all the strategies mentioned above is that students are working on contextualised problems and are interacting with a system, other students and/or a tutor that provide feedback, additional information or hints when needed. Furthermore, not all of the essential principles are presented before problem solving and also students do not have to discover all necessary knowledge and principles themselves during the course of action.

In this section it was stated that important elements of instructional design for ill-structured problems according to Jonassen (1997) are the use of cases that are placed in a context, and that have problem constraints instead of clear or obvious solutions. Other important elements are the support of knowledge base and argument construction, and assessment based on process and product criteria.

These elements are characteristic for student centred learning environments in which problem based learning is an important element. In the previous section it was stated that simulations and case studies are instructional environments that could support learning to solve wicked problems. Games were not explicitly mentioned, but as was stated in Chapter 2 these concepts are closely related. In comparison with case studies, games have a higher level of interactivity and feedback and in comparison with simulations, games can introduce unexpected events and a higher level of fantasy. These elements make that games probably lead to higher levels of intrinsic motivation to learn and play and as such are interesting learning environments to learn problem solving in the knowledge management domain. In the next section knowledge management games will be introduced.

4.3 Knowledge management games and/or simulations

A review of literature and Internet resources showed that there are a lot of general and functional business simulation games, but that there are hardly any knowledge management games or simulations available. In this section three examples will be given of knowledge management learning games.

4.3.1 Resense kennisspel (knowledge game)

Resense (a Dutch consultancy firm specialised in knowledge management) developed a knowledge game in 1999 (www.resense.nl). One or more teams can play the knowledge game. Each team has four to eight players and has it's own game board. Every player has an individual task he or she has to accomplish. For this task knowledge has to be gathered, shared and applied. The first person to finish his or her task wins. At the same time the team as a whole must beat the other teams by being the first to solve all its individual tasks.

It is possible to gain, lose, and/or apply knowledge through actions such as team discussions and by collecting or sharing so-called knowledge cards. This process is affected by the occurrence of events, upon which players have to take action. For example, during the game a participant might leave one team for another. Both teams will have to react to this loss or increase in knowledge.

After playing the game, an evaluation takes place. The game process is evaluated critically, and the learning experiences are discussed as well as the opportunities for integrating them into daily working practices. The duration of the game is approximately 90 minutes including the evaluation (Van der Poel and Van Holstein, 2001).

4.3.2 Knowledge game from Kessels Smit

Kessels Smit (http://www.kessels-smit.com/), also a Dutch company, developed the Knowledge Game. The purpose of the Knowledge Game is to discover and to discuss various learning functions that constitute the corporate curriculum. The game consists of a 'micro-economy' where market demands are translated into products. The main factors are capital, material, human resources and knowledge acquisition. Teams design strategic plans to analyse and develop various learning functions that lead to knowledge productivity. As a result the teams who are proficient in transforming their learning into knowledge productivity will perform better in a competitive marketplace. The players are invited to participate in the market by producing the products for which there is a (temporary) demand. They can buy the raw material and produce the commodities, which they can sell on the market. The bank offers loans on the basis of an interest rate and collects the human capital tax. The bank also calculates the financial performance of the various teams. The commodities to be produced are based on Chinese Tangram figures, composed of triangles, squares and parallelograms. This raw material can be bought with the bank. The market price of the commodities drops as soon as a team has offered a product. Therefore, the teams have to find out how to produce fast and cost effective.

The game can be played in three to five teams of four to seven team members (35 participants as a maximum). The game is based on several time series, during which the teams combine production, learning and reflection on their learning functions and knowledge productivity. The facilitators of the game act also as the central marketplace and the central bank (Kessels, 1997).

4.3.3 Tango from Celemi

Tango (www.tangonow.net) is a business simulation designed by Celemi in Sweden for all decision makers in knowledge organizations. Tango provides a model that clarifies the business logic behind the knowledge organization and defines the specific factors that enhance profitability. These include familiar tangible factors such as pricing and capacity, as well as critical intangible factors such as image, know-how, personal chemistry and individual competence.

Tango participants see how these intangible factors are directly linked to financial results, and learn practical strategies to manage them.

Participants are divided into four-member management teams. Each team is given a company to run for seven annual cycles, pursuing its business strategy in order to maximize profitability. Each team competes with the other teams for the same customers and key personnel. The simulation takes one day or two days (advanced level) to complete. After a dry-run in the first “year” to give players a feel of the game, the teams are required to make their own decisions about the kind of people they want to recruit, and the kind of clients they want to attract, and then to plan and execute projects. The most important decision, at this stage, is what strategy to adopt.

At the end of each “year” the facilitator asks the teams what they have learned, and what conclusions they have drawn from their results. About halfway through the simulation, some of the control indicators that measure intangible assets and the flows of knowledge to, from, and within the invisible balance sheet are introduced. Thereafter, the groups use these control indicators to monitor their operations. First Tango was a board game but the representation form of Tango has been changed to a computer-based environment.

4.3.4 Conclusion

All three games cover the features that are described in Section 2.2. They are situated in a certain context (although the context of the first two games is rather poor), there is competition (beating other teams/players), there is a goal (completing a task, getting a large market share), uncertainty (events, behaviour of other teams) and interactivity. The first two games are board games that need a facilitator. The last game was a board game too but has been changed to a computer based environment but learner support still mainly is provided by an external facilitator whose role is to initiate the activities that are central to the cognitive apprenticeship model (see Section 4.2.2). The first two games have no specific learning goals. Their main goal is to raise awareness of knowledge management. Although all three games are reported to be used regularly, there are no data about the effects that are produced by these games.

So there is a need for a game environment that could be played without a facilitator and that contains educational tools that support learning and important processes like exploration, modelling, articulation, and reflection. Such an environment will be introduced in the next sections. Furthermore, there is a need for data concerning the effectiveness of games in an ill structured domain like knowledge management.

4.4 KM Quest

In 2000 the KITS project started. KITS is an acronym for Knowledge management Interactive Training System. The project was based on changing views in the field of learning and instruction in the form of *constructivism*, *situationism*, and *collaborative* learning. Respectively, these new views on learning imply that learners are encouraged to construct their own knowledge instead of copying it from an authority, be it a book or a teacher, in realistic situations instead of decontextualised, formal situations such as propagated in traditional textbooks and together with others instead of on their own. The overall objective of the KITS project was to develop and evaluate a learning environment that comprises an educationally supported, distributed simulation in the domain of knowledge management. This environment is constructivistic since learners are in charge and have to solve all kinds of problems; it is situated because the situations presented in the simulation are realistic and placed in the practical context of the participants, and it is collaborative since the players work together on the same tasks.

The environment combines a business simulation with game elements. The actions learners can take in the learning environment are different from the ones which usually can be taken in simulations. In pure simulations learners change the value of one or more well-defined variables to discover the effects of this change on other well-defined variables. However, this approach will not work for a knowledge management simulation. The actions to be taken by the learners in such a simulation will be “global” actions, e.g. “Implement a job rotation and enrichment system” or “Organise regular researchers visits to professional conferences” that have a direct or delayed effect on certain knowledge processes which indirectly have an influence on business process indicators. The task of the learner is not to discover all the underlying rules of the simulation model. This is far too complicated. Furthermore, the simulation model is context specific; the effectiveness of certain knowledge management actions is dependent on the context in which they are taken. Knowledge management actions will be different in a large product leadership organization than in a small customer intimacy type of organization.

Some game features are introduced to make the simulation more valid and comparable to real life situations in which a knowledge manager will be working. In simulations chance and surprise do not play an important role while they do in real situations. For instance, in real life the government comes with new legislation, competitors launch new products etc. Implementation of such elements makes the simulation more game like. Another feature that is not found in pure simulations is limited resources. In real life knowledge managers will not be able to take every action that they want. They have to work with limited resources or have to face other kinds of limitations.

The knowledge management simulation game is based on a case based learning situation in which teams of players had to react upon unexpected events related to a company description given to the learners (De Hoog, Van Heijst, Van der Spek, Edwards, Mallis, Van der Meij, and Taylor, 1999). In this initial situation no feedback mechanism was incorporated in the learning context, and no instructional support was given to the learners.

In the KITS project the initial case description was transformed into a collaborative and constructive Internet based learning environment by enriching it with several tools and components that will be briefly described below.

To support the players in solving knowledge management problems, several elements were implemented that should enhance the learning process (see Section 4.6). A main element is the introduction of a knowledge management model that describes a systematic approach to solving knowledge management problems (a form of modelling and of scaffolding by structuring, see the end of Section 4.2.2). This approach is based on a prescriptive view of how knowledge management should be done and is based on the KM consultancy experiences of one of the project partners: Cibit Consultants/Educators. Although the model is prescriptive, this does not mean that the use of the model leads to the “right” solutions. It is not an algorithmic model but a process model that that 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 in order to come up with the best fitting knowledge management 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 knowledge management problems that one can encounter.

A business model is implemented to simulate the behaviour 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 knowledge management. The set of variables is divided into four layers, of which two reflect general business concerns, and two others 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 like market share, profit, level of sales and so on.
- Business process related variables reflect the quality of internal processes and “how well” work is done in the company. Examples are “production quality index” 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 & development, and production)
- Knowledge process related variables reflect the properties of processes involving knowledge in relevant domains, like speed of knowledge gaining, effectiveness of knowledge transfer.

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 knowledge management 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. 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 player’s need is an Internet connection and a web browser.

To support collaboration and communication at a distance, tools are implemented like 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.

4.4.1 Learning goals and target group

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

The learning goals can be subdivided into goals (first four named below) that have to do with the procedure to follow when performing knowledge management (KM strategic knowledge) and knowledge that is used in the procedure (KM conceptual knowledge). After having completed all phases in the learning scenario (see Section 4.5), learners:

- Are able to specify which phases can be distinguished in solving knowledge management (KM) problems;
- Can perform the steps in the different phases (focus, organize, implement and monitor) in the knowledge management model;
- Are able to assess the KM situation and advise/implement appropriate interventions;
- Are able to monitor and evaluate the consequences of interventions.
- Are able to identify the main knowledge processes (gaining, development, retention, transfer and use),
- Are able to give a description of these processes,
- Are able to describe the basic characteristics of these processes
- Are able to identify (types of) interventions that have an influence on certain knowledge processes.

4.4.2 Brief description of the core of the simulation game

The combination of a task relevant business simulation model and game elements characterizes the learning environment as a simulation game. The simulation game is situated in the context of a fictitious (large) product leadership organization “Coltec”, a manufacturer of adhesives, coatings etcetera. 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.

When entering the simulation game the players obtain a description of their role in the Coltec Company: “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 pro-active and re-active actions.”

The simulation game can be 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 behaviour of the company). Next to the general goal players can also set their own objectives during game play by specifying desired values for certain business or knowledge (process) indicators. Players play their role for three consecutive years in the life span of the company.

Basically, in the game, players can inspect the status of business process indicators and knowledge process indicators (in three general domains), ask for additional information, and choose knowledge management interventions to (try to) change the behaviour 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 predefined pool of 57 interventions. At some moments in time certain interventions will not be effective (because they can only be implemented a limited number of times). This depends on the past actions of the players.

Changes in the status of the business indicators will only be computed 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 all of the indicators. The game ends after the players have indicated that they have implemented the last intervention(s) in the fourth quarter of the third year in the life span of the company.

To trigger activities from the players and to make sure that players are confronted with different types of knowledge management problems, at the beginning of each quarter an (unexpected) event is introduced that could affect the knowledge household of the company. Players have to decide if and how they want to react on 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 either can be positive or negative.

Which event is selected can depend on several conditions: 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 4-1). 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 and gives access to feedback on the previous event. The simplified organization chart at the right hand 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 visualisation system, which can display the (current and old) values of a set of 65 indicators in the business model (using different types of visualisations). The books on the lowest two bookshelves give access to additional information about knowledge management, the indicators in the business model and the interventions, which can be implemented. The books on the top two shelves contain "historic" data about the player's actions and game states 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 knowledge management model.

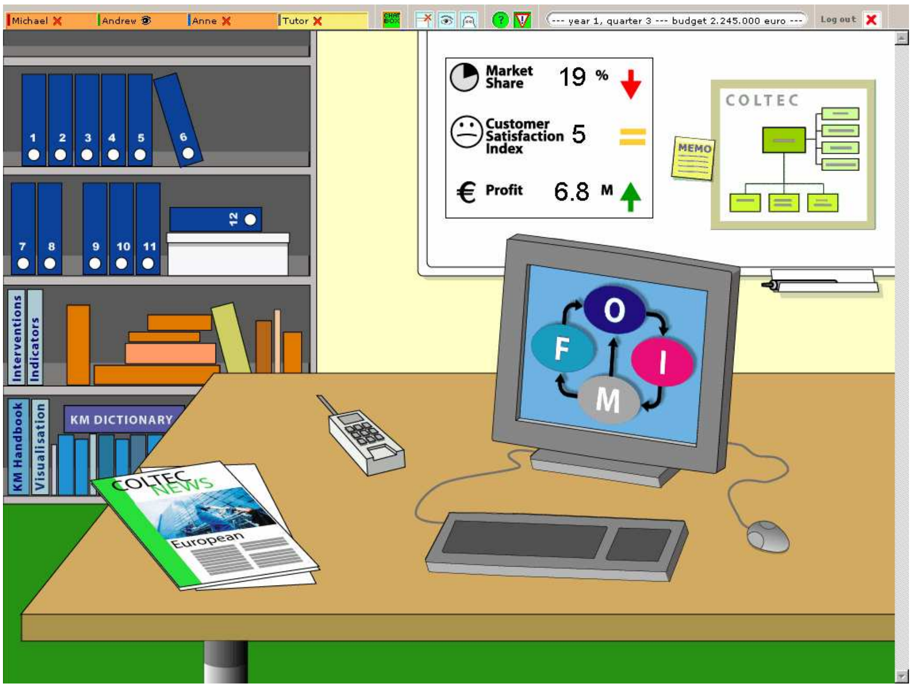


Figure 4-1. *Virtual office interface of KM Quest.*

The implementation of interventions involves costs as well do several other activities that the players can perform. Players receive a limited budget that they can use to implement interventions and buy information. Other constraints to the actions of the players are: 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.

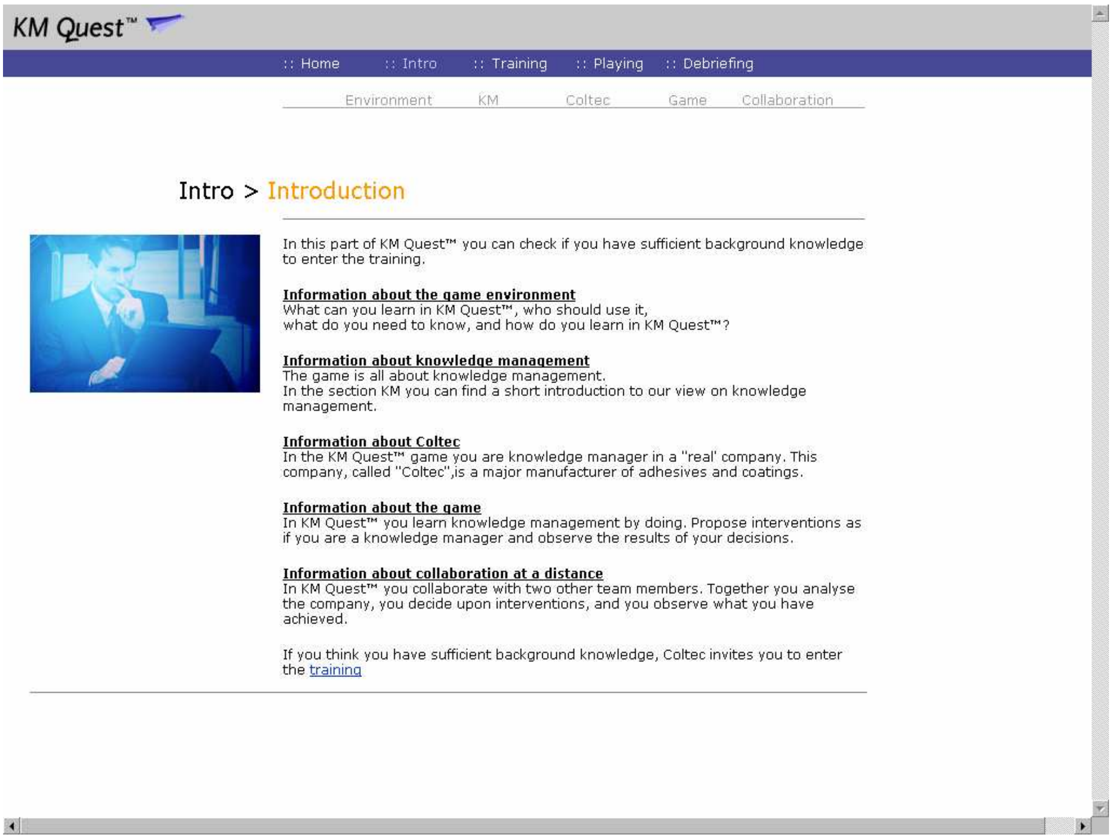
These constraints are introduced for practical reasons. Reorganizing the company would mean that the relations between variables in the business model would have to be changed, which is very difficult. Furthermore, the static information about the company would be "outdated". The business model comprises 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 only possible to inspect the status of general business indicators and knowledge process indicators in three global domains: research & development, marketing & sales, and production.

4.5 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 or enrich elements of a knowledge management course.

4.5.1 Introduction

In the introduction (see Figuur 4-2) the main elements of the learning environment and simulation game are introduced as well as some basic information about knowledge management and collaboration.



Figuur 4-2. *Screendump of the introduction of KM Quest.*

4.5.2 *Instruction*

The instruction phase is used to develop (shared) knowledge that forms the basic knowledge base needed to play the simulation game and to 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. An example of a screen in this phase is presented in Figure 4-3.

Modelling in this phase is done by presenting the main phases and the choice points and sub-steps in the different pathways in the knowledge management model (see Section 4.6.1) to the players step-by-step, and by giving them examples.

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 behaviour. Furthermore, by giving them process worksheets (see below) that are based on the knowledge management model, and by presenting prompts and hints about what to do and how to do it. Freedom of choice is increased gradually.

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

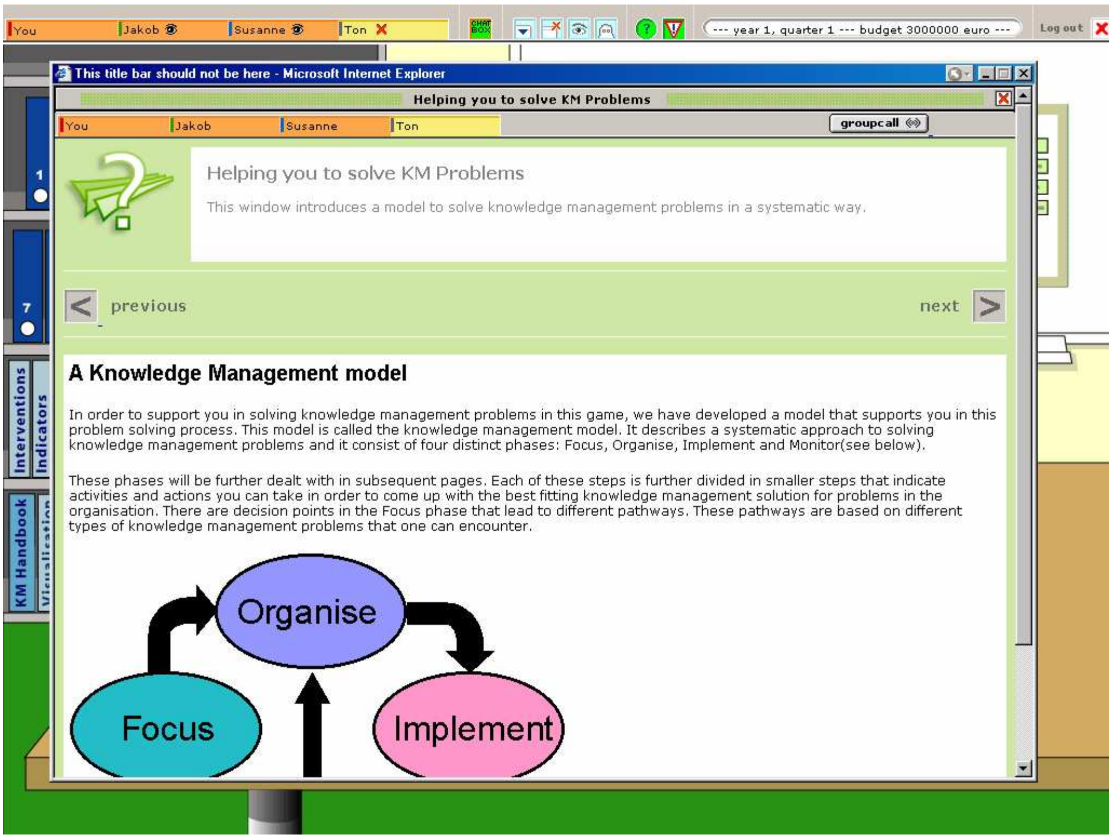


Figure 4-3. *KM Quest instruction phase (example).*

4.5.3 *Playing*

In the playing phase the players actually play the simulation game collaboratively for three 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 Merrienboer, & Bäumer, 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, like knowledge management, interventions, the company, business indicators, etcetera (see Figure 4-1). Furthermore, tools are implemented to support articulation and explicitation of knowledge, and the monitoring and reflection of one's own behaviour. These tools will be described in the next sections.

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 first year. Freedom of choice is at its maximum. Feedback will only be given to the players indirectly by means of the values of the indicators in the business model.

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 4-4).

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 at a certain moment in time, the content of the chatbox is not cleared after each session (as is mostly the case in chat systems, for instance 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 4-1). 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, etcetera. 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.

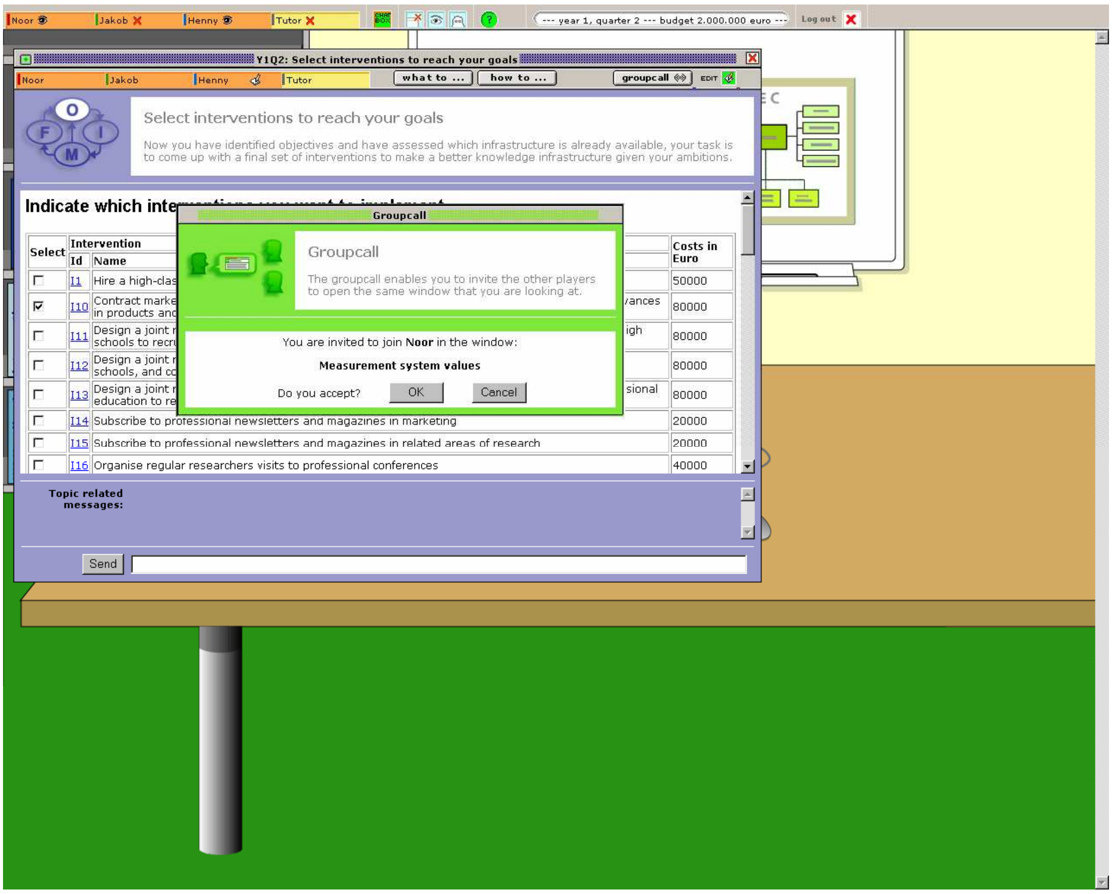


Figure 4-4. *Shared worksheet with a group call by one of the other team members.*

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, while another is analyzing the event. To keep track of each other's "position" in the environment, in the top of each window behind the names of the players' icons are displayed to indicate which of the players has opened the same window (see Figure 4-4). 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.

4.5.4 Reflection and debriefing

As stated in Section 3.5.5 reflection and debriefing are essential parts of the learning scenario when using games. Debriefing aims at using the information generated during the experimental activity to facilitate learning for those who have been through the process.

In the learning environment described in this chapter, players are triggered to reflect on their actions. At the end of each year the knowledge management 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), which results were accomplished (until that moment) or are foreseen in the coming period. And, not the least important, why certain assumptions, 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 wrote. 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 advisor is appointed to each team. This person is a kind of non-playing group member that can observe the behaviour of the players, can inspect the worksheets they have filled, and can participate in chats. The advisor will be invited to the debriefing session.

4.6 Instructional support tools

To support the learners in doing their task and to support learning while playing the game several features have been implemented in the environment:

- A knowledge management model
- Shared worksheets related to the steps in the knowledge management model
- Just-in-time information
- Feedback
- Advice

- Visualisation tools
- Monitoring tools

These features will be described below.

4.6.1 Knowledge management model

The knowledge management model (see Figure 4-5) describes a systematic approach to solving knowledge management problems (a type of scaffolding by structuring). It resembles the guidance used by Stark, Graf, Renkl, Gruber, and Mandl (1995) that was described in Section 3.5.2. However, as stated before, the use of the model does not necessarily lead to the "right" solutions, it is not an algorithmic model but a process model that 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 in order to come up with the best fitting knowledge management solution for problems in an organization. Although the model consists of a limited set of steps, there are choice points in the focus phase, each leading to different pathways in the model. These pathways are based on different types of knowledge management problems that one can encounter.

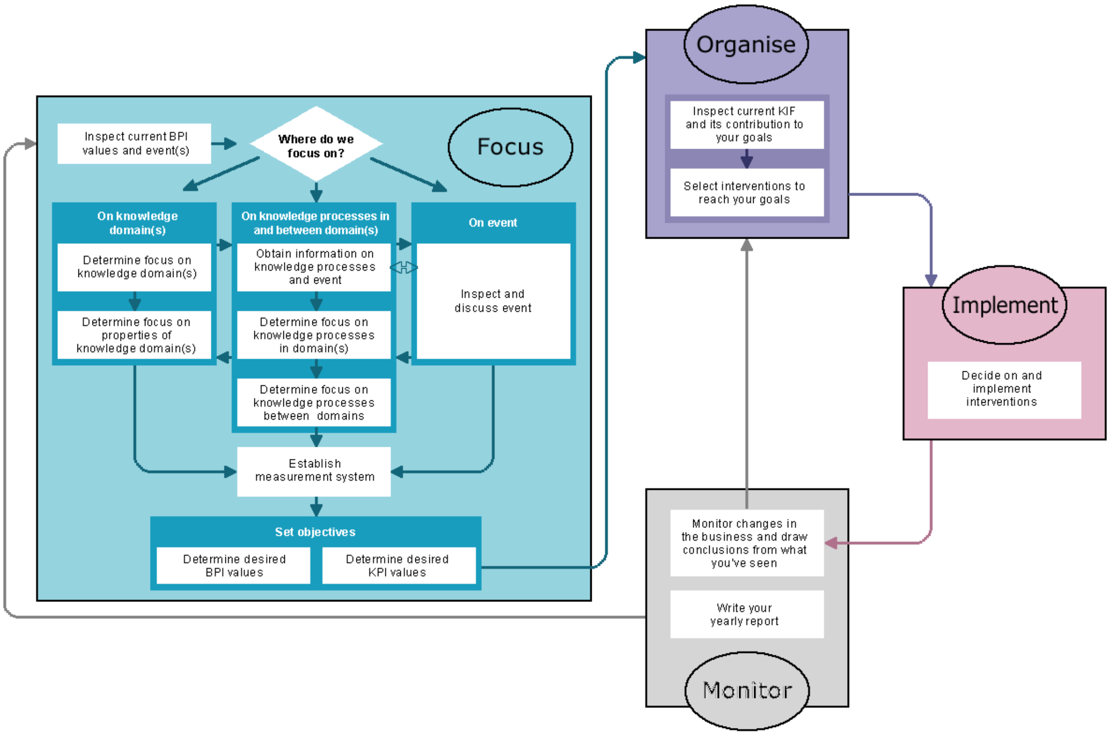


Figure 4-5. *The KM Quest knowledge management model.*

In the steps students search for information, perform analyses and make choices. The model contains steps and choice points but does not contain cues that indicate what kind of information is the most relevant in a certain situation and also does not indicate which choices are "right" or which solutions are more preferable than others. The model tries to prevent players from using a "trial and error" approach and tries to structure their way of problem solving.

4.6.2 Shared process worksheets

Although the knowledge management model indicates the steps that could be followed when solving a knowledge management problem, it does not give any clues/indications which specific activities should be performed (in the learning environment) in each step. To provide the learners with this information, process worksheets are implemented. These process worksheets guide the learners through the steps in the knowledge management model. For this they contain several elements:

- Clues on what to do and how to do it (see next section).
- Tools to structure the process and make the results of the activities explicit.

This means that each worksheet contains:

- Links to relevant information. This means that each worksheet has a “What” and a “How” button (see next section) and has hyperlinks to information in the handbooks. For instance when a name of an indicator is displayed, pressing the link will open the indicator handbook and will display a description of that indicator.
- A text field, and/or checkboxes and/or dropdown menus that 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.
- A dedicated chat facility that can be used to discuss ideas with team members without having to open the general chat facility.
- The content of the worksheet and the related discussion are saved together and are always available for inspection. So team members that were not present at a certain point in time still can see what the others have done, and can 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 and is available by means of quarterly reports (see below). This means that players can always monitor their behaviour during the game, and have the opportunity to reflect on it.
The worksheets have the same kind of role in supporting learning as does the KM model (see end of the previous section).

4.6.3 Just-in-time information

Information and tools should be easily accessible at the time players need them. This principle is used to structure the information in several ways.
Information that is directly related to a step in the knowledge management model can be accessed by using links that are presented in the process worksheets. Two types of links are used:

- What (to do). This contains information about what the learner is expected to do in a certain step and why, or what the result of a step could be, and of the relationship (and dependencies) with other steps.
- How (to do it). This contains information about how to proceed to complete the activities related to this step (and worksheet). It gives hints what to think about when performing these activities, and in some cases tells how these activities are to be performed outside the KM Quest environment.

Information that is more general and can be of use at anytime during the process, is available by using resources that are placed in the virtual office (see Figure 4-1) like books on a bookshelf, the organigram (a link to static information about the company), and a help functionality in the task bar. The following books are available:

- Interventions handbook containing additional information about the interventions that can be implemented. This information concerns the costs involved, the knowledge domains they are related to, and the knowledge processes that they can influence.
- Indicator handbook with descriptions of the indicators in the business model that can be inspected.

- Knowledge management handbook containing general ideas about knowledge management, and the knowledge management model.
- Visualisation handbook with information about all the visualisation packages that can be installed in the measurement system.
- Knowledge management dictionary with information about the main concepts in the knowledge management domain.

Just-in-time information does not necessarily support one or the other information processing strategy (experiential or reflective). On the one hand it can promote reflection because the information that is necessary at a certain point in time is easily available and players do not have to put in a lot of effort to find it. On the other hand it can promote an experiential search and apply strategy because the information is easy accessible and players do not have to think critically about what they need and about whether the information that is presented is “correct”.

4.6.4 Feedback

Feedback is a critical event in instruction. It should give learners the opportunity to assess the appropriateness of their actions during practice. In the KM Quest environment, feedback is based on several sources:

1. The behaviour of the underlying business model
2. Pre-canned conceptual knowledge about knowledge management that is based on the experiences from KM experts and is coupled to certain events.
3. A human tutor.
4. An advisor functionality in the system (see next section).

1. Feedback based on the business model
In the learning environment it is possible to get intrinsic feedback from the business model at the end of each quarter. Players have the possibility to see/monitor the status of (a large set of) indicators (and their history) in the business model. The values (and trends) of the business and knowledge (process) indicators give them indirect feedback on the quality of their actions.

2. Feedback based on conceptual knowledge
Pre-canned event related feedback is available after a quarter in the game has been finished. This contains information about the type of event, the knowledge domains and the knowledge processes that it is related to. Furthermore, it contains a list of interventions that are considered to be relevant to react upon this specific event. Players can compare their own interpretation of the event with the description given and can compare their actions with the suggested interventions. An example is given below:

> *The event*
> *It seems that the communication and collaboration between the people in the marketing and production department is somewhat lacking. They do not have a very well established communication with the people from the other department and do not seem to receive the right information. This leads to misinterpretations of product specifications. This event reveals weaknesses of Coltec in transfer of knowledge between these two departments. The effectiveness of knowledge transfer from marketing to R&D and the other way around is not optimal.).*
>
> *Relevant interventions*
> 1. *Organise monthly meetings between marketing and production employees to exchange information*

2. *Implement a company information system which supports Intranet and forums to conduct E-discussions an make available news about ongoing research project s and product developments*

Additional information
Ad 1: This intervention will have an effect on the indicators related to transfer of knowledge in both the marketing and production department. There is no delay in the effect of this intervention and this intervention can only be chosen when it not already active in the game.
Ad 2: This intervention will influence the knowledge transfer and utilisation processes in all departments of Coltec. There is no delay in the effect of the intervention and you can only select the intervention when it is not already active.

3. Feedback given by a tutor
It is possible that a tutor or advisor logs on to the environment as a fourth (non-playing) team member. This person is a kind of non-playing group member that can observe the behaviour of the players, can inspect the worksheets they have filled, and can participate in chats. This tutor can give the players additional feedback about the steps they have taken and the interventions they have chosen.

The first type of feedback (based on the business model) does not necessarily support one or the other information processing strategy. It could evoke reflective thought especially when changes in the indicators are not in the expected direction. It could also lead to trial and error behaviour because the underlying business model is very complex and the rules in this model are not open for inspection. The second and third type of feedback should support a reflective strategy because it gives players the opportunity to compare their own thoughts and solutions by those given by the system or by a human tutor. This could lead to confirmation or rejection of hypotheses or rules that were developed by the players or could transform implicit rules into explicit ones.

4.6.5 Advice

Advice is available when certain values in the business model are below a fixed threshold value. The advisor icon in the status bar (a triangle with a **!** in it, see Figure 4-1) normally is passive but starts blinking when advice is available.

When the player clicks on this icon pre-canned text will be displayed (see example below) that indicates there is a problem and that indicates what one can do by means of a list of suitable classes of interventions. An example is given below.

The value of "Efficiency of knowledge gaining in research" has dropped below a value of 4.5. This may be a reason for concern. It is possible that you overlooked this decrease of "Efficiency of knowledge gaining in research" because you focused to much on the event or did not include "Efficiency of knowledge gaining in research" in your measurement system. If you want to improve the value of "Efficiency of knowledge gaining in research", you could consider interventions that influence this value. Most of the time several interventions are available. In the case of "Efficiency, of knowledge gaining in research" you could take a look at interventions of the type listed below (see Interventions handbook). Note that there maybe other interventions also.

- *Interventions that aim at cooperation with partners, implementation of new projects or hiring services*
- *Interventions that aim at the implementation of Information Communication Technology*
- *Interventions that aim at recruiting and hiring people*

When a player clicks on a class of interventions the chapter of the interventions handbook will be opened in which additional information about these interventions is given.

As is the case with the support tools mentioned in the previous sections, this type of support does not necessarily support one or the other information processing strategy. On the one hand it can promote reflection because players' attention is focused on certain problems that they might overlook and because information that is necessary at a certain point in time is easily available and players do not have to put in a lot of effort to find it. Furthermore, they get clues that could lead to possible solutions for the problems that they are facing. This last aspect and the fact that the information is easy accessible and players do not have search the entire environment and do not have to think critically about what they need and do not have to question whether the information that is presented is "correct", could make that players keep using an experiential search and apply strategy.

4.6.6 Monitoring tools (history)

To be able to monitor their own behaviour and to reflect on it, 12 quarterly reports are available on the top two bookshelves (see Figure 4-1). These reports give information about the players' actions and about data generated by the system in the quarters that are completed. This gives teams the opportunity to go back in time without having the opportunity to reverse activities and/or actions that they have chosen. They are able to inspect:

- Which event has occurred in a specific quarter
- The content of the worksheets they filled in that quarter
- The interventions they implemented,
- The feedback and advice that were provided by the system

Data are only available from resources that were actually used in the specific quarter. So, when the players did not consult feedback in a certain quarter, no link to feedback will be available in the report about that quarter.

The monitoring tools mainly support a reflective strategy because they give players the opportunity to look back at their own behaviour and to compare data from previous quarters with the current data. This could lead to new insights or revision of already existing ideas.

4.6.7 Visualisations

The business model consists of a large set of indicators. To help the players with interpreting the values of the indicators and with seeing trends in the data, several types of visualisations are implemented like line or bar charts (an extensive description of these visualisations can be found in Purbojo, 2005). A special type of visualisation is the knowledge map. The Knowledge Map (see Figure 4-6) represents the three knowledge domains displayed in three squares. Each square is divided into 5 sections that refer to 5 knowledge processes: gaining, development, retention, utilisation, and transfer. The Knowledge Map contains two important elements: colour changing from red to green indicating the level of effectiveness of knowledge processes, and text information representing the speed of the knowledge processes by means of 5 categories. Next to the picture are two buttons that enable going back and forth to the knowledge maps of other quarters. By using these buttons players are able to see developments in the effectiveness and speed of the knowledge processes.

The visualisation tools could support a reflective strategy because they give players the opportunity to compare data from previous quarters with the current data. This could lead to new insights or revision of already existing ideas.

Figure 4-6. *Example of the knowledge map.*

4.7 Use of KM Quest and experiences

Several universities and institutions for higher education in the Netherlands like the University of Twente, the Radboud University in Nijmegen, the University of Utrecht, and Hogeschool Zuyd in Maastricht have used (and still are using) the KM Quest learning environment in courses on knowledge management. Furthermore, the Yeditepe University in Istanbul (Turkey) has used it.

Four staff members of the Universities of Twente and Amsterdam have used the learning environment for research purposes and have published results of several experiments that have been done in the past years (Shostak & de Hoog, 2004, Christoph, Sandberg and Wielinga, 2005, and Purbojo, 2005).

Data show that players are able to perform their task of knowledge manager in the game successfully. Most of them succeed in improving the knowledge household and indicators like market share, customer satisfaction of the fictitious company. Furthermore, use of the environment leads to significant knowledge gains (Christoph, 2005). However, before players actually start playing they should be prepared and have some introduction and training in using the environment (Purbojo, 2005).

4.8 Summary

In this chapter an extensive description was given of a game (KM Quest) in the domain of knowledge management. Most problems in this domain are ill structured. It is stated that games could be effective settings for training in solving such ill-structured problems because they contain contextualised problems and constraints, offer opportunities for exploration and direct manipulation, and give direct feedback to the learners.

KM Quest is an appealing environment to use in research on elements that should be included in a game to support a reflective selective mode of information processing because it is a rich and complex game. In such games players tend to use an experiential mode of information processing. The game however, contains some elements that are essential for the use of a reflective strategy like monitoring tools, product and process feedback and essential background information. Furthermore, the game already contains elements that could support the use a reflective strategy like advice. Additional supports can be introduced relatively easy in the game without a large programming effort. The game also has a log functionality which makes it possible to track the behaviour of players and to check whether supports actually are used.

5 Focus questions and lessons learned

5.1 Introduction

In Chapter 3 it was hypothesised that in rich dynamic, low transparent environments in which the key variables and their interrelationships are not salient (like in many games) students often use a (low cost) unselective, experiential mode of information processing that is perceptual and event driven. In this mode players acquire new concepts that are applicable in the game, and instances and examples of successful and unsuccessful sequences of actions. When new abstractions, rules or insights are learned this is mostly implicit and context specific knowledge. This type of knowledge is difficult to articulate and to transfer to other situations. While using this strategy, players can be very successful in a game, but in many cases they can not explain how they did it or why they did what they did. To be able to do this and to be able to transfer knowledge gained in the game to other contexts it is necessary that students at certain points in time use a reflective selective mode of information processing.

Students use the experiential mode of processing as long as it is successful in reaching certain goals in a game. If this mode is not successful anymore and they get into an impasse students might change to a (more costly) reflective mode of processing in which they, based on their experiences (in this game and in other games or similar situations) and on resources that are available (in the game environment), try to induce new knowledge. Because the game is complex and contains many cues, one runs the risk that such a reflective strategy does not lead to new explicit knowledge because players do not know which information is essential, can not access the essential information or are not able to formulate and validate hypotheses about relationships between concepts, events and/or actions. In such cases the use of tools (inside or outside the game environment) or the help of other people (other players or a tutor/supervisor) can support a reflective strategy. Furthermore, tools could also support the use of a reflective strategy in cases where players would not consider this based on their actions so far. For instance when they are still getting closer to the games goals and do not experience an impasse.

In this chapter results are reported from an experiment in which it was investigated whether the availability of certain support tools led to different learning results. This was done by using two versions of the simulation game to learn about knowledge management (KM Quest) that was described in the previous chapter.

In Chapter 3 several instructional elements were described that could support a reflective strategy. Several of these supports are already implemented in the KM Quest environment (see previous chapter). In the game support is given by means of feedback, monitoring tools, just-in-time information, and an advisor functionality. Furthermore, players have to collaborate in teams. They have to discuss ideas, make choices and have to reach agreement. This can also support a reflective mode of information processing.

The current study focused on two additional elements that could support the use of a reflective strategy also in game situations where players would not consider this strategy based on the cues and information available and on the effect of their actions so far. The reason is that data from evaluations of a KM Quest prototype that was not fully operational (Christoph et al., 2003) showed that most players/teams were successful in the game in the sense that they managed to improve the knowledge household and general business indicators (market share, customer satisfaction and profit). However, there were no significant knowledge gains. This could imply that students gained implicit or explicit knowledge that was not measured. But it could also indicate that students did not use a reflective mode of information processing and the supports available because they were successful in the game anyhow.

It is hypothesised that the use of a reflective mode could be supported by giving the players additional tasks. There are indications that such tasks are effective in learning with simulations. De Jong and Van Joolingen (1998) concluded that three instructional measures can be seen as holding the promise of positively influencing learning outcomes in scientific discovery learning with computer simulations: providing direct access to domain information, providing assignments, questions or exercises, and model progression (when the model is sufficiently complex). “for other individual measures (e.g. hypothesis support, experimentation hints, monitoring tools, prediction support) the evidence is not substantial enough to warrant conclusions”. De Jong, Härtel, Swaak, and Van Joolingen (1996) found that students who were free to choose, used assignments very frequently in a simulation, and that using assignments had a positive effect on the gaining of intuitive knowledge. This seems to indicate that the type of assignments that were used mainly supported an experiential mode and not a reflective mode.

The assignments used in these simulation environments are mostly investigation assignments that prompt the learner to start an inquiry about the relationship between specified variables (Swaak, 1998). Van Joolingen and De Jong (2003), apart from investigation assignments, also distinguish specification assignments that ask students to predict a value of a certain variable, explicitation assignments that ask the student to explain a certain phenomenon in the simulation environment, optimisation assignments that ask students to reach a specified optimal situation, and operation assignments in which a certain procedure is applied.

These kinds of additional assignments are effective in simulations with a limited number of variables, but probably are less effective in relatively complex game environments, with a lot of variables and where the relationships between variables and between variables and user actions are less self evident.

In these kinds of environments assignments that focus attention on aspects that might have been overlooked or taken for granted without mindful processing of information (Reiser, 2002), might be more effective, as well as assignments that ask the learner to make generalisations based on their experiences so far.

In the current experiment a version of the KM Quest game with two additional assignments was compared with a version of the game (see instruments section below) in which these were not implemented. These assignments are:

- Focus questions that have to do with the event that occurred in the previous quarter in the game. The goal of these questions is to make the task more problematic by focusing attention on aspects that might have been overlooked or taken for granted without mindful processing of information. For instance: a “solution” is presented and students have to state whether they think it to be good solution.
- Formulating lessons learned after a quarter in the game is finished. This lesson has to reflect upon knowledge management problems, strategies and/or processes: “Based on your experiences so far, formulate a lesson learned concerning knowledge management problems, strategies and/or processes that could be of help to others or yourself in the future.”

The assignments were available by means of the Coltec News icon that is on the desk of the virtual office. When players click on the icon a window is opened that describes the event of the current quarter and displays links to feedback and the additional assignments (see Figure 5-1)

The hypothesis is that students using the version with additional assignments will gain more explicit knowledge while playing the game than the ones who did not have these assignments, because the additional tasks support players to reflect on their own behaviour and that of "virtual" others and furthermore ask them to make implicit knowledge that was gained while using an experiential mode more explicit.

To test this hypothesis the knowledge gain was measured by administering a pre-test before players entered the game environment and a post-test after completing the game. These tests contained items that intended to measure different types of explicit knowledge but also some items that were meant to test implicit knowledge. To test whether students could apply the knowledge they learned in the game also in different circumstances, a transfer task was given after the post-test was completed. The transfer task is a case description with events that is situated in a different context.

To investigate whether the additional tasks had an influence on the way students played the game their behaviour in the game was logged in a file together with the data that are generated by the business simulation model. These data are also used to investigate whether the use of tools, like feedback, handbooks or visualisations, was related to learning gains or game performance.

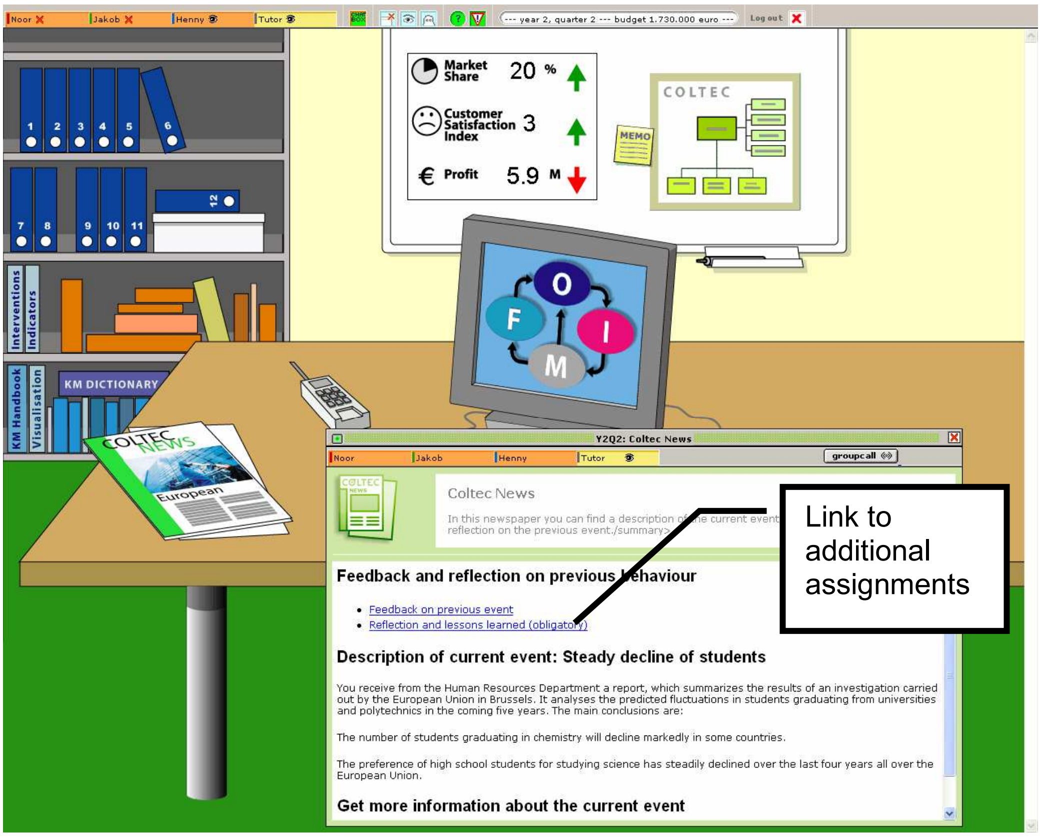


Figure 5-1. *Screen dump showing the content of Coltec News with a link to the additional assignments.*

5.2 Method

5.2.1 Subjects

The students who participated in the experiment did so because the use of the simulation game was an assignment in a master's course "Knowledge management in learning organizations" at the University of Twente. All students were from the Communication Studies department and followed a preliminary course on Knowledge management in the second year. The average age was 21.

36 Students had enlisted for the course. They were randomly assigned to one of the two conditions, before the experiment started. 28 students (20 women and 8 men) actually played the game till the end and did the tests. Eight dropped out before the course started or during the experiment. Because of this the students were not equally distributed over the two conditions. In the condition with additional assignments there were 16 students and in the other (called the standard version) there were 12.

5.2.2 Instruments

The game environment that was used in both conditions was slightly different from the version that is described in Chapter 4. In the current study players played individually, the order of the events was not random but fixed and the same for all students, and the starting values of the indicators were lowered (several are below 5 on a ten point scale).

Players played individually because collaborative game play could intervene with the experimental design. As stated in Section 3.5.4 collaboration and group discussions are seen as important factors that could improve learning in games because they "force" players to reflect on behaviour and to articulate thoughts. The level of collaboration and the quality of communication between players therefore could have an influence on the learning outcomes. Purbojo (2005) showed that the quantity and quality of communication between players had an influence on game performance and learning results.

The events and the order of the events were fixed to prevent that differences in types of events that occurred during the game (because of the random generator that normally selects the events) could have an influence on the game- and test results.

The starting values are lowered to create a situation in which events can occur that refer to internal problems related to knowledge processes. In the original game set up in the beginning of the game many events are generated that have to do with external (opportunity) events because knowledge processes in the company still were running smoothly (score of 6 or higher on a ten point scale). Observations in try-outs showed that players found these kinds of events difficult to deal with when they had limited domain knowledge. Lowering the starting values led to a business model state that fits with the selected events.

In both versions the following supports were available: the knowledge management model, visualisations, a history, what and how information related to the process worksheets, a help file, advice, and books with background information about the interventions, indicators, visualisations and knowledge management in general. For a detailed description of these supports see Chapter 4.

In the version with additional assignments from quarter 2 onwards each quarter a new focus question (related to the event in the previous quarter) was available and the players were asked to (re)formulate a lesson learned in each quarter.

5.2.2.1 Pre and post-test

Knowledge gain is measured by comparing the score on a pre-test and a post-test. Each consisted of 26 multiple choice questions. The test contained 18 questions with four answering alternatives that aimed to measure explicit knowledge and 8 questions with three answering possibilities to measure implicit knowledge.

Explicit knowledge of knowledge management concepts and principles is tested by giving students textual multiple-choice questions that refer to declarative knowledge. Four types of questions were included. There were seven items about concepts that are used in the learning environment, like the knowledge processes. Two questions about events. Three questions about steps in the knowledge management model. Furthermore, six questions are included that refer to relationships between indicators and interventions. An example of an explicit knowledge item is given in Figure 5-2.

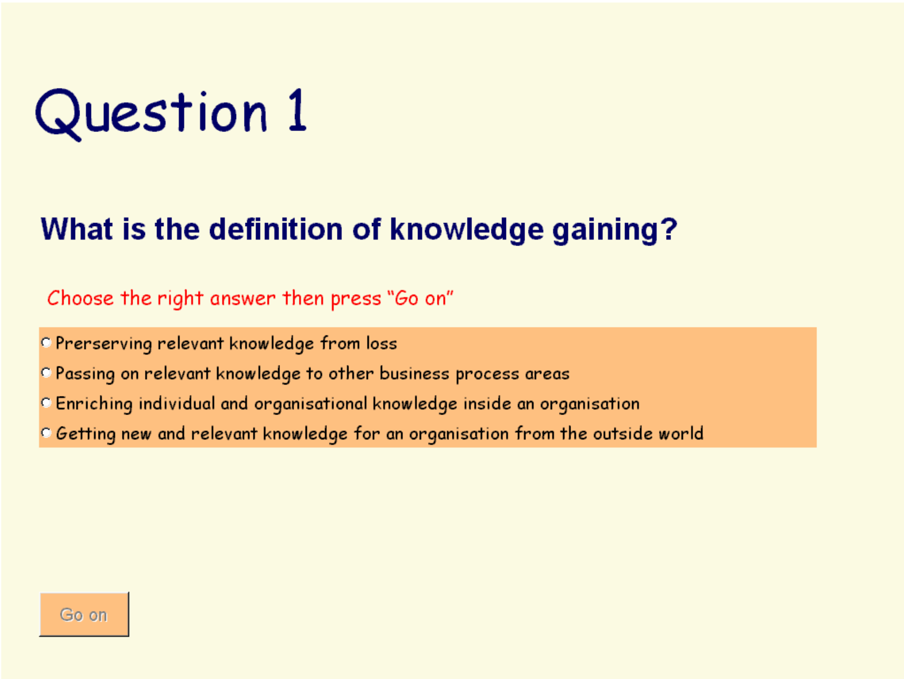


Figure 5-2. *Example of an explicit knowledge item of the pre and post-test.*

Implicit knowledge items are included to measure intuitive knowledge that is difficult to articulate. These items are based on the guidelines given by Swaak (1998) who characterizes intuitive knowledge by a "quick perception of anticipated situations". In the test a situation is given, an action is described and a set of possible post action situations is given. In each item the textual information is kept to a minimum and a picture or chart is used to present the alternatives. The underlying idea is that students who are not able to express what the exact relationship is between a knowledge management intervention and certain indicators, might still be able to predict what would happen with an indicator, based on the intuitive knowledge that they have gained during game play. An example of an implicit knowledge item is given in Figure 5-3.

The pre-test and post-test were identical. The tests were electronically administered. The student could choose an answer by selecting a radio button that was presented before the text. When a button was selected the "Go on" button on the left bottom of the screen is enabled en when the student presses this button the next question is displayed. Students were not able to go back to previous questions once the Go on button is clicked. Before pressing that button however, they were able to change the answer to the question that is displayed. The answers and answering times of the students were directly logged into a file.

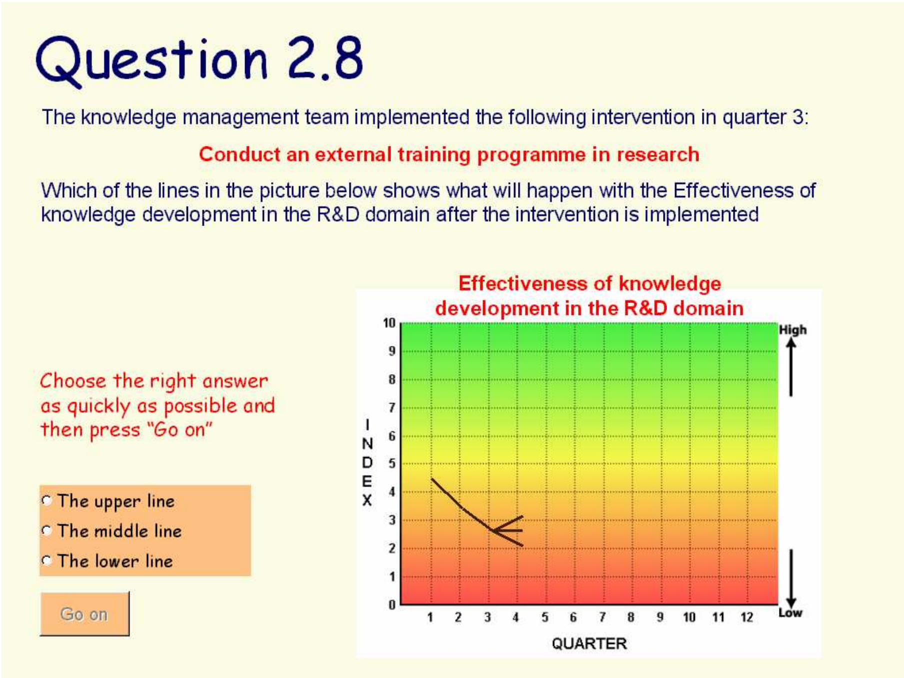


Figure 5-3. *Example of an implicit knowledge item.*

5.2.2.2 Transfer task

A transfer task was administered after the post-test was completed. The KM Quest game is situated in a large product leadership organization (see Treacy and Wiersema, 1995). The transfer task used a different type of company: a small customer relationship type of company (a travel agency called HollandSky). The first type of company competes by bringing innovative products to the market before competitors do so. This implies short product life cycles and innovative research and development. The second type of company competes by trying to become a partner for a limited number of clients through providing customised solutions.

In the task a case description was presented with four event descriptions. For each event students were asked to answer the following questions:

- Indicate what kind of event is presented. Eight alternatives were presented, like: an internal problem/threat that calls for KM actions, an internal problem but not KM related.
- The general management of HollandSky expects from you as a knowledge manager, an advice about which actions to take to react upon the KM related problem, threat or opportunity that the company is facing (in KM Quest™ we do not talk about actions but about interventions that should be implemented).
- Describe which activities you (as a knowledge manager) would perform before coming up with a set of interventions. Which steps would you take, and what are their goals?
- Based on the information you have so far, which (set of) knowledge management interventions would you propose to the management of HollandSky?
- Indicate what the expected effect of each of the proposed interventions is on certain business indicators, processes, and/or on specific types of knowledge.

Students could take the assignment home and had to hand it in a few days later. A disadvantage was that there could have been communication between the students about the assignment. However, since it was an assignment that was part of the final grade for the entire course it was expected that students would not do so. A standardised scoring table was used. The maximum score on the transfer test was 20 points.

5.2.2.3 Logfiles

Player performance in the game was logged into a database. These data make it possible to see for each of the twelve quarters in the game, which resources people used (and in which order), which interventions they implemented and what the values of the business and knowledge process indicators were.

5.2.3 Procedure

In the first lecture of the course the set up of the course was described and KM Quest was introduced. In two consecutive weeks following on this lecture two four-hour sessions were planned to work with the KM Quest environment. The sessions were located in a computer room with a large number of computers. Each student had a computer.

At the start of the first session the general procedure was explained. Students were told that they would get a pre-test and a post-test after the game was played and an additional assignment (the transfer task). It was indicated that the goal of this pre and post-test was to give the course lecturers an idea of the effectiveness of the game as a learning tool in the course. Furthermore, it was explained that players were expected to play 12 quarters in the game and were supposed to reach the games goals, but that the fact whether they reached these goals or not, would not effect their grades for the course. The transfer task was used to give students a grade. This was part of the final grade for the course.

After the introduction by the lecturer, the pre-test was given to the students. After the students completed this test they received the Internet address (and password) to access the server where they could find the learning environment. They were urged to read the introductory texts and to work through the training demo (see Section 4.5.2). After they had finished the training demo they received a note with the login name and password to actually play the simulation game. Students also could access the game outside the session, for instance from a home computer (as long as this was using Internet Explorer 6). Students in the condition with additional assignments were instructed that there was a link in the Coltec newspaper to these extra tools that could be used from quarter 2 onwards. During the session a lecturer was available to answer questions or solve technical problems.

In the second session students could finish the game and after they did, they were given the post-test. After they finished the post-test, they received the additional assignment (transfer task), which they had to make at home. Students were not able to get access to the game environment while they were working on the transfer task.

A debriefing session was held in one of the course lectures after the students had handed in the transfer task. In this session the lecturer summarized the data from the playing phase of the game and gave examples of the actions taken, based on the data from two students: one who did well and one who performed worse.

5.3 Results

First data are presented from the tests. Next data are described about game performance. Finally data are presented about the use of additional and standard tools and the relationship between the use of these tools (based on the logfiles) and test scores as well as game performance.

5.3.1 Test results

Table 5-1 shows the average scores (and standard deviations) on the pre-test and post-test for the total group and the groups with the standard support tools and with the additional assignments. On the pre-test students on average gave a good answer on 38.4% of the items. On the post-test this was 48.7%. Although the score on the post-test is still low, there is evidence for a small learning gain. The difference between the post-test and pre-test score was significant for both experimental groups (paired samples t-test Additional assignments group: t=-3.26, df=14, p=0.006; Standard tools: t=-3.43, df=10, p=0.006). The gain of knowledge especially occurs on the explicit knowledge items. The difference between the post-test and pre-test score on these items was significant for both experimental groups (paired samples t-test Additional assignments group: t=-3.46, df=14, p=0.004; Standard tools: t=-3.16, df=10, p=0.01). The difference on the implicit knowledge items was not significant. There are no significant differences between the two experimental groups on the pre-test, post-test as well as on the transfer test.

Table 5-1. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the pre-test and post-test and the score on the transfer test for the total group and for the groups with standard tools and with additional assignments.

	Pre-expl max=18	Pre-impl max=8	Pre-tot max=26	Post-expl max=18	Post-impl max=8	Post-tot max=26	Transfer max=20
Add. Assign.	7.20 (1.57)	2.73 (1.22)	9.93 (1.91)	9.31 (1.70)	3.00 (1.10)	12.31 (2.27)	13.13 (2.42)
Standard	7.75 (1.96)	2.42 (0.90)	10.17 (2.44)	10.56 (2.11)	2.64 (0.92)	13.18 (5.71)	12.22 (2.77)
Total	7.44 (1.74)	2.59 (1.08)	10.04 (2.12)	9.81 (1.94)	2.85 (1.03)	12.67 (2.40)	12.80 (2.53)

Table 5-2. Average number of correct answers (and standard deviations) on the different types of explicit knowledge items of the pre-test and post-test referring to concepts (con), events (ev), knowledge management model (km), and relationships (rel) for the total group and for the groups with standard tools and with additional assignments.

	Pre-con Max=7	Pre-ev max=2	Pre-km max=3	Pre-rel max=6	Pst-con max=7	Pst-ev max=2	Pst-km max=3	Pst-rel max=6
Add. assign.	2.67 (1.05)	1.73 (0.46)	1.33 (0.90)	1.47 (0.99)	4.38 (1.26)	1.75 (0.45)	1.13 (0.81)	2.06 (1.06)
Standard	3.17 (1.34)	1.67 (0.65)	1.25 (0.87)	1.67 (1.23)	4.45 (1.13)	2.00 (0.00)	1.27 (0.90)	2.82 (1.33)
Total	2.89 (1.19)	1.70 (0.54)	1.30 (0.87)	1.56 (1.09)	4.41 (1.19)	1.85 (0.36)	1.19 (0.83)	2.37 (1.21)

Several types of questions were included in the explicit knowledge items: questions about concepts, events, steps in the knowledge model and questions about the relationship between interventions and indicators. In Table 5-2 the average number of correct answers is presented for each of these types. This indicates that the average knowledge gain on the explicit items of 2.4 (see Table 5-1) is mainly due to a gain of conceptual knowledge about knowledge processes and the like. The difference between pre- and post-test scores is significant for both experimental groups (paired samples t-test Additional assignments group: t=-4.01, df=14, p=0.001; Standard tools: t=-2.67, df=10, p=0.024). And to a lesser degree to a gain in knowledge about the relationship between interventions and indicators (only a significant difference for the standard tools group: paired samples t-test: t=-3.55, df=10, p=0.005). This last type of knowledge could have been induced by the students themselves, but also was available to students by means of the feedback that was given and indirectly by the advice functionality that was available. A third source was the interventions handbook. The advice actually refers to certain parts of the interventions handbook. The differences between the two experimental groups on the four different types of items were not significant.

5.3.2 Game performance

Table 5-3 shows the starting and end values (after quarter 12 is finished) for some of the business indicators. It shows that it was difficult to improve market share. Most of the students managed to improve it during the game, but at the end market share went down again. Most of the other indicators have been improved substantially. There were only small differences between the two experimental groups.

Further research showed that market share went down because of a combination of events that had a negative influence on market share. This also had an influence on profit and turnover.

Table 5-3. Average values for some important business (process) indicators in the business simulation model at the end of the game for the total group and for the groups with standard tools and with additional assignments. At the bottom row the starting values.

	MS*	CSI	Profit	JSI	PQI	ATM	Turnover
Add. assign.	18.09 (2.69)	7.48 (0.70)	37.1 (16.3)	8.91 (2.15)	8.57 (1.76)	1.37 (0.70)	559.7 (83.1)
Standard	18.81 (5.71)	7.56 (0.93)	47.3 (23.7)	8.63 (1.78)	8.66 (1.00)	1.49 (0.72)	632.2 (113.0)
Total	18.39 (4.10)	7.51 (0.78)	41.3 (19.9)	8.80 (1.98)	8.61 (0.85)	1.40 (0.70)	587.6 (100.2)
Start values	20.0	4.40	-	4.22	4.80	2.4	625.0

* MS = Market share, CSI = Customer satisfaction index, Profit = Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM = Average time for new product to market, Turnover in last quarter in millions.

Table 5-4. Average level of competence in three knowledge domains for the total group and for the groups with standard tools and with additional assignments. At the bottom row the starting values. Scale from 1 to 10.

	Competence in marketing	Competence in R&D	Competence in production
Add. assign.	7.99 (1.47)	7.95 (1.04)	5.72 (1.23)
Standard	8.62 (1.78)	8.33 (1.16)	5.96 (1.15)
Total	8.25 (1.75)	8.11 (1.08)	5.82 (1.18)
Start values	4.93	4.38	5.34

Table 5-4 shows the average level of competence in the three knowledge domains within the Coltec company at the end of the game together with the starting values. Level of competence in the marketing and in the research and development domain has been improved considerably. In the production domain only a small improvement has been achieved. This is due to the fact that indicators related to the knowledge processes of gaining and development in the production domain were very low. For instance the average value of the effectiveness of knowledge gaining was 2.7 and of knowledge development was 4.3. In the R&D domain these values were 6.1 and 9.5 and in the marketing domain 8.2 and 8.2. During game play it became clear that the

KM Quest environment did not contain enough interventions to influence these two knowledge processes in that particular domain.

5.3.3 Relationship between test results and game play

From the sections above it is clear that players gain knowledge and that they are able to improve business and knowledge indicators. It is interesting to see whether there is a correlation between the scores on the tests and the values of game indicators. Table 5-5 shows that the correlations between pre-test and post-test score, knowledge gain (from pre-test to post-test) and some of the business and knowledge indicators for both groups are very low. None of them was significant. So there are no indications that a high level of prior knowledge leads to “better” game play or that being able to perform well in the game also means that one has a high post-test score or high knowledge gain.

Table 5-5. Correlation between total pre-test and post-test score, knowledge gain and the average values for some important business and knowledge indicators at the end of the game for the groups with standard tools and with additional assignments.

	MS*	CSI	JSI	PQI	CM	CR	CP
Add. assign.							
Pre-test	-.05	.30	.23	.31	.09	.27	.15
Post-test	.15	.14	-.04	.15	.12	.24	-.03
Kn. gain	.19	-.07	-.18	-.07	.05	.02	-.12
Standard							
Pre-test	-.03	.08	.33	.07	.23	.11	.18
Post-test	-.18	.21	-.10	.24	.12	.34	.20
Kn. gain	.01	.12	-.30	.16	-.10	.21	.02

* MS = Market share, CSI = Customer satisfaction index, JSI = Job satisfaction index, PQI = Product quality index, CM= Level of competence in marketing, CR= Level of competence in R&D, CP= Level of competence in production.

5.3.4 Use of additional assignments

As stated before the players in the condition with additional assignments could use these assignments, but their use was not enforced by the system. It was possible to ignore them. As it turned out 5 students (out of 16) never formulated a lesson learned and 4 never answered a focus question. The average number of quarters in which a lesson learned was formulated was 5.50 (standard deviation is 4.43) and the average number of quarters in which a focus question was answered was 5.31 (standard deviation 4.25).

Table 5-6. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the pre-test and post-test and the score on the transfer test for the total group with additional assignments and for the groups who formulated lessons learned in 5 quarters or less and for those who did in 6 quarters or more.

	Pre-expl max=18	Pre-impl max=8	Pre-tot max=26	Post-expl max=18	Post-impl max=8	Post-tot max=26	Transfer max=20
LL in < 6 quarters N=8	7.43 (1.62)	2.71 (1.11)	10.14 (1.68)	10.25 (1.39)	3.00 (0.93)	13.25 (2.12)	12.50 (2.51)
LL in > 6 quarters N=8	7.00 (1.60)	2.75 (1.39)	9.75 (2.19)	8.38 (1.51)	3.00 (1.31)	11.38 (2.13)	13.75 (2.32)
Total	7.20 (1.57)	2.73 (1.22)	9.93 (1.91)	9.31 (1.70)	3.00 (1.10)	12.31 (2.27)	13.13 (2.42)

If a comparison is made of the score on the explicit items of the post-test (see Table 5-6) between the group that formulated lessons learned less than the average (5 quarters or less) and those who did more often than the average (6 quarters or more) it shows that the first group has a score that is significantly higher than the second group (Anova: F=6.70, df=1, p=0.021).

The same holds for those students who answered the focus questions less than the average and those who did more often (see Table 5-7). The first group has a significantly higher score on the explicit knowledge items (Anova F=9.02, df=1, p=0.009) and total test score than the second group (Anova F=5.36, df=1, p=0.036).

These two measures are not independent. Analysis showed that students who used focus questions often were the same as those who formulated lessons learned often (except for one student).

Table 5-7. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the pre-test and post-test and the score on the transfer test for the total group with additional assignments and for the groups who answered focus questions in 5 quarters or less and for those who did in 6 quarters or more.

	Pre-expl max=18	Pre-impl max=8	Pre-tot max=26	Post-expl max=18	Post-impl max=8	Post-tot max=26	Transfer max=20
FQ in < 6 quarters N=9	7.38 (1.51)	2.63 (1.06)	10.00 (1.60)	10.22 (1.30)	3.11 (0.93)	13.33 (2.00)	12.67 (2.40)
FQ in > 6 quarters N=7	7.00 (1.73)	2.86 (1.46)	9.86 (2.34)	8.14 (1.46)	2.86 (1.35)	11.00 (2.00)	13.71 (2.50)
Total	7.20 (1.57)	2.73 (1.22)	9.93 (1.91)	9.31 (1.70)	3.00 (1.10)	12.31 (2.27)	13.13 (2.42)

The use of focus questions and lessons learned obviously did not support the acquisition of explicit knowledge as was expected. This might be because they mainly focus the attention of the players on game behaviour and game goals (maximise market share, customer satisfaction and profit) and to a lesser degree on underlying principles and ideas or the knowledge management model. To illustrate this, some of the lessons learned formulated by different players are presented below.

- *“I have to give more attention to customer satisfaction.”*
- *“Market share had to be improved and I succeeded in doing that”*
- *“Keep your customers satisfied!”*
- *“Training people was a good idea, but turned out to be bad for the profit”*
- *“To improve things you have to spend money, but you have to look how many years you have to do with your money. In my case I have spend too much money, because I have to do 9 quarters with the same money as I spend in 3 quarters”*

5.3.5 Access of standard tools

Learning and reflection in the KM Quest environment was supported in several ways. Several resources were available that could give the learners additional information when needed, like an Intervention handbook, Indicator handbook, what, how and help files, and visualisation tools. Players could look at past performance by means of historic data about their own actions and about the status of the business model indicators (history). Furthermore, they could get feedback on the previous events (type of event, and possible interventions), and they could get advice (alerts that indicate that certain indicators are low and that give hints about the types of interventions that could be implemented).

Table 5-8 gives an indication about the frequency of access of the support tools available in the system. The table shows that advice is accessed frequently by most of the players: in 83% of the quarters where advice was available it actually was consulted (students pressed the advice button in the menu bar to display information). The Intervention handbook, the feedback and the visualisation tool were also accessed frequently (in about half of the 12 quarters). The other support tools/information are rarely accessed. It is striking that the history information about one's own behaviour (as well as system and business model behaviour) is hardly used at all. Although there are differences in the use of tools between the two experimental conditions, none are significant. Within the additional assignments group there were also no significant differences between the subjects who accessed the focus questions and lessons learned often and those who did not.

Table 5-8. Average number of quarters in which a selection of the standard support tools were used by the learners for the total group and for the groups with standard tools and with additional assignments.

	Feedb	Adv*	Intv HB	Indc HB	Hist	What	How	Help	Visual
Add. assign.	6.25 (4.31)	0.78* (0.31)	6.38 (1.91)	1.44 (1.15)	0.81 (0.83)	0.75 (0.66)	0.63 (0.62)	0.31 (0.47)	5.50 (3.97)
Standard	7.18 (3.66)	0.89* (0.30)	7.00 (3.46)	2.73 (3.00)	1.82 (0.92)	0.91 (0.70)	0.82 (0.60)	0.45 (0.52)	8.18 (3.76)
Total	6.63 (4.01)	0.83* (0.31)	6.62 (3.63)	1.96 (2.16)	1.22 (1.43)	0.81 (0.68)	0.70 (0.61)	0.37 (0.49)	6.59 (4.04)

- *Use of advice is indicated by a proportional measure (number of quarters advice was used divided by the number of quarters advice was actually available in the system)*

5.4 Differences between players with a high and low knowledge gain

In this section a different view on the data is presented. It is investigated whether players with a low knowledge gain from pre-test to post-test (1 point or less) behave differently in the game than players who have high gain (4 points or more). A comparison of the access of some of the support tools (feedback, advice, intervention handbook and visualisations) of these groups of players is made. The other support tools were not included because they were sparsely used.

A comparison of the data presented in Table 5-9 shows that the students with high a knowledge gain accessed the support tools more often, except for the advice functionality. The difference between the total group scores regarding the access of feedback is significant ($t=-2.09$, $df=18$, $p=0.05$).

Table 5-9. Average number of quarters in which a selection of the standard support tools were used by the learners with a low knowledge gain from pre-test to post-test (1 point or less) and with a high knowledge gain (4 points or more) for the groups with standard tools and with additional assignments.

	Feedback	Advice	Intervention HB	Visualisations
Add. assignments				
Low, N=5	5.00 (3.81)	0.88*(0.09)	6.20 (1.64)	3.20 (2.77)
High, N=7	8.57 (3.87)	0.85 (0.26)	7.43 (4.65)	7.43 (4.35)
Standard				
Low, N=4	6.75 (3.77)	1.00 (0.00)	5.00 (2.94)	8.25 (3.59)
High, N=4	10.00 (2.71)	0.95 (0.11)	8.75 (2.75)	9.00 (4.24)
Total group				
Low, N=9	5.78 (3.67)	0.93 (0.31)	5.67 (2.24)	5.44 (3.97)
High, N=11	9.09 (3.42)	0.88 (0.31)	7.91 (3.96)	8.00 (4.17)

The table indicates that a low knowledge gain is not related to non-use of the support tools. The data however also seem to indicate that more frequent access of some of the standard support tools is related to the gain of knowledge. In the next section this will be investigated into more detail.

5.5 Additional analyses on the use of support tools

In the next subsections it will be investigated whether there is a relationship between the use of some of support tools (the ones that have been used regularly) and game performance and learning. In this analysis the two experimental groups were taken together because the analyses presented in the previous sections showed that there were no significant differences between these groups. New groups were distinguished based on the frequency of access of particular support tools. It was decided to divide the total group into three. Using two groups probably would mean that certain nuances would not be visible and using four groups or more probably would mean that the number of students within groups would be too small to find meaningful differences. The same grouping procedure was used in all sections.

Caution has to be taken with conclusions based on these analyses. There is a possibility that intermediate variables that have not been measured play a role. For instance, it could be that the use of specific tools coincides with certain personal traits or intelligence level. This could mean that the analysis reveals a relationship between the use of feedback and knowledge gain while in fact there is a relationship between intelligence and knowledge gain.

Furthermore, the groups that are distinguished in the different sections are not totally independent. It might be that the players who use feedback often also use the intervention handbook often. In that case it is difficult to attribute differences in test scores to the use of one or the other support tool. To get an impression whether there is a relationship between the access of the support tools that will be dealt with in the next sections, a correlation analysis was performed. As stated above the players have been divided into three groups based on the frequency of the access of each of the supports. An analysis showed that there is a correlation of 0.46 between the access of feedback and of the intervention handbook ($p=0.015$). Furthermore, there is a correlation of 0.24 ($p=0.23$) between access of feedback and of visualisation tools, and of 0.27 ($p=0.17$) between the access of intervention handbook and visualisation tools. These last two are not significant. This indicates that the grouping of players is not the same for each of the different support tools. This means that the ones who access feedback often are not the same ones as those who access the visualisations often.

5.5.1 Feedback

In this section data are presented about the relationship between the (frequency of) access of feedback and test scores, as well as game performance.

5.5.1.1 Test scores

Table 5-10 shows the average post-test scores and knowledge gaining score for different groups of learners. For those who actually consulted feedback in 0–4 quarters in the game, for those who did use feedback in 4-8 quarters and for those who did so in 9-12 quarters. There are significant differences between groups on the explicit knowledge items of the post-test (Anova: $F=3.37$, $df=2$, $p=0.038$) and regarding knowledge gain (Anova: $F=3.50$, $df=2$, $p=0.047$). A post-hoc analysis (a Tukey HSD test for multiple comparisons) revealed that those who consulted feedback in more than 2/3 of the quarters gave significantly more good answers on the explicit knowledge items of the post-test ($p=0.048$) in comparison to those who consulted feedback in less than 1/3 of the quarters. The difference in knowledge gain between these two groups was not significant ($p=0.11$). Their pre-test scores were almost the same: 9.70 (standard deviation 2.16) for the first group and 9.55 (standard deviation 2.11) for the last group.

Table 5-10. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test and average knowledge gain compared to the pre-test, for the total group and for groups who actually consulted the feedback information in different number of quarters.

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
Feedback consulted in 0-4 quarters N=10	8.60 (1.90)	2.90 (1.45)	11.50 (2.88)	1.80 (2.25)	13.00 (3.59)
Feedback consulted in 5-8 quarters N=5	10.60 (2.07)	2.20 (0.45)	12.80 (2.28)	1.00 (2.24)	13.50 (1.73)
Feedback consulted in 9-12 quarters N=12	10.50 (1.51)	3.08 (0.67)	13.58 (1.68)	4.18 (2.96)	12.36 (1.57)
Total group	9.81 (1.94)	2.85 (1.03)	12.67 (2.40)	2.65 (2.83)	12.80 (2.53)

If the pre-test and post-test scores on four different types of explicit knowledge items are compared (see Table 5-11) it appears that the difference in post-test scores is mainly due to a difference in knowledge about the concepts that are used in the learning environment (Anova: F=4.05, df=2, p=0.03). A post-hoc analysis (a Tukey HSD test for multiple comparisons) revealed that those who consulted feedback in more than 2/3 of the quarters gave significantly more good answers on the conceptual knowledge items of the post-test (p=0.02) in comparison to those who consulted feedback in less than 1/3 of the quarters.

Table 5-11. Average number of correct answers (and standard deviations) on the different types of explicit knowledge items (about *con*cepts, *ev*ents, *k*nowledge *m*anagement model, and *rel*ationships) of the pre-test and post-test for the total group and for the groups who actually consulted the feedback information in different number of quarters.

	Pre-con	Pre-ev	Pre-km	Pre-rel	Pst-con	Pst-ev	Pst-km	Pst-rel
FB in 0-4 quarters N=10	3.10 (1.10)	1.80 (0.42)	1.10 (0.88)	1.20 (0.79)	3.70 (0.67)	1.70 (0.48)	1.00 (0.67)	2.20 (1.14)
FB in 5-8 quarters N=5	2.26 (0.89)	1.60 (0.89)	1.80 (0.84)	2.60 (1.52)	4.40 (1.34)	2.00 (0.00)	0.80 (0.83)	3.40 (1.14)
FB in 9-12 quarters N=12	2.91 (1.44)	1.64 (0.50)	1.36 (0.81)	1.27 ().79)	5.00 (1.21)	1.92 (0.29)	1.50 (0.90)	2.08 (1.16)
Total	2.92 (1.20)	1.69 (0.55)	1.35 (0.85)	1.50 (1.07)	4.41 (1.19)	1.85 (0.36)	1.19 (0.83)	2.37 (1.21)

5.5.1.2 Game performance

The number of times feedback was consulted also had an effect on certain aspects of game performance (see Table 5-12 and Table 5-13). There are significant difference between groups on the product quality index (Anova: F=8.71, df=2, p=0.001), and on the level of competence in research and development (Anova: F=13.71, df=2, p=0.000). A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that in both cases the value of the group who consulted feedback in 0-4 quarters was significantly lower (p<0.03) than that of the other two groups.

Table 5-12. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually consulted the feedback information in different numbers of quarters.

	MS*	CSI	Profit	JSI	PQI	ATM	Turnover
FB in 0-4 quarters N=10	16.68 (4.95)	6.86 (0.82)	35.0 (22.7)	8.22 (2.69)	7.91 (0.89)	1.59 (0.79)	5.62 (0.91)
FB in 5-8 quarters N=5	20.44 (3.08)	7.80 (0.66)	50.6 (13.8)	9.27 (1.62)	8.90 (0.71)	1.22 (0.63)	6.40 (0.97)
FB in 9-12 quarters N=12	18.95 (3.38)	7.93 (0.38)	42.5 (19.1)	9.08 (1.37)	9.06 (0.39)	1.33 (0.67)	5.85 (1.08)
Total group	18.39 (4.10)	7.51 (0.79)	41.3 (19.9)	8.80 (1.98)	8.61 (0.85)	1.40 (0.70)	5.88 (1.00)

* MS = Market share, CSI = Customer satisfaction index, Profit= Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM = Average time for new product to market, Turnover in last quarter in hundred millions.

Table 5-13. Average level of competence in three domains for the total group and for the total group and for groups who actually consulted the feedback information in different numbers of quarters.

	Competence in marketing	Competence in R&D	Competence in production
FB in 0-4 quarters N=10	7.29 (2.08)	7.10 (0.90)	5.27 (1.39)
FB in 5-8 quarters N=5	9.13 (1.19)	8.47 (0.76)	6.13 (1.22)
FB in 9-12 quarters N=12	8.67 (1.33)	8.79 (0.65)	6.14 (0.87)
Total group	8.25 (1.75)	8.11 (1.08)	5.82 (1.18)

5.5.2 Advice

On the average advice was available in 10.85 of the quarters (see Table 5-14). The advice functionality was used very often. In 83% of the quarters that advice was available it was actually accessed by the players.

Additional analysis of the logfiles showed that once players have discovered the advice functionality, this is often the first resource that is opened in a new game quarter. While observing players, the experimenter heard them make comments like "Let's see what my adviser says". Players seem to be using the advice as a first indication that steers the search for additional cues and that steers the selection of interventions.

Comparison of groups who used advice frequently and those who did less frequently is difficult because advice is not always available. If a player is doing well in the game there is no advice and therefore it can not be accessed. That is why the proportion of advice that is actually accessed is also given in the table. However, this measure also has some drawbacks. Somebody who receives advice twice and opens it twice gets the same proportional value as somebody who has advice available in 12 quarters and accesses it in 12 quarters. In fact, this latter player received more information than the first because he was not doing well in the game. Table 5-14 shows that advice was available very often and accessed often also. This means that there is only a very small group who could access advice in a limited number of quarters. Therefore the proportional measure is used in the following analyses.

Table 5-14. Availability and access of advice (in numbers of quarters) for the groups with standard tools and with additional assignments.

	Advice available	Advice accessed	Proportion of advice accessed
Add. assign.	11.38 (1.99)	9.00 (4.11)	0.78 (0.31)
Standard	10.09 (2.12)	8.82 (3.65)	0.89 (0.30)
Total	10.85 (2.11)	8.93 (3.86)	0.83 (0.31)

5.5.2.1 Test scores

In Table 5-15 the average post- and transfer test scores are given as well as knowledge gain (from pre-test to post-test) for three groups based on the proportion of advice that was consulted. It shows that the first two groups are very small, and therefore is hard to find meaningful and significant differences. In fact, analyses of variance of test scores did not reveal any such differences.

Table 5-15. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test and average knowledge gain compared to the pre-test, for the total group and for groups who actually accessed the advice in different number of quarters (proportional measure).

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
Adv. Prop 0 - 0.33 **N=3**	9.00 (0.00)	2.67 (0.50)	11.67 (0.58)	2.67 (0.58)	12.00 (4.58)
Adv. Prop 0.33 - 0.66 **N=2**	10.50 (0.71)	3.50 (0.71)	14.00 (0.00)	5.00 (0.00)	12.00 (2.83)
Adv. Prop 0.67 - 1 **N=22**	9.86 (2.12)	2.82 (1.09)	12.68 (2.61)	2.43 (3.06)	13.00 (2.29)
Total group	9.81 (1.94)	2.85 (1.03)	12.67 (2.40)	2.65 (2.83)	12.80 (2.53)

5.5.2.2 Game performance

Looking at game performance (see Table 5-16 and Table 5-17) analyses of variance showed significant differences ($p<0.01$) on all indicators except for ATM and profit, even though some of the groups were very small. A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that in all cases the value of the first group (0-0.33) was significantly lower than that of the other two groups. So there seems to be a relationship between game performance and the use of advice.

Table 5-16. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually accessed advice in different numbers of quarters (proportional measure).

	MS*	CSI	Profit	JSI	PQI	ATM	Turnover
Adv. Prop **0 - 0.33** **N=3**	11.63 (6.46)	5.93 (0.85)	31.3 (35.8)	4.27 (0.69)	6.90 (0.89)	2.13 (1.23)	3.29 (2.58)
Adv. Prop **0.33 - 0.66** **N=2**	19.50 (0.57)	8.00 (0.42)	50.7 (19.9)	10.00 (0.00)	9.15 (0.49)	0.75 (0.07)	6.09 (0.17)
Adv. Prop **0.67 - 1** **N=22**	19.20 (3.38)	7.68 (0.53)	41.8 (18.0)	9.29 (1.27)	8.79 (0.56)	1.45 (0.72)	5.96 (0.98)
Total group	18.39 (4.10)	7.51 (0.79)	41.3 (19.9)	8.80 (1.98)	8.61 (0.85)	1.40 (0.70)	5.88 (1.00)

Table 5-17. Average level of competence in three domains for the total group and for the total group and for groups who actually accessed advice in different numbers of quarters (proportional measure).

	Competence in marketing	Competence in R&D	Competence in production
Adv. Prop 0 - 0.33	5.17	6.37	3.65
N=3	(2.36)	(1.09)	(1.04)
Adv. Prop 0.33 - 0.66	8.65	8.58	6.92
N=2	(1.92)	(0.82)	(0.80)
Adv. Prop 0.67 - 1	8.63	8.30	6.02
N=22	(1.25)	(0.90)	(0.88)
Total group	8.25	8.11	5.82
	(1.75)	(1.08)	(1.18)

5.5.3 The intervention handbook

In this section data will be presented about the relationship between the (frequency of) use of the intervention handbook and test scores, as well as game performance. The intervention handbook contains descriptions of the interventions that can be implemented and information about the costs involved, the knowledge domains they are related to, and the knowledge processes that they can influence. In the analysis the two experimental groups are taken together and new groups are distinguished. The grouping procedure was the same one as described Section 5.5.

5.5.3.1 Test scores

Analyses of variance revealed significant differences between groups for the explicit knowledge items (Anova: F=4.70, df=2, p=0.02) and for the total post-test score Anova: F=3.33, df=2, p=0.05). A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that heavy users of the intervention handbook (2/3 of the quarters or more) have significant higher test scores than the group who did in 5-8 quarters. Other comparisons showed no significant differences between groups.

In Table 5-19 the scores on the different types of the explicit knowledge items on the post-test are presented. Analysis showed that there is a significant difference on the items that refer to concepts that are used in the game (Anova: F=5.60, df=2, p=0.01. A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that there is a significant difference between the heavy users of the intervention handbook (2/3 of the quarters or more) and the other two groups.

Table 5-18. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test, average knowledge gain compared to the pre-test, and transfer test score for the total group and for groups who actually consulted the intervention handbook in different numbers of quarters.

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
Int. HB consulted in 0-4 quarters	9.75	2.75	12.50	2.38	11.25
N=8	(1.75)	(1.16)	(2.78)	(2.50)	(2.96)
Int. HB consulted in 5-8 quarters	8.70	2.80	11.50	1.70	13.63
N=10	(1.70)	(1.23)	(2.17)	(3.40)	(2.45)
Int. HB consulted in 9-12 quarters	11.11	3.00	14.11	4.13	13.44
N=9	(1.69)	(0.71)	(1.62)	(1.89)	(1.67)
Total group	9.81	2.85	12.67	2.65	12.80
	(1.94)	(1.03)	(2.40)	(2.83)	(2.53)

Table 5-19. Average number of correct answers (and standard deviations) on the different types of explicit knowledge items of the pre-test and post-test (concepts, events, knowledge management model, and relationships) for the total group and for the groups who actually consulted the intervention handbook in different numbers of quarters.

	Pre-con	Pre-ev	Pre-km	Pre-rel	Pst-con	Pst-ev	Pst-km	Pst-rel
IHB in 0-4 quarters N=8	2.88 (0.83)	1.75 (0.46)	1.00 (0.76)	1.75 (1.58)	4.00 (0.76)	1.88 (0.35)	1.13 (0.64)	2.75 (1.28)
IHB in 5-8 quarters N=10	3.00 (1.33)	1.80 (0.42)	1.40 (1.08)	1.20 (0.79)	3.90 (0.99)	1.80 (0.42)	1.00 (1.05)	2.00 (0.94)
IHB in 9-12 quarters N=9	2.88 (1.46)	1.50 (0.76)	1.63 (0.52)	1.63 (0.74)	5.33 (1.22)	1.89 (0.33)	1.44 (0.73)	2.44 (1.42)
Total	2.92 (1.20)	1.69 (0.55)	1.35 (0.85)	1.50 (1.07)	4.41 (1.19)	1.85 (0.36)	1.19 (0.83)	2.37 (1.21)

5.5.3.2 Game performance

Looking at game performance there are differences between groups (see Table 5-20 and Table 5-21). But only the difference in the customer satisfaction index is significant (Anova: F=3.43, df=2, p=0.049). The groups who use the intervention handbook on 1/3 of the quarters or more have better scores than the ones who hardly use the book.

Table 5-20. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually consulted the intervention handbook in different numbers of quarters.

	MS*	CSI	Profit	JSI	PQI	ATM	Turnover
IHB in 0-4 quarters N=8	15.86 (5.18)	6.95 (1.05)	42.2 (24.0)	7.78 (2.86)	8.01 (1.13)	1.66 (0.89)	4.83 (1.95)
IHB in 5-8 quarters N=10	19.81 (3.04)	7.76 (0.56)	36.2 (17.4)	9.76 (0.67)	8.86 (0.59)	1.36 (0.88)	6.20 (0.96)
IHB in 9-12 quarters N=9	19.04 (3.40)	7.73 (0.51)	46.0 (19.5)	8.64 (1.69)	8.86 (0.55)	1.43 (0.66)	5.85 (1.08)
Total group	18.39 (4.10)	7.51 (0.79)	41.3 (19.9)	8.80 (1.98)	8.61 (0.85)	1.40 (0.70)	5.68 (1.43)

Table 5-21. Average level of competence in three domains for the total group and for the total group and for groups who actually consulted the intervention handbook in different numbers of quarters.

	Competence in marketing	Competence in R&D	Competence in production
IHB in 0-4 quarters N=8	7.08 (2.28)	7.39 (1.22)	5.14 (1.59)
IHB in 5-8 quarters N=10	8.82 (1.14)	8.25 (1.09)	6.42 (0.61)
IHB in 9-12 quarters N=9	8.64 (1.39)	8.59 (0.62)	5.76 (1.01)
Total group	8.25 (1.75)	8.11 (1.08)	5.82 (1.18)

5.5.4 The visualisation tools

In this last section data will be presented related to the use of the visualisation tools. There are large differences between players in the access of these tools. Ten players use these tools only in 1/3 of the quarters or less. There are also ten players that uses them in 2/3 or more.

5.5.4.1 Test scores

The use of the visualisation tools is not related to differences on the post-test scores or on the transfer test score (see Table 5-22). The differences between the groups are very small.

Table 5-22. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test, average knowledge gain compared to the pre-test, and transfer test score for the total group and for groups who actually used the visualisation tools in different numbers of quarters.

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
Visualisation used in 0-4 quarters N=10	9.90 (2.28)	2.80 (1.03)	12.70 (3.06)	2.56 (3.28)	11.90 (2.51)
Visualisation used in 5-8 quarters N=7	9.57 (2.15)	3.29 (1.11)	12.86 (1.77)	2.00 (2.89)	14.00 (2.16)
Visualisation used in 9-12 quarters N=10	9.90 (1.60)	2.60 (0.97)	12.50 (2.27)	3.20 (2.53)	12.88 (2.70)
Total group	9.81 (1.94)	2.85 (1.03)	12.67 (2.40)	2.65 (2.83)	12.80 (2.53)

5.5.4.2 Game performance

Looking at game performance, there are some differences between groups (see Table 5-23 and Table 5-24), but most of these are not significant, except for market share (Anova: F=3.76, df=2, p=0.04) and profit (Anova: F=5.54, df=2, p=0.01). A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that players who used the visualisation tools only rarely have significantly lower scores on market share and profit than the other two groups.

Table 5-23. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually used the visualisation tools in different numbers of quarters.

	MS*	CSI	Profit	JSI	PQI	ATM	Turnover
Vis. in 0-4 quarters N=10	15.83 (5.17)	7.19 (1.06)	29.4 (22.0)	8.59 (2.36)	8.29 (1.16)	1.75 (0.87)	4.85 (1.88)
Vis. in 5-8 quarters N=7	19.61 (2.59)	7.86 (0.38)	38.9 (16.0)	10.0 (0.00)	8.97 (0.41)	1.37 (0.97)	6.13 (0.81)
Vis. in 9-12 quarters N=10	20.08 (2.43)	7.59 (0.59)	54.7 (19.5)	8.16 (2.03)	8.67 (0.62)	1.27 (0.54)	6.19 (0.83)
Total group	18.39 (4.10)	7.51 (0.79)	41.3 (11.2)	8.80 (1.98)	8.61 (0.85)	1.40 (0.70)	5.68 (1.43)

* MS = Market share, CSI = Customer satisfaction index, Profit= Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM = Average time for new product to market, Turnover in last quarter in hundred millions.

Table 5-24. Average level of competence in three domains for the total group and for the total group and for groups who actually used the visualisation tools in different numbers of quarters.

	Competence in marketing	Competence in R&D	Competence in production
Vis. in 0-4 quarters	7.51	7.73	5.61
N=10	(2.29)	(1.44)	(1.47)
Vis. in 5-8 quarters	8.44	8.38	6.23
N=7	(1.08)	(0.73)	(0.61)
Vis. in 9-12 quarters	8.85	8.29	5.74
N=10	(1.39)	(0.62)	(1.21)
Total group	8.25	8.11	5.82
	(1.75)	(0.85)	(1.18)

5.6 Additional data from the logfiles and observations

Data presented in the sections above about the frequency of access of several tools were based on the data that were logged while playing the game. Analyses of these files revealed some other interesting findings that are briefly described below together with data from observations of some players.

Data showed that players in the beginning of game play tend to access most of the worksheets that are related to the steps of the knowledge management model (see Section 4.6.1), but along the way skip steps and only use a limited set of worksheets. For instance, most players do not set objectives in the focus phase. When no objectives are set, there is nothing to monitor in the monitor phase, so they skip this too. In the Organisation phase of the model the worksheet that has to do with the inspection of the knowledge infrastructure is hardly used.

Observations of players and analysis of the logfiles (by comparing sequences of actions in different quarters) showed that players use the same limited set of worksheets in most of the quarters. There are some indications that they change this set and their searching strategy only when they are faced with a situation in which the cues that are available do not give enough information. For instance, when the indicators related to “knowledge gaining in production” keep going down (this is because there are not enough interventions in the game that can influence these indicators). When they encounter this situation some players open other resources or worksheets than they did before, looking for new clues, which they cannot find. This leads to frustration that could initiate a more reflective strategy as is illustrated by the following quote from a lesson learned that is formulated by one of the players: “gaining in production is very difficult. I have tried a lot. I only have focused on gaining the last 7 quarters. Lesson for me is that I have to learn a lot about gaining”. In this case a reflective strategy does lead to new insights that it is not possible to influence the particular indicators or that one does not know how to do it, but this insight does not improve performance. The same holds for the situation in which market share and profit go down. Players start searching for information about how to influence these indicators but cannot find information because these indicators can only be influenced indirectly. They come up with good ideas but due the unfortunate combination of events these are not successful. A frustrated player stated: “I do not know what to do about the profit that is going down. I have invested in marketing but this did not have an effect. Now profit is even negative”.

5.7 Summary and discussion

In this chapter results are reported from an experiment in which the effectiveness of additional support tools was examined using two versions of the simulation game to learn about knowledge management (KM Quest) that was described in the previous chapter.

The results showed that the learning environment was effective. The difference between the post-test and pre-test score was significant. The gain of knowledge is mainly found on items referring to explicit conceptual knowledge and to a lesser degree on items referring to explicit knowledge about the relationship between interventions and indicators. There is no significant knowledge gain on test items that measure implicit knowledge.

In one of the two versions of the game that were used, additional assignments were implemented into the environment to support the use of a selective reflective mode of information processing (focus questions and a task to formulate lessons learned). Students could use these additional assignments, but it was possible to skip them. The logfiles show that these assignments were used in about half of the game quarters. There were no differences between the two experimental groups on test scores and on game performance. The frequency of access of the additional assignments did have a significant effect on knowledge gain on the explicit knowledge items. However, the effect was contrary to what was expected. Those subjects who used these assignments less often had higher scores on the explicit knowledge items. So the main hypothesis that students using the version with additional assignments will gain more explicit knowledge while playing the game could not be confirmed. However, analysis of the available data showed some interesting findings regarding the access of the other support tools available in the learning environment.

Apart from the two additional tools in the KM Quest environment, several standard support tools were available. For instance, resources were available that could give the learners additional information when needed, like an Intervention handbook, an Indicator handbook, what, how and help files, and visualisation tools. Players could look back at past performance by means of historic data about their own actions and about the status of the business model indicators (history). Furthermore, they could get feedback on the previous events (type of event, and possible interventions), and they could get advice (alerts that indicate that certain indicators are low and that give hints about the types of interventions that could be implemented).

Advice is accessed frequently by most of the players. In 83% of the quarters where advice was available it was actually consulted. In many cases it was the first resource players accessed when they entered a new quarter in the game. The Intervention handbook, the feedback and the visualisation tools were also accessed frequently (in about half of the 12 quarters). The other support tools/information resources are sparsely accessed.

A comparison of the access of these resources by players who had a high knowledge gain (from pre-test to post-test) and those who had a low knowledge gain revealed that the last group used feedback significantly more than the first group. Furthermore, there were some differences in the access of the intervention handbook and the visualisation tools. The advice was frequently accessed by both groups. This was a reason to explore into more detail whether there were relationships between the use of these support tools and test and game performance.

Additional analyses revealed that the frequency of access of advice did not have a relationship with test scores but did have a relationship with game performance. The ones who accessed advice sparsely (only three players) had significantly lower values on a set of business and knowledge indicators in the game than the other players.

Frequent access of feedback and the intervention handbook was related with learning. Those who consulted feedback in more the 2/3 of the quarters gave significantly more good answers on the explicit knowledge items of the post-test and had a significant larger knowledge gain, in comparison to those who consulted feedback in less than 1/3 of the quarters.

Heavy users of the intervention handbook have higher test scores. The players who accessed the intervention handbook in 2/3 of the quarters (or more) have a higher score on the post-test especially on the explicit knowledge items that refer to conceptual knowledge (a significant difference with the other two groups). Access of feedback, the intervention handbook and the visualisation tools had relationships with some of the business and knowledge indicators in the game. Frequent use of these supports correlated with higher scores on some of the indicators.

Although there is a significant knowledge gain, the total score on the post-test was not high (about 50% correct answers) and the knowledge gain is mainly in conceptual knowledge about knowledge processes, their characteristics, types of interventions and the like. There is no knowledge gain on the questions referring to the knowledge management model and the events. This could be because these questions partly refer to steps in that model that are not used very often by the players.

There is a small gain in explicit knowledge about the relationship between certain interventions and certain indicators. Despite the fact the students do not have much knowledge about this last aspect, they manage to perform their task in the game very well. Most of them succeed in getting the indicators in the business model to a higher level (except for some indicators). This finding is in line with the results of Berry and Broadbent (1988). They noticed that participants could achieve a good level of control of the system in a Sugar factory simulation, even though they remain unable to describe precisely the rules of the system in post-experimental structured questionnaires. Berry and Broadbent explained this finding by the fact that players had acquired intuitive knowledge that they could use in the simulation but that was difficult to verbalise. In the experiment that is reported in this chapter however, the scores on the implicit knowledge items of the post-test that were supposed to measure this type of intuitive knowledge were low and on chance level and there also was not any gain in this type of knowledge compared to the pre-test. This could mean either that students gained some intuitive knowledge but that the items were not suited to measure it. Or it could mean that players could not gain implicit knowledge because the underlying business model is much more complex than the model used in the Berry and Broadbent studies (in the KM Quest model there are more than 50 indicators and more than 50 interventions available that could have a direct or indirect influence on the indicators) and because players often implement several interventions at the same time. This seems unlikely however, since Hayes and Broadbent (1988) posed that u-mode learning is probable in situations in which there is much information in the learning environment and the key variables and their interrelationships are not salient (p. 271).

Another option could be that players were using a more selective mode of information processing but were not successful and that this led to a limited gain in explicit knowledge, but that this mode also limited the gain of implicit intuitive knowledge. That players still were successful in the game could be because the environment contained enough cues and hints to perform the task of knowledge manager in the game. By browsing through the information available and by using links between resources in the environment, like the advisor functionality, the intervention handbook and the feedback players are able to find cues about interventions that could be effective. They apply the information that is available without processing it deeply. In most cases this is enough to improve game performance, but learning is limited. They learn about the concepts that are used and gain some explicit knowledge about relations between interventions and indicators. This latter seems to be the case since frequent use of feedback, the intervention handbook and the visualisation tools had a limited effect on game performance and on learning results.

It seems that the standard tools in the game support players in selecting and focusing on relevant information but that they do not support or limit mindful and reflective thought. This could be because players can apply the information directly and do not need to interpret or value the information before they can apply it. Since the advice is the functionality that is used most frequently and also contains the most direct cues supporting the selection of relevant information, it is interesting to see whether removal of this functionality leads to differences in game play and to other learning results. In a second experiment this will be investigated. This will be described in the next chapter.

6 The role of advice

6.1 Introduction

In the KM Quest simulation game (that is described in Chapter 4) several tools/resources were embedded to support learning by means of a selective/reflective mode of information processing like a knowledge management model, shared worksheets related to the steps in the knowledge management model, just-in-time information (in books and in what and how pop up files), feedback, an advice functionality, visualisation and monitoring tools. Data from the first experiment with this game (that is reported in the previous chapter) showed that from these resources the advice functionality was accessed most often. Advice was available when the value of certain knowledge process indicators in the business simulation model went below a threshold value. The advice texts presented a list of indicators that were below a threshold value and contained links to groups of interventions that could be implemented to influence each of these indicators.

It appeared that in 83% of the cases where advice was available it was actually consulted. Most of the time it was the first resource players consulted when they entered a new quarter in the game. Based on the available data from that experiment however, it is hard to say whether the use of advice supported learning. There was only a small group who accessed the advice sparsely although it was available. The data indicate that there are no differences in learning results between those who accessed advice frequently on those who do not, but that there are differences in game performance. The values of a set of business and knowledge indicators are lower when advice is sparsely used.

A literature review did not lead to many cues about the role of advice on learning in these kinds of learning environments. A study from Leutner (1993) also used advice in a simulation game. In that study part of the players during the game were provided with warnings if their decisions were likely to lead to problems. Results of the experiments (with 7th grade students and with university students) showed that advice increased verbal domain knowledge, but decreased game performance (contrary to the data from the experiment reported in the previous chapter). Furthermore, the data indicated that system-initiated adaptive advice had short-term effects (measured directly after game play), while learner requested non-adaptive background information had long-term effects (measured by a test that was administered a week after game play).

The role of advice in Leutners' study was to focus the player's attention on important aspects and misconceptions. Mayer (2004) envisions the same role for guidance in discovery learning environments (like simulations and games) in general. He states that pure discovery learning often fails because students may not come into contact with the relevant information. Guidance should prevent this last thing from happening. "The challenge of teaching by guided discovery is to know how much and what kind of guidance to provide and to know how to specify the desired outcome of learning" (Mayer, 2004, p.17). Looking at the two modes of information processing that were discussed in Section 3.4, one could say that guidance offered by advice in a simulation game could support a selective reflective strategy because it helps students in selecting and focusing on relevant information. On the other hand, by doing this and by giving hints about possible solutions (as is done in KM Quest), reflective thought could be limited because players have easy access to relevant information, do not have to search and value information and can apply it directly in the game.

To test whether advice supports a selective reflective mode of information processing and the gain of explicit knowledge, an experiment was carried out in which two versions of the KM Quest simulation game were used: one with the advice and one in which this resource was removed. It was hypothesized that students in the advice group would gain more explicit knowledge (in line with Leutners findings) and would perform better in the game because they receive hints about possible solutions. This last hypothesis is not in line with Leutners findings, but this is because the type of advice given in the current study is different from the advice given in the experiments performed by Leutner. In those experiments only warnings were provided by the system. In the KM Quest environment warnings are also given, but these are accompanied with general suggestions to improve the state of the specific indicators (see Section 4.6.5).

6.2 Method

6.2.1 Subjects

The students who participated in the experiment did so because the use of the simulation game was an assignment in a master course “Knowledge management in learning organizations” at the University of Twente. All students were from the Communication Studies department and had followed a preliminary course on Knowledge management in the bachelor phase.

29 Students participated in the course (18 women and 11 men). They were randomly assigned to one of the two conditions, in the first experimental session. 15 students were in the Advice condition and 14 in the No-advice condition.

6.2.2 Instruments

The game environment that was used in both conditions was slightly different from the version described in Chapter 4. In this case players again played individually, the order of the events was not random but fixed and the same for all students, and the starting values of the indicators were lowered (several are below 5 on a ten point scale). The game set-up was the same as the one described in Section 5.2.2. The events and the order in which they were presented in the game were almost the same as the ones used in the experiment described in the previous chapter. However, two events were replaced by new ones, and one was presented in a different quarter of the game. This was done because there were indications that the combination of events led to a decline of market share and profit in the last year of play that could not be prevented by the players.

6.2.2.1 Pre and post-test

Knowledge gain is measured by comparing the score on a pre-test and a post-test. Each consisted of 26 items that contain questions to measure explicit (18 items) as well as implicit knowledge (8 items). Explicit knowledge of knowledge management concepts and principles is tested by giving students textual multiple-choice questions that refer to declarative knowledge about concepts used in the learning environment like the knowledge processes, and steps in the knowledge management model. Furthermore, questions are included that refer to relationships between indicators and interventions.

The tests were almost the same as the ones described in the previous chapter. The two questions about events were replaced by two questions about the relationships between indicators and interventions because the questions about the events were too easy. More than 80% of the students knew the right answer on these questions already on the pre-test in the first experiment.

6.2.2.2 Transfer task

A transfer task was administered after the game and the post-test were completed. The task was the same one as the one described in Section 5.2.2.2. Students could take the assignment home and had to hand it in a few days later. Maximum score on the transfer test was 10 points. This was different from experiment 1, where the maximum score was 20 points. The number of points was lowered because the total number of points students could earn during the course (based on four assignments and a final exam) was much lower in that year than in the year before.

6.2.2.3 Logfiles

Player performance in the game was logged into a database. These data make it possible to see for each of the twelve quarters in the game, which resources people used (and in which order), which interventions they implemented and what the values of the business and knowledge process indicators were.

6.2.3 Procedure

In the first lecture of the course the set up of the course was described and KM Quest was introduced. During the four weeks following this lecture four two-hour sessions were planned to work with the KM Quest environment. The sessions were located in a computer room with a large number of computers. Each student had a computer.

At the start of the first session the general procedure was explained. Students were told that they would get a pre-test and a post-test after the game was played and an additional assignment (the transfer task). It was indicated that the goal of this pre and post-test was to give the course lecturers an idea of the effectiveness of the game as a learning tool in the course. Furthermore, it was explained that players were expected to play 12 quarters and were supposed to reach the games goals, but whether they reached these goals or not would not affect their grades for the course. The transfer task was used to give students a grade. This was part of the final grade for the course.

After the introduction by the lecturer the pre-test was administered. After the students completed this test they received the Internet address (and password) to access the server where they could find the learning environment. They started to read the introductory texts and after that they worked through the training (demo). After they had finished the training demo they received a note with the login name and password to actually play the simulation game. Students also could access the game outside the session, for instance from a home computer. During the session a lecturer was available to answer questions or solve technical problems.

In the next sessions students could finish the game. After they did that in the fourth session a post-test was administered. After they finished the post-test they received the additional assignment (transfer task), which they had to make at home. Students were not able to get access to the game environment while they were making the transfer task.

A debriefing session was held in one of the course lectures after the students had handed in the transfer task. In this session the lecturer summarized the data from the playing phase of the game and gave examples of the actions taken, based on the data from two students: one who did well and one who did not.

6.3 Results

First data are presented from the tests. After that data are presented about game performance followed by data about the use of additional and standard tools and the relationship between the use of these tools (based on the logfiles) and test scores as well as game performance.

6.3.1 Test results

In Table 6-1 the test results are summarised. It shows that on the average students answered 39.6% of the questions of the pre-test correctly. For the post-test the average score was 50.3%. A paired samples t-test shows that this knowledge gain is significant (T=-4.62, df=28, p=0.00).

The data in Table 6-1 show that both groups have gained explicit knowledge. The difference between pre-test and post-test scores on the explicit knowledge items for both groups is significant (Advice group: paired samples t-test t= -3.57, df=14, p=0.003; No advice group: paired samples t-test t= -3.29, df=13, p=0.006), and that this gain is mainly in the conceptual domain (see Table 6-2). There is no significant gain in knowledge related to the knowledge management model (KMm), nor on explicit knowledge concerning relationships between indicators and interventions (rel).

The No-advice group however, has also gained implicit knowledge. The difference between pre-test and post-test scores on these items is significant (paired samples t-test: t=-3.86, df=13, p=0.002), while the group with advice did not show any gain in this type of knowledge (paired samples t-test: t=0.25, df=14, p=0.809). The difference between the two experimental groups on the score on the implicit knowledge items of the post-test is nearly significant (Anova: F=4.18, df=1, p=0.051).

Table 6-1. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the pre-test and post-test and the score on the transfer test for the total group and for the groups with and without advice.

	Pre-expl Max=18	Pre-impl Max=8	Pre-tot Max=26	Post-expl Max=18	Post-impl Max=8	Post-tot Max=26	Transfer Max=10
Advice N=15	6.80 (1.86)	3.80 (1.61)	10.60 (2.87)	8.80 (2.04)	3.67 (1.35)	12.47 (2.77)	7.20 (1.53)
No adv. N=14	6.86 (2.88)	3.14 (1.56)	10.00 (3.35)	9.07 (1.97)	4.64 (1.22)	13.71 (2.30)	6.98 (1.71)
Total N=29	6.83 (2.36)	3.48 (1.59)	10.31 (3.07)	8.93 (1.98)	4.14 (1.36)	13.07 (2.59)	7.10 (1.59)

Table 6-2. Average number of correct answers (and standard deviations) on the different types of explicit knowledge items (conceptual, KMmodel, and relationships) of the pre-test and post-test for the total group and for the groups with and without advice.

	Pre-conc Max=7	Pre-KMm Max=3	Pre-rel Max=8	Post-conc Max=7	Post-KMm Max=3	Post-rel Max=8
Advice N=15	2.13 (1.25)	1.33 (0.82)	3.33 (1.23)	4.13 (1.73)	1.47 (0.74)	3.20 (1.32)
No adv. N=14	2.93 (1.44)	1.14 (1.03)	2.79 (1.72)	4.50 (1.51)	1.57 (0.85)	3.00 (1.41)
Total N=29	2.52 (1.38)	1.24 (0.91)	3.07 (1.49)	4.31 (1.61)	1.53 (0.78)	3.10 (1.35)

6.3.2 Game performance

Looking at game performance there are hardly any differences between the experimental groups (see Table 6-3 and Table 6-4). Both groups have managed to improve the business and knowledge management (process) indicators substantially.

Table 6-3. Average values for some important business (process) indicators in the business simulation model at the end of the game for the total group and for the groups with and without advice. At the bottom row the starting values.

	MS*	CSI	Profit	JSI	PQI	ATM
Advice	23.79	8.15	64.73	9.60	8.77	1.34
	(3.76)	(0.90)	(23,26)	(0.88)	(0.99)	(0.77)
No adv.	24.43	8.33	68,58	9.50	9.04	1.14
	(3.18)	(0.61)	(19,54)	(0.76)	(0.66)	(0.55)
Total	24.10	8.23	66,59	9.55	8.90	1.24
	(3.45)	(0.77)	(21,25)	(0.81)	(0.84)	(0.67)
Start values	20.0	4.40	-	4.22	4.80	2.40

* MS = Market share, CSI = Customer satisfaction index, Profit = Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM = Average time for new product to market,

Table 6-4. Average level of competence in three knowledge domains for the total group and for the groups with and without advice. At the bottom row the starting values. Scale from 1 to 10.

	Competence in marketing	Competence in R&D	Competence in production
Advice	8.63	8.27	6.43
	(1.22)	(1.29)	(0.79)
No advice	8.72	8.60	6.40
	(1.00)	(1.02)	(0.71)
Total	8.68	8.43	6.41
	(1.10)	(1.16)	(0.74)
Start values	4.93	4.38	5.34

The average level of competence in production is low compared to the levels of competence in the other two domains. This is due to a lack of interventions (in the game) that have an influence on the process of knowledge gaining in the production domain, as was already stated in the previous chapter.

6.3.3 Relationship between test results and game play

Table 6-5 shows the correlations between pre-test and post-test score, knowledge gain and some of the business and knowledge indicators for both groups. In general the correlations are low and not significant, except for the correlation between post-test core and market share in the no-advice group (p=0.04). So there are no indications that the level of prior knowledge leads to differences in game play or that being able to perform well in the game leads to a high post-test score or high knowledge gain.

Table 6-5. Correlation between total pre-test and post-test score, knowledge gain and the average values for some important business and knowledge indicators at the end of the game for the groups with and without advice.

	MS*	CSI	Profit	JSI	PQI	CM	CR	CP
Advice								
Pre-test	.05	.17	.04	-.03	.04	.07	-.03	.09
Post-test	.25	.30	.21	-.08	.15	.37	.15	.07
Kn. gain	.16	.10	.14	-.04	.09	.25	.16	-.02
No advice								
Pre-test	.25	.28	.34	.12	.26	.08	.26	-.06
Post-test	.55	.17	.40	.11	.23	.49	.18	.50
Kn. gain	.13	-.17	-.07	-.05	-.11	.28	-.15	.45

* MS = Market share, CSI = Customer satisfaction index, Profit = Profit in Q13, JSI = Job satisfaction index, PQI = Product quality index, CM= Level of competence in marketing, CR= Level of competence in R&D, CP= Level of competence in production.

6.3.4 Access of standard tools

In this section an overview will be given of the access of the standard tools available in the learning environment, starting with access of the advice that was available in one of the two experimental groups. Advice is only available when certain indicators drop below a certain threshold value. Everybody consulted the advice functionality at least once. There was one player who consulted it only once, while for this person advice was available in 12 quarters. The other subjects used it in 50% or more of the quarters where it was available. On average advice was available in 9.33 quarters and was consulted in 7.07 quarters. This means that in 77% of the cases where advice was available it was actually consulted.

Table 6-6 gives an indication about the frequency of access of the other resources available in the learning environment. The Intervention handbook, the feedback and the visualisation tool were the most accessed resources. The indicator handbook and the history books were less frequently accessed, and the other resources are sparsely accessed.

Although there are differences in the access of tools between the two experimental conditions, most of them are not significant, except for one. The no-advice group consulted the indicator handbook significantly more (Anova: F=5.22, df=1, p=0.03) than the advice-group.

Table 6-6. Average number of quarters in which a selection of the standard resources were used by the learners for the total group and for the groups with and without advice.

	Feedb	Intv HB	Indc HB	Hist	What	How	Help	Visual
Advice	5.73	6.13	3.13	3.67	0.80	1.00	0.47	6.73
	(4.33)	(4.36)	(1.99)	(2.19)	(0.86)	(0.76)	(0.52)	(4.93)
No adv.	5.93	4.57	5.43	3.14	1.00	1.14	0.50	5.29
	(5.08)	(4.50)	(3.30)	(1.29)	(0.55)	(0.86)	(0.52)	(3.99)
Total	5.83	5.38	4.24	3.41	0.90	1.07	0.48	6.03
	(4.62)	(4.42)	(2.90)	(1.80)	(0.72)	(0.80)	(0.51)	(4.48)

In the next sections additional data about the use of these support tools are presented.

6.4 Differences between players with a high and low knowledge gain

In this section a different view on the data is presented. It is investigated whether players with a low knowledge gain from pre-test to post-test (0 point or less) behave differently in the game than players who have high gain (6 points or more). A comparison of the access of some of the support tools (feedback, advice, intervention handbook, indicator handbook and visualisations) of these groups of players is made. The other support tools were not included because they were sparsely accessed.

Table 6-7 shows that in general the students with a low knowledge gain accessed the different support tools more frequently than the ones with a high knowledge gain. These differences however are not significant. The table also shows that this difference is mainly due to the students in the advice group. The players with a low knowledge gain in this group were heavy users.

The data are not in line with the data from experiment 1 (see Section 5.4). In that experiment the ones with a high knowledge gain were also the ones who used the support tools most frequently (like in the No advice group in Table 6-7).

Table 6-7. Average number of quarters in which a selection of the standard support tools were used by the learners with a low knowledge gain from pre-test to post-test (0 points or less) and with a high knowledge gain (6 points or more) for the groups with advice and without advice.

	Feedback	Advice	Intervention HB	Indicator HB	Visualisations
Advice					
Low, N=6	8.33 (4.08)	0.91*(0.16)	7.00 (5.18)	3.67 (2.42)	7.67 (5.57)
High, N=3	3.00 (1.73)	0.67 (0.29)	2.33 (0.58)	2.67 (2.89)	4.00 (1.00)
No advice					
Low, N=3	3.67 (5.51)	-	4.67 (4.04)	4.67 (3.21)	5.33 (4.16)
High, N=6	4.50 (4.76)	-	5.50 (5.68)	7.00 (3.52)	5.33 (3.39)
Total group					
Low, N=9	6.78 (4.84)		6.22 (4.71)	4.00 (2.55)	6.89 (5.01)
High, N=9	4.00 (3.94)		4.44 (4.77)	5.56 (3.81)	4.89 (2.80)

6.5 Additional analyses on the use of support tools

In the next sections it will be investigated whether there is a relationship between the use of some of support tools (the ones that have been used regularly) and game performance and learning. In this analysis the two experimental groups were taken together as was done in experiment 1 (see Section 0). New groups were distinguished based on the frequency of access of particular support tools. It was decided to divide the total group into three. Using two groups probably would mean that certain nuances would not be visible and using four groups or more probably would mean that the number of students within groups would be too small to find meaningful differences. The same grouping procedure was used in all sections.

As stated in Section 0 caution has to be taken with conclusions based on these analyses since there is a possibility that intermediate variables that have not been measured play a role.

Furthermore, the groups that are distinguished in the different sections are not totally independent. It might be that the players who use feedback often also use the intervention handbook often. In that case it is difficult to attribute differences in test scores to the use of one or the other support tool. To get an impression whether there a relationships between the accesses of the support tools that will be dealt with in the next sections, a correlation analysis was performed (see Table 6-8). As stated above the players have been divided into three groups based on the frequency of the access of each of the supports.

Table 6-8. Correlations between the categorisations of the access of different support tools, with significance level (two-tailed) between brackets.

	Feedback	Intervention HB	Indicator HB	Visualisation tools
Feedback	1			
Intervention HB	0.42 (0.02)	1		
Indicator HB	0.24 (0.22)	0.19 (0.32)	1	
Visualisation tools	0.36 (0.05)	0.81 (0.00)	0.23 (0.24)	1

Table 6-8 shows that there is a high correlation between the access of the intervention handbook and of the visualisation tools. Furthermore, access of feedback correlates with the access of the intervention handbook and of the visualisation tools. These data indicate that the grouping of players for the different support tools overlaps. Only the access of the indicator handbook has no significant correlations with the access of the other tools.

6.5.1 Feedback

In the experiment reported in the previous chapter there was a relationship between the access of feedback and knowledge gain. In this section data will be presented about the relationship between the (frequency of) use of feedback and test score, as well as game performance that could show whether this finding could be replicated. In the analysis the two experimental groups were taken together and new groups were distinguished based on the frequency of use of feedback. The grouping procedure was described in Section 6.5.

6.5.1.1 Test results

Table 6-9 shows that subjects who consulted feedback often, have only a small knowledge gain. The group that consulted feedback rarely gained more knowledge. The differences between groups on knowledge gain however are not significant. The first group already had a relatively high score on the pre-test 11.50 (2.32). The ones who consulted feedback sparsely had a pre-test score of 9.29 (3.47). These data do not confirm the findings of experiment 1 (see Section 5.5.1) which indicated that the ones who consulted feedback regularly had significant higher scores on the explicit knowledge items than the ones who used feedback sparsely.

Table 6-9. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test and average knowledge gain compared to the pre-test, for the total group and for groups who actually consulted the feedback information in different numbers of quarters.

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
Feedback consulted in 0-4 quarters	8.36	4.36	12.71	3.43	7.23
N=14	(2.31)	(1.34)	(2.97)	(3.69)	(1.17)
Feedback consulted in 5-8 quarters	9.33	5.00	14.33	4.00	5.80
N=3	(2.52)	(1.73)	(3.21)	(3.46)	(1.77)
Feedback consulted in 9-12 quarters	9.50	3.67	13.17	1.67	7.29
N=12	(1.31)	(1.23)	(2.04)	(2.64)	(1.96)
Total group	8.93	4.14	13.07	2.76	7.10
	(1.98)	(1.36)	(2.59)	(3.29)	(1.59)

6.5.1.2 Game performance

The frequency of access of feedback also did not have any significant relationship with game performance (see Table 6-10 and Table 6-11).

Table 6-10. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually consulted the feedback information in different numbers of quarters.

	MS*	CSI	Profit	JSI	PQI	ATM
FB in 0-4 quarters	24.00	8.11	67.99	9.20	8.73	1.29
N=14	(4.06)	(0.86)	(24.47)	(0.98)	(0.93)	(0.75)
FB in 5-8 quarters	25.57	8.57	65.35	10.00	9.37	1.43
N=3	(4.13)	(0.15)	(23.66)	(0.00)	(0.15)	(0.64)
FB in 9-12 quarters	23.85	8.29	65.27	9.85	8.99	1.14
N=12	(3.38)	(0.38)	(18.31)	(0.49)	(0.39)	(0.61)
Total	24.10	8.23	66,59	9.55	8.90	1.24
	(3.45)	(0.77)	(21,25)	(0.81)	(0.81)	(0.67)

* MS = Market share, CSI = Customer satisfaction index, Profit= Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM= Average time for new product to market.

Table 6-11. Average level of competence in three domains for the total group and for the total group and for groups who actually consulted the feedback information in different numbers of quarters.

	Competence in marketing	Competence in R&D	Competence in production
FB in 0-4 quarters	8.71	8.22	6.24
N=14	(1.11)	(1.29)	(0.75)
FB in 5-8 quarters	8.56	9.08	6.87
N=3	(1.31)	(0.18)	(0.24)
FB in 9-12 quarters	8.66	8.51	6.49
N=12	(1.14)	(1.13)	(0.77)
Total group	8.68	8.43	6.41
	(1.10)	(1.16)	(0.74)

6.5.2 The intervention handbook

Next to feedback, the intervention handbook is one of the resources that is accessed frequently. In this section it will be investigated whether there is a relationship between the access of this resource, test results and game performance. As stated in the beginning of this section there is a significant correlation (0.42) between the access of feedback and of the intervention handbook. This means that the grouping of players overlaps meaning that it is difficult to distinguish between the access of these tools.

6.5.2.1 Test results

Analyses of variance did not reveal significant differences between groups on test scores and knowledge gain. The players who consulted the intervention handbook in 2/3 of the quarters (or more) have a higher score on the post-test than the ones who consulted this book less frequently, but the first group already had a higher score on the pre-test. Their knowledge gain is even a bit smaller than the gain of the players who used the intervention handbook in a limited number of quarters.

Table 6-12. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test and average knowledge gain compared to the pre-test, for the total group and for groups who actually consulted the intervention handbook information in different numbers of quarters.

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
IHB consulted in 0-4 quarters	8.35	4.06	12.41	2.76	6.53
N=17	(2.03)	(1.48)	(2.50)	(3.67)	(1.78)
IHB consulted in 5-8 quarters	9.33	3.33	12.67	3.67	8.03
N=3	(2.52)	(0.57)	(3.06)	(2.08)	(0.80)
IHB consulted in 9-12 quarters	9.89	4.56	14.44	2.44	7.80
N=9	(1.45)	(1.24)	(2.35)	(2.64)	(0.94)
Total group	8.93	4.14	13.07	2.76	7.10
	(1.98)	(1.36)	(2.59)	(3.29)	(1.59)

6.5.2.2 Game performance

Table 6-13 and Table 6-14 indicate that the players who consulted the intervention handbook in 2/3 of the quarters (or more) have a higher score on most of the business (process) indicators than the ones who consulted this book in 1/3 of the quarters (or less). However, statistical analyses showed that these differences were not significant.

Table 6-13. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually consulted the intervention handbook in different numbers of quarters.

	MS*	CSI	Profit	JSI	PQI	ATM
IHB in 0-4 quarters	23.65	8.08	69.45	9.46	8.72	1.26
N=17	(3.80)	(0.76)	(24.52)	(0.86)	(0.82)	(0.72)
IHB in 5-8 quarters	24.50	7.93	63.45	9.29	8.63	1.27
N=3	(3.24)	(1.25)	(22.62)	(1.22)	(1.34)	(0.98)
IHB in 9-12 quarters	24.82	8.61	62.25	9.81	9.33	1.20
N=9	(3.38)	(0.54)	(18.31)	(0.57)	(0.39)	(0.53)
Total	24.10	8.23	66,59	9.55	8.90	1.24
	(3.45)	(0.77)	(21,25)	(0.81)	(0.81)	(0.67)

* MS = Market share, CSI = Customer satisfaction index, Profit= Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM= Average time for new product to market.

Table 6-14. Average level of competence in three domains for the total group and for the total group and for groups who actually consulted the intervention handbook in different numbers of quarters.

	Competence in marketing	Competence in R&D	Competence in production
IHB in 0-4 quarters	8.36	8.16	6.26
N=17	(1.12)	(1.13)	(0.57)
IHB in 5-8 quarters	9.02	8.15	6.34
N=3	(1.14)	(1.74)	(1.11)
IHB in 9-12 quarters	9.15	9.02	6.72
N=9	(0.94)	(0.90)	(0.90)
Total group	8.68	8.43	6.41
	(1.10)	(1.16)	(0.74)

6.5.3 The indicator handbook

The indicator handbook is accessed less frequently than the intervention handbook, and is accessed more by the no-advice group than by the advice group. The access of this tool did not have significant correlations with the access of the other tools. In this section it will be investigated whether there is a relationship between the access of this resource, test results and game performance

6.5.3.1 Test results

There is only a small group who consulted the indicator handbook in 2/3 of the quarters (or more). The majority of players only consulted the book in 1/3 of the quarters or less. Analyses of variance revealed that there are significant differences between groups on the explicit knowledge items (Anova: F=4.68, df=2, p=0.02) and on the total post test score (Anova: F=4.4, df=2, p=0.02). A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that there is a significant difference (p=0.04 in both cases) between the heavy users of the intervention handbook (9-12 quarters) and the group who uses it in 0-4 quarters.

Table 6-15. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test and average knowledge gain compared to the pre-test, for the total group and for groups who actually consulted the intervention handbook information in different numbers of quarters.

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
IndHB consulted in 0-4 quarters	8.13	3.94	12.06	2.13	6.99
N=16	(1.82)	(1.29)	(2.50)	(3.07)	(1.32)
IndHB consulted in 5-8 quarters	9.64	4.27	13.91	3.00	7.14
N=11	(1.75)	(1.49)	(3.06)	(3.55)	(2.02)
IndHB consulted in 9-12 quarters	11.50	5.00	16.50	6.50	7.75
N=2	(0.71)	(1. 41)	(0.71)	(0.71)	(1.48)
Total group	8.93	4.14	13.07	2.76	7.10
	(1.98)	(1.36)	(2.59)	(3.29)	(1.59)

6.5.3.2 Game performance

Table 6-16 shows that the differences on game performance between the groups are small. Analyses of variance did not reveal significant differences. Table 6-17 shows that there are differences in level of competence but only the differences in level of competence in production are significant (Anova: F= 3.74, df=2, p=0.04). A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that there is a significant difference (p=0.03) between the heavy users of the intervention handbook (9-12 quarters) and the group who accessed it in 0-4 quarters. The first group has a higher value.

Table 6-16. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually consulted the intervention handbook in different numbers of quarters.

	MS*	CSI	Profit	JSI	PQI	ATM
IndHB in 0-4 quarters	23.26	8.02	60.32	9.43	8.63	1.45
N=16	(3.30)	(0.80)	(19.37)	(0.88)	(0.85)	(0.74)
IndHB in 5-8 quarters	24.82	8.44	76.99	9.46	9.16	1.05
N=11	(3.24)	(0.71)	(22.57)	(1.22)	(0.76)	(0.50)
IndHB in 9-12 quarters	26.90	8.85	59.52	10.00	9.65	0.70
N=2	(2.55)	(0.07)	(0.21)	(0.00)	(0.07)	(0.00)
Total	24.10	8.23	66,59	9.55	8.90	1.24
	(3.45)	(0.77)	(21,25)	(0.81)	(0.81)	(0.67)

* MS = Market share, CSI = Customer satisfaction index, Profit= Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM= Average time for new product to market.

Table 6-17. Average level of competence in three domains for the total group and for the total group and for groups who actually consulted the intervention handbook in different numbers of quarters.

	Competence in marketing	Competence in R&D	Competence in production
IndHB in 0-4 quarters	8.35	8.11	6.22
N=16	(1.09)	(1.11)	(0.57)
IndHB in 5-8 quarters	8.99	8.72	6.47
N=11	(1.06)	(1.21)	(1.11)
IndHB in 9-12 quarters	9.59	9.40	7.60
N=2	(0.43)	(0.09)	(0.04)
Total group	8.68	8.43	6.41
	(1.10)	(1.16)	(0.74)

6.5.4 The visualisation tools

The visualisation tools are the most frequently accessed resources in the game. On average they are used in half of the quarters during the game. There is a strong correlation between the access of the visualisation tools and access of feedback, and a less strong correlation with access of feedback. This means that it is difficult to distinguish the effects of these tools. In this section it will be investigated whether use of visualisation tools has a relationship with test results and game performance.

6.5.4.1 Test results

Analyses of variance revealed significant differences between groups on the score on the explicit knowledge items (Anova: F=5.54, df=2, p=0.01), total post test score (Anova: F=6.41, df=2, p=0.005) and on knowledge gain (Anova: F=3.48, df=2, p=0.046). The differences on the transfer test score were not significant (p=0.08). A post hoc analysis (a Tukey HSD test for multiple comparisons) revealed that regarding the explicit knowledge items and knowledge gain there is a significant difference between the group who uses these tools in 5-8 quarters and the group who uses them in 0-4 quarters. On the total post test score this difference is also significant as well as the difference between subjects who use these tools in 9-12 quarters and the group who uses them in 0-4 quarters. More frequent access correlates with a higher score. This differs from the data in experiment 1. In that experiment there were no differences between groups on test scores.

Table 6-18. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the post-test and average knowledge gain compared to the pre-test, for the total group and for groups who actually used the visualisation tools in different numbers of quarters.

	Post-expl	Post-impl	Post-tot	Kn. gain	Transfer
Vis. used in 0-4 quarters	7.86	3.71	11.57	2.00	6.38
N=14	(1.92)	(1.29)	(2.21)	(3.46)	(1.87)
Vis. used in 5-8 quarters	10.33	4.50	14.83	5.67	7.80
N=6	(1.86)	(1.49)	(2.40)	(2.07)	(0.92)
Vis. used in 9-12 quarters	9.67	4.55	14.22	2.00	7.68
N=9	(1.22)	(1. 24)	(2.05)	(2.78)	(1.06)
Total group	8.93	4.14	13.07	2.76	7.10
	(1.98)	(1.36)	(2.59)	(3.29)	(1.59)

6.5.4.2 Game performance

Although the differences between groups on the test scores were striking, the differences on game performance are less salient (see Table 6-19 and Table 6-20). None of the differences between groups is significant.

Table 6-19. Average end values for some important business (process) indicators in the business simulation model for the total group and for groups who actually used the visualisation tools in different numbers of quarters.

	MS*	CSI	Profit	JSI	PQI	ATM
Vis. in 0-4 quarters	23.64	8.11	67.36	9.54	8.83	1.31
N=14	(3.62)	(0.67)	(23.21)	(0.71)	(0.73)	(0.75)
Vis. in 5-8 quarters	25.03	7.92	70.33	9.63	8.63	1.35
N=6	(4.26)	(1.10)	(26.61)	(0.86)	(1.19)	(0.75)
Vis. in 9-12 quarters	24.20	8.64	62.91	9.51	9.20	1.07
N=9	(2.81)	(0.53)	(15.37)	(1.01)	(0.75)	(0.48)
Total	24.10	8.23	66,59	9.55	8.90	1.24
	(3.45)	(0.77)	(21,25)	(0.81)	(0.81)	(0.67)

* MS = Market share, CSI = Customer satisfaction index, Profit= Total profit in 3 years in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM= Average time for new product to market.

Table 6-20. Average level of competence in three domains for the total group and for the total group and for groups who actually used the visualisation tools in different numbers of quarters.

	Competence in marketing	Competence in R&D	Competence in production
Vis. in 0-4 quarters	8.44	8.35	6.25
N=14	(1.14)	(0.91)	(0.49)
Vis. in 5-8 quarters	8.81	8.03	6.64
N=6	(1.28)	(1.72)	(0.77)
Vis. in 9-12 quarters	8.95	8.82	6.51
N=9	(0.94)	(1.11)	(1.03)
Total group	8.68	8.43	6.41
	(1.10)	(1.16)	(0.74)

6.6 Summary and discussion

In this chapter results are reported from an experiment in which the effectiveness of optional advice was examined using two versions of the simulation game to learn about knowledge management (KM Quest) that was described in Chapter 4 (one with advice, and one without advice).

Data from a pre-test and post-test show that the learning environment was effective. The difference between the scores on these tests (that were identical) was significant. The gain of knowledge in both conditions was mainly found on items referring to explicit conceptual knowledge. There was no knowledge gain on items referring to the embedded knowledge management model or to the relationship between interventions and indicators. However, in the no-advice condition there is a significant knowledge gain on test items that measure implicit knowledge.

Advice was not always available and the use of advice was optional. Data from the logfiles show that in 77% of the cases where advice was available, it was actually consulted. This finding is in line with the findings of the experiment reported in the previous chapter in which advice was consulted in 83% of quarters when it was available. This indicates that the players appreciated the advice functionality, but there are also indications that the effectiveness of the advice was low. Players in the no-advice condition score equally well on game performance, on the explicit knowledge items of the post-test and on the transfer test. The hypothesis was that advice would support a selective reflective mode of information processing because it helps students in selecting and focusing on relevant knowledge and because it prevents players from missing essential information by means of the alerts that were provided (concerning indicators that are low) and the cues that were given concerning possible solutions (classes of interventions). Therefore it was expected that players in the advice group would gain more explicit knowledge and would perform better in the game. This expectation could not be confirmed. Since the information processing strategies were not measured, it is unclear whether the advice did not support a selective and reflective strategy or whether players used this strategy but were not successful in gaining more explicit knowledge. There are some indirect measures however that can shed some light on this matter.

An important finding is that in the no-advice condition there is a significant knowledge gain on test items that measure implicit knowledge while there was no gain in the advice condition. It was assumed that implicit knowledge is gained while using an unselective experiential mode of information processing. So this finding seems to indicate that players in the no-advice groups were mainly using this experiential mode.

The fact that the players in the advice condition did not gain implicit knowledge but also did not gain more explicit knowledge could indicate that they were using a different mode of information processing but that this mode was not effective. This could have been due to the fact that players in the advice condition put less mental effort in solving the knowledge management problems in the learning environment and rely too heavily on the suggestions given by the advice functionality. An indication for this is that the links between the advice texts and the intervention handbook are used frequently.

There are some indications that players who put in more effort and are actively searching for information in the games resources that are not directly linked to the advice are learning more or performing better in the game. For instance there is a relationship between the frequency of access of the indicator handbook and scores on the explicit knowledge items of the post-test, and game performance as measured by the level of some of the business process and knowledge process indicators that are included in the business simulation model. Players who used the indicator handbook more often had higher scores.

In conclusion, the advice given in KM Quest seems to diminish the use an unselective experiential strategy of information processing and seems to make players “lazy”. Players rely heavily on the information (alerts and suggestions) and on the links provided by the advice functionality.

7 The role of advice - revisited

7.1 Introduction

In the previous chapter an experiment was reported in which it was investigated whether advice given by the game environment (KM Quest) could help students to apply a selective and reflective strategy and thereby in acquiring more explicit knowledge. The underlying idea was that the advice that was available would support a reflective mode of information processing because it helps students in selecting and focusing on relevant knowledge in the complex environment and because it prevents players from missing essential information by means of the alerts and cues that were given in the advice texts. The data presented showed that although the advice functionality was heavily used, the students in the group with advice did not have higher scores on a post-test nor on game performance indicators than the students in the group that could not make use of the advice functionality. It was concluded that the advice given in KM Quest seems to diminish the use of an unselective experiential strategy of information processing but also seems to reduce the effort that players put in to actively process the information that is presented. Players seem to rely too heavily on the alerts (concerning indicators that are low) and/or on the suggestions (concerning the types of interventions that could be implemented to solve certain problems) given by the advice functionality. Since the advice contains two elements: alerts/warnings and cues, this leads to the question whether advice that contains alerts, but less cues about the type of interventions that could be implemented, would be more successful in supporting a selective and reflective strategy of information processing.

In this chapter an experiment is reported in which three versions of the KM Quest simulation game were used:

- A version in which advice was available when certain indicators are below a threshold value. The content of the advice was described in Section 4.6.5.
- A second version in which advice was available when certain indicators are below a threshold value (as in version 1). The content however was different. The advice given does not contain cues about possible solutions but tries to stimulate active thinking, problem solving and searching for information by presenting a set of questions. An example is given below.
- A third version in which no advice was available.

Example of the advice that is available in version 2:

The low value of the indicators listed below is reason for concern. When there are no items below, most values of important knowledge (process) indicators are above the threshold values, and no advice is available.

- *Efficiency of knowledge transfer from marketing*
- *Efficiency of knowledge development in production*

Maybe you did not focus on improving these indicators. If you did try to improve them, ask yourself the following questions:

- *Could the effect of the intervention(s) you implemented be expected immediately, or is there a delay?*

- *Has the effect of the intervention(s) already lost its strength and should new interventions be implemented?*
- *Is it sensible to implement the same intervention a second time during the game?*
- *Could a new event, or delayed consequences of an old event, have diminished the effect of the interventions that you took?*
- *How many interventions are needed to improve the indicator(s) substantially?*
- *Are there interventions that have contradictory effects?*

A click on the name of one of the indicators shows a text like
The value of "Efficiency of knowledge transfer from marketing" has dropped below a value of 4.5. This indicator refers to the relevance / time and resources ratio of knowledge transfer. Knowledge transfer is efficient if relevant knowledge from the marketing domain is received in related business process areas with a minimum expenditure of energy, time and resources. The indicator is influenced by the speed and effectiveness of knowledge transfer, which can be influenced directly by the interventions taken by your team. In the Interventions handbook information can be found concerning the interventions that could have an influence on this indicator.
An overview of the interventions that you took in the past quarters can be found in the quarterly reports on the top of your bookshelf in the file "Decide on and implement interventions".
Please take notice of the following questions that are also on the bottom of the main "Advisor" window:

- *Could the effect of the intervention(s) you implemented be expected immediately, or is there a delay?*
- *Has the effect of previous intervention(s) already lost its strength and should new interventions be implemented?*
- *Is it sensible to implement the same intervention a second time during the game?*
- *Could a new event, or delayed consequences of an old event, have diminished the effect of the interventions that you took?*
- *How many interventions are needed to improve the indicator(s) substantially?*
- *Are there interventions that have contradictory effects?*

It was hypothesised that the alternative advice would support a selective and reflective mode of information processing better than the “traditional” advice, and therefore would lead to more explicit knowledge (than in the other two groups) because it helps players in selecting and focusing on relevant information (by means of the warnings) and invites reflective thought by means of the questions that are represented. Furthermore, it is hypothesised that the “traditional” advice group would perform better in the game (than the other two groups) because of the alerts and the cues/hints that are provided by the advice functionality. Based on the data that are reported in the previous chapter it was hypothesised that players in the no-advice group would gain more implicit knowledge than the two advice groups because they mainly use an experiential unselective mode of information processing.

To test these hypotheses the (implicit and explicit) knowledge gain was measured by administering a pre-test before players entered the game environment and a post-test after completing the game.

To investigate whether (the type of) advice had an influence on game play the players' behaviour in the game was logged in a file together with the data that are generated by the business simulation model.

7.2 Method

In this section the subjects that participated in the research will be described as well as the instruments that were used and the experimental procedure. The set up is almost the same as in experiment 2. There are two differences: the students played 8 quarters instead of 12, and no transfer test was used because of time and curriculum constraints

7.2.1 Subjects

The students who participated in the experiment did so because the use of the simulation game was an assignment in a course at the Radboud University in Nijmegen. Two groups participated. A group of 68 students from the international exchange program who followed a third year bachelor course Knowledge Management that is part of the English Business Administration program. A larger group of 262 Dutch students who participated in a third year bachelor course Knowledge Management that is part of the Dutch Business Administration program.

Students were randomly assigned to one of the three conditions, before the experiment started. As it turned out 286 students (56 from the first group and 230 from the second group) actually played the game till the end and did the tests. The others dropped out before the course started or during the experiment. Because of this the students were not equally distributed over the conditions. In the "traditional" advice condition there were 94 students, in the alternative advice condition 92 and in the no advice condition 100.

7.2.2 Instruments

The game environment that was used in both conditions was slightly different from the version that is described in Chapter 4. In the current study players played individually, the order of the events was not random but fixed and the same for all students, and the starting values of the indicators were lowered (several are below 5 on a ten point scale). The general game set-up was the same as the one described in Section 5.2.2. The events presented during the game were the same ones as in experiment 2. The only difference compared to the second experiment is that students played 8 quarters instead of 12. The reason for this was a practical one. There was not enough time because the large group had to be divided into three subgroups that played after each other (see Section 7.2.3).

7.2.2.1 Pre and post-test

Knowledge gain is measured by comparing the score on a pre-test and a post-test. Each consisted of 26 multiple-choice questions. There were 18 questions with four answering possibilities and 8 with three options. The first 18 questions were meant to measure explicit knowledge of knowledge management concepts and principles and consisted of textual multiple-choice questions that refer to declarative knowledge about concepts used in the learning environment like the knowledge processes, and steps in the knowledge management model. Furthermore, questions are included that refer to relationships between indicators and interventions. The questions were the same as the ones used in experiment 2 (see Section 6.2.2.1). The last eight questions were meant to measure implicit knowledge. These questions are related to those about the relationships between indicators and interventions but have a different set-up. In these questions a situation is given, an action is described and a set of possible post action situations is given. In each item the textual information is kept to a minimum and a picture or chart is used to present the alternatives. The underlying idea is that students who are not able to express what the exact relationship is between a knowledge management intervention and certain indicators, might still be able to predict what would happen to an indicator, based on the intuitive knowledge that they have gained during game play.

The pre-test and the post-test were identical. The tests were administered on paper and not electronically, as was the case in the first two experiments. This was because it was not possible to give an electronic version to such a large group at the same time. The main differences between the electronic and the paper version are that students are able to go back and forth through the list of questions in the paper version and could not do so in the electronic version, and that there is colour in the electronic version and not in the paper based test.

7.2.2.2 Logfiles

Player performance in the game was logged into a database. These data make it possible to see for each of the eight quarters in the game, which resources people used (and in which order), which interventions they implemented and what the values of the business and knowledge process indicators were.

7.2.3 Procedure

The lecturer of the course in Nijmegen introduced the game in a regular lecture. At the end of this lecture students made the pre-test on paper. After that students could play the game in a predetermined period of time. The total group was split into three subgroups. The reason for this split was because there was no experience with large groups of students working with the KM Quest game environment in the same period of time. There was some doubt whether the underlying architecture would be sufficient for such heavy use. To minimise the possibility of system crashes, the three groups got access in three different time slots, each for two consecutive weeks. Because time was limited the students did not play twelve quarters but eight.

The division of groups was as follows: Group 1 consisted of Dutch students with surnames beginning with N to Z. The students from the international exchange program were all in group 2 as well as the Dutch students with surnames beginning with K – M. The third group consisted of Dutch students with surnames beginning with A to J. Each member of these groups was randomly assigned to one of the three experimental conditions. So in each time slot there were students playing with all three versions of the game.

The post-test was administered to the international students in a lecture the week after game period 2 and to the Dutch students the week after game period 3. So, for the Dutch students the delay between actual game play and the post-test was not the same for every student. This could have had an influence on the scores on the post-test. However, since students from different time slots were spread over the three conditions it is expected that influence is the same for all three experimental conditions.

7.3 Results

In this section data will be presented. Before this is done an important remark has to be made. Although the advice functionality in general is heavily used (see Section 7.4), about ten percent of the players (9 players in the advice group, and 11 in the alternative advice group) never accessed the advice although it was available. These players were not able to “profit” from the support offered by the advice and therefore their data make the view turbid. That is why data from these players are excluded from the analyses and are presented separately (see Section 7.6).

First data are presented from the tests. Next data are reported about game performance. Finally data are presented about the use of additional and standard tools and the relationship between the use of these tools (based on the logfiles) and test scores as well as game performance.

7.3.1 Test results

The results of the pre- and post-test are summarised in Table 7-1. This shows that the scores on the pre-test are almost the same for the three experimental groups. So their prior knowledge level was the same. The average knowledge gain on the post-test compared to the pre-test is 2.42, which is a bit smaller than the gain of the students in the experiment described in the previous chapter (in which the same test items were used) which was 2,76. The students in the current experiment however, played less quarters. For all three groups the difference between the pre- and post-test score is significant. The results of a paired samples T-test are: Advice group t=-7.27, df=84, p=0.00; Alternative advice group t=-7.94, df=80, p=0.00; No advice group t=-6.37, df=99, p=0.00). The no-advice group has the lowest knowledge gain, but the differences between groups are not significant (Anova: F=1.04, df=2, p=0.36).

Table 7-2 indicates that the gain of knowledge in general is mainly on conceptual knowledge (difference between pre and post-test = 1.29) and to a lesser degree in the area of the relationships between indicators and interventions (difference = 0.65).

It is remarkable that students in all three groups have a score of a little bit more than 50% on the implicit knowledge items (see Table 7-1) on the pre-test. In the two previous experiments this score was around chance level (around 33%). Probably the business administration background makes that students have more intuitive knowledge that is applicable in the test than the communication science students in the previous experiments. The table also shows that there is only a small gain in knowledge on these items when the pre- and post-test score are compared.

For all three groups the difference between the pre- and post-test score on the implicit knowledge items is significant. The results of a paired samples T-test are: Advice group t=-2.56, df=84, p=0.012; Alternative advice group t=-3.03, df=80, p=0.003; No advice group t=-2.01, df=99, p=0.048). The no-advice group has the smallest knowledge gain on implicit knowledge. This means that the finding that the advice group had no significant knowledge gain on implicit knowledge that was reported in the previous chapter could not be replicated.

Table 7-1. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the pre-test and post-test for the total group and for the groups with different types of advice and without advice.

	Pre-expl Max=18	Pre-impl Max=8	Pre-tot Max=26	Post-expl Max=18	Post-impl Max=8	Post-tot Max=26	Kn. gain
Advice N=85	8.25 (2.20)	4.09 (1.38)	12.34 (2.56)	10.27 (2.23)	4.56 (1.25)	14.83 (2.80)	2.49 (3.16)
Alt. adv. N=81	8.12 (2.35)	4.06 (1.26)	12.19 (2.76)	10.43 (2.03)	4.60 (1.27)	15.04 (2.41)	2.85 (3.37)
No adv. N=100	8.39 (2.23)	4.04 (1.20)	12.43 (2.83)	10.22 (2.56)	4.36 (1.24)	14.58 (3.18)	2.15 (3.37)
Total N=266	8.26 (2.25)	4.06 (1.27)	12.32 (2.72)	10.30 (2.30)	4.50 (1.25)	14.80 (2.84)	2.47 (3.27)

Table 7-2. Average number of correct answers (and standard deviations) on the different types of explicit knowledge items (conceptual, KMmodel, and relational) of the pre-test and post-test for the total group and for the groups with different types of advice and without advice.

	Pre-conc Max=7	Pre-KMm Max=3	Pre-rel Max=8	Post-conc Max=7	Post-KMm Max=3	Post-rel Max=8
Advice N=85	3.78 (1.37)	1.51 (0.81)	2.96 (1.23)	5.08 (1.21)	1.62 (0.83)	3.56 (1.30)
Alt. adv. N=81	3.81 (1.36)	1.59 (0.79)	2.72 (1.33)	5.28 (0.99)	1.75 (0.86)	3.40 (1.42)
No adv. N=100	3.98 (1.29)	1.58 (0.77)	2.83 (1.28)	5.09 (1.27)	1.62 (0.92)	3.51 (1.51)
Total N=266	3.86 (1.34)	1.55 0.79)	2.84 (1.28)	5.15 (1.17)	1.64 0.87)	3.49 (1.42)

In the previous section it was mentioned that the delay between the actual playing of the game and the moment the post-test was administered was not the same for all students because there were three consecutive rounds of game play. This could have influenced the post-test scores because for some groups their game experience was more recent than for others. Table 7-3 indicates that the third group over all has the largest knowledge gain. This is the group with the shortest delay between game play and test. The first group in general has the smallest gain (difference with other groups is not significant). This is especially true for the No-advice group (Anova: F=3.50, df=2, p=0.03). The difference between the experimental groups within the first group was significant (Anova: F=3.33, df=2, p=0.04). A post hoc analysis showed that the difference between the Alternative advice and No advice group is significant. There is a difference on the explicit but also on the implicit knowledge items of the post-test between these two groups. This seems to indicate that (alternative) advice leads to better retention of both types of knowledge.

Table 7-3. Average knowledge gain from pre-test to post-test for the three experimental groups in each of the three time slots (based on the delay between game play and post-test).

	First group (long delay)	Second group (intermediate delay)	Third group (short delay)
Advice	2.32 (3.79) N=28	2.27 (3.07) N=26	2.84 (2.66) N=31
Alternative advice	2.97 (2.65) N=29	2.50 (3.19) N=24	3.04 (3.85) N=28
No advice	0.91 (3.16) N=33	2.78 (3.48) N=32	2.74 (3.24) N=35
Total N=266	2.01 (3.31)	2.53 (3.24)	2.86 (3.23)

7.3.2 Game performance

Looking at game performance (see Table 7-4 and Table 7-5), all groups have managed to improve the business and knowledge (process) indicators significantly (except profit). The values of the No-advice group for almost all indicators are the lowest but the differences with the others in general are small, except for the level of competence in R&D. Here the difference between groups is significant (Anova: F=4.08, df=2, p=0.02). A post hoc analysis (Tukey HSD) showed that the difference between the Advice and No-advice groups is significant (p=0.01).

Table 7-4. Average end values for some important business (process) indicators in the business simulation model for the total group and for the groups with different types of advice and without advice.

	MS*	CSI	Profit	JSI	PQI	ATM
Advice	24.65	7.48	5.48	7.54	8.21	1.94
N=85	(2.78)	(0.83)	(2.05)	(1.38)	(0.78)	(0.61)
Alt. adv.	24.66	7.32	5.34	7.92	8.06	1.94
N=81	(3.68)	(1.03)	(2.35)	(1.62)	(1.05)	(0.66)
No adv.	24.66	7.21	5.50	7.50	7.89	1.89
N=100	(3.61)	(0.98)	(2.56)	(1.66)	(0.99)	(0.67)
Total	24.66	7.33	5.45	7.64	8.05	1.92
N=286	(3.38)	(0.96)	(2.34)	(1.57)	(0.95)	(0.65)
Start values	20.0	4.40	6.30	4.22	4.80	2.40

* MS = Market share, CSI = Customer satisfaction index, Profit= profit in quarter 8 in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM = Average time for new product to market.

Table 7-5. Average level of competence in three domains for the total group and for the groups with different types of advice and without advice.

	Competence in marketing	Competence in R&D	Competence in production
Advice	7.83	7.90	5.98
N=85	(1.21)	(1.02)	(0.87)
Alt. adv.	7.75	7.62	6.07
N=81	(1.21)	(1.32)	(0.93)
No adv.	7.56	7.38	5.86
N=100	(1.54)	(1.36)	(0.93)
Total	7.70	7.62	5.96
N=286	(1.34)	(1.26)	(0.92)
Start values	4.93	4.38	5.34

7.3.3 Relationship between test results and game play

In the previous two chapters no significant relationships were reported between test score and the end values of a subset of game performance indicators. Table 7-6 shows that in the current study the correlations are also low, but in the advice group there are some significant correlations between pre-test scores and the level of some indicators (customer satisfaction, product quality index and the level of competence in the three knowledge domains). These correlations however are still low. There are also some significant correlations between post-test scores and the level of some indicators. This means that there are indications that a high level of prior knowledge leads to “better” game play when advice is available. This is not the case when no advice is available or when a different type of advice is given.

Table 7-6. Correlation between total pre-test and post-test score, knowledge gain and the average values for some important business and knowledge indicators at the end of the game for the groups without and with different types of advice.

	MS	CSI	Profit	JSI	PQI	CM	CR	CP
Advice								
Pre-test	.14	.24*	.01	.12	.21	.28*	.22*	.23*
Post-test	.17	.26*	-.01	.05	.22*	.15	.21	.28*
Kn. gain	-.04	.04	-.01	-.05	.03	-.09	-.00	.06
Alt. advice								
Pre-test	-.02	.14	-.06	-.11	.09	-.04	.13	-.05
Post-test	-.17	-.16	-.19	-.13	-.16	-.14	-.18	-.16
Kn. gain	-.11	-.24*	-.09	-.01	-.19	-.07	-.24*	-.16
No advice								
Pre-test	.08	.08	-.01	.04	.09	-.07	.04	.08
Post-test	-.02	.11	-.02	-.05	.14	-.18	.14	-.01
Kn. gain	-.08	.04	-.02	-.08	.06	.12	.10	-.06

* Correlation is significant at the 0.05 level (2-tailed). MS = Market share, CSI = Customer satisfaction index, Profit = Profit in quarter 8, JSI = Job satisfaction index, PQI = Product quality index, CM= Level of competence in marketing, CR= Level of competence in R&D, CP= Level of competence in production.

7.4 Advice

In this section the access of advice is discussed and it is investigated whether there is a relationship between the frequency of access, test scores and game performance. Advice is not always available. It is only presented when the value of certain indicators gets below a threshold value. Analysis of the logfiles shows that for the Advice group on the average advice was available in 5.94 (1.97) of the eight quarters and was consulted in 4.64 (2.20) quarters. This means that in 78% of the cases where advice was available it was actually consulted. For the Alternative advice group advice was available in 5.96 (2.12) quarters and was consulted in 4.94 (2.22) quarters. This means that this group consulted the advice in 82% of the cases. This is remarkable since the content of the advice for a large part (the list of questions) was the same every time it was displayed and no indications were given about possible solutions as was done in the other advice group. The main element that was different in the alternative advice every time it was accessed, was the list with names of the indicators that were below a threshold value. Apparently for the players this information was valuable enough to keep accessing the advice functionality.

In the next sections a comparison is made between those players who accessed advice often (51% or more of the quarters where it was available) and those who did so less often (50% or less). Table 7-7 shows that in both experimental conditions in which advice was given advice was available in more than half of the quarters for those who accessed advice often and for those who did less often. This indicates that the frequency of access of advice is not based on the availability of advice per se.

Table 7-7. Average number of quarters (and standard deviations) in which advice was available for those who accessed advice often (51-100%) and less often (1-50%).

	Advice available
Advice	
1-50% (N=18)	5.61 (2.23)
51-100% (N=67)	6.03 (1.90)
Alternative advice	
1-50% (N=9)	4.67 (2.50)
51-100% (N=72)	6.13 (2.03)

7.4.1 Test scores

In Table 7-8 test scores are presented for those players who used advice often (51% or more) and those who did so less often (50% or less) and those who did not have advice. It shows that the frequency of access of the advice available did not result in large differences on the post-test. There seems to be a difference in knowledge gain between those who consulted advice frequently and those who did not in the Advice-group, but this difference is not significant (Anova: F=1.21, df=1, p=0.27).

Table 7-8. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the pre-test and post-test for the groups with different types of advice and without advice for those who accessed advice often (51-100%) and less often (1-50%).

	Pre-total Max=26	Post-explicit Max=18	Post-implicit Max=8	Post-total Max=26	Knowledge gain
Advice					
1-50% (N=18)	11.61 (2.57)	10.39 (2.73)	4.44 (1.20)	14.83 (3.03)	3.22 (3.34)
51-100% (N=67)	12.54 (2.54)	10.24 (2.10)	4.60 (1.27)	14.84 (2.76)	2.30 (3.11)
Alt. adv.					
1-50% (N=9)	12.67 (2.55)	11.33 (1.66)	4.44 (1.24)	15.78 (1.56)	3.11 (2.85)
51-100% (N=72)	12.13 (2.80)	10.32 (2.05)	4.63 (1.28)	14.94 (2.49)	2.82 (3.29)
No adv.					
N=100 *	12.43 (2.83)	10.22 (2.56)	4.36 (1.24)	15.04 (2.41)	2.85 (3.37)

7.4.2 Game performance

Table 7-9 shows differences between and within groups regarding the level of some of the business indicators in the business simulation model. The differences on the customer satisfaction index (Anova: F=7.30, df=1, p=0.008) and the product quality index (Anova: F=4.19, df=1, p=0.044) between those who consulted advice frequently (51-100%) and those who did less frequently in the Advice-group is significant. The first group has higher scores. No such difference was found between these two groups in the Alternative advice condition. This seems to indicate that the hints provided in the advice texts are useful to perform better in the game. However, this does not indicate that these players learned more (see Table 7-8).

Table 7-9. Average level of business indicators (and standard deviations) for the groups with different types of advice and without advice for those who accessed advice often (51-100%) and less often (1-50%).

	MS	CSI	Profit	PQI	JSI
Advice					
1-50% (N=18)	24.23 (2.98)	7.02 (1.11)	5.08 (2.24)	7.89 (1.02)	7.58 (1.64)
51-100% (N=67)	24.77 (2.73)	7.60 (0.70)	5.61 (1.99)	8.30 (0.68)	7.53 (1.31)
Alt. adv.					
1-50% (N=9)	24.70 (4.86)	7.39 (1.63)	5.20 (2.34)	8.01 (1.77)	8.20 (1.71)
51-100% (N=72)	24.66 (3.55)	7.31 (0.95)	5.36 (2.37)	8.06 (0.93)	7.92 (1.62)
No adv.					
N=100	24.66 (3.61)	7.21 (0.98)	5.50 (2.56)	7.50 (1.66)	7.89 (0.99)

* MS = Market share, CSI = Customer satisfaction index, Profit = Profit in quarter 8, JSI = Job satisfaction index, PQI = Product quality index.

In Table 7-10 the average level of competence in the three knowledge domains is presented. Analyses of variance did not reveal significant differences between those who consulted advice or the alternative advice frequently and those who did less frequently.

Table 7-10. Average level of competence (and standard deviations) in three domains for the groups with different types of advice and without advice for those who accessed advice often (51-100%) and less often (1-50%).

	Competence in Marketing	Competence in R&D	Competence in Production
Advice			
1-50%.(N=18)	7.61 (1.65)	7.51 (1.36)	5.99 (1.14)
51-100% (N=67)	7.89 (1.07)	8.01 (0.89)	5.97 (0.79)
Alt. adv.			
1-50%.(N=9)	7.80 (1.62)	7.56 (2.15)	5.99 (1.36)
51-100% (N=72)	7.75 (1.16)	7.63 (1.32)	6.07 (0.94)
No adv.			
N=100	7.56 (1.54)	7.38 (1.36)	5.86 (0.93)

7.5 Access of the support tools

In this section the access of the other support tools that are available in the learning environment is documented. Table 7-11 shows that the Intervention handbook and the visualisation tools are accessed in 75% of the quarters and feedback and the Indicator handbook in about 50%. The other resources are rarely used. There are no significant differences between the three experimental groups, except for the use of the Intervention handbook (Anova: F=7,72, df=2, p=0.001). A post hoc analysis (Tukey HSD) revealed that the advice group uses this book significantly more often than the no-advice group. This is probably caused by the direct links between the texts that are displayed in the advice functionality and the intervention handbook. Clicking on these links directly opens a particular chapter of the intervention handbook.

Table 7-11. Average number of quarters in which a selection of the standard resources were accessed by the learners for the total group and for the groups with different types of advice and without advice.

	Feedb	Intv HB	Indc HB	Hist	What	How	Help	Visual
Advice	4.04	6.75	4.22	2.06	0.60	0.53	0.32	6.21
N=85	(2.96)	(1.90)	(1.99)	(1.65)	(0.82)	(0.57)	(0.60)	(2.82)
Alt. Adv.	4.17	6.15	4.02	2.20	0.75	0.58	0.32	5.86
N=100	(2.89)	(2.73)	(1.81)	(2.19)	(0.97)	(0.76)	(0.59)	(2.90)
No adv.	4.85	5.29	4.23	1.87	0.55	0.52	0.35	5.25
N=81	(3.12)	(2.87)	(2.01)	(1.77)	(0.66)	(0.69)	(0.61)	(3.15)
Total	4.38	6.02	4.17	2.03	0.63	0.54	0.33	5.75
	(3.01)	(2.62)	(1.94)	(1.87)	(0.83)	(0.67)	(0.59)	(2.99)

7.6 Data from students excluded from the advice groups

As stated before data from 19 students were not included in the analyses because they did not access advice although it was available. The data from these students show that advice was actually available in 4.22 (2.22) quarters for the Advice group and in 5.60 (2.17) quarters for the Alternative advice group. So, the reason that they did not access advice is not that advice was not available. Compared to the group that was included in the analyses (see Section 7.4) for the “outliers” in the Advice group advice was available in fewer quarters (4.22 compared to 5.94). This difference is significant (T-test: t=2.46, df=92, p=0.02). For the Alternative advice groups this difference was not significant (5.60 compared to 5.96). The fact that advice was available in fewer quarters is because certain indicators were less frequently below a threshold value, indicating that these players performed better in the game. Looking at the end values of a subset of all indicators this is confirmed. On all the indicators the “outliers” from the Advice group have a higher value (see Table

7-12). However, these differences are not significant except for the Level of competence in production (T-test: t=-2.35, df=92, p=0.02).

Table 7-12. Average end values for some important business (process) indicators in the business simulation model for the users and non-users of advice in the two advice conditions.

	MS*	CSI	Profit	JSI	PQI	ATM	CM	CR	CP
Advice	24.65	7.48	5.48	7.54	8.21	1.94	7.83	7.90	5.98
N=85	(2.78)	(0.83)	(2.05)	(1.38)	(0.78)	(0.61)	(1.21)	(1.02)	(0.87)
Alt. adv.	24.66	7.21	5.34	7.92	8.06	1.94	7.75	7.62	6.07
N=81	(3.61)	(0.98)	(2.35)	(1.62)	(1.05)	(0.66)	(1.21)	(1.32)	(0.93)
Non users Adv.	25.73	7.66	5.70	7.90	8.30	1.56	8.26	7.91	6.67
N=9	(2.11)	(0.73)	(2.27)	(0.92)	(0.80)	(0.49)	(0.91)	(1.14)	(0.54)
Non users Alt.	24.36	7.29	3.32	8.21	8.02	1.80	7.24	7.44	5.99
adv.	(4.57)	(0.95)	(2.38)	(1.89)	(1.17)	(0.59)	(1.69)	(1.57)	(1.44)
N=10									

* MS = Market share, CSI = Customer satisfaction index, Profit = profit in quarter 8 in millions, JSI = Job satisfaction index, PQI = Product quality index, ATM = Average time for new product to market, CM =.Level of competence in Marketing, CR = Competence in R&D, CP = Competence in Production.

This leaves the question why the outliers performed better in the game. Is it because they behave differently? In Table 7-13 data are presented of those players who were excluded from the groups because they did not access advice although it was available. A comparison with the data in Table 7-11 shows that there are no striking differences between these players and the other players who did access advice. So, there are no indications that these players behaved differently in the game because they did not access advice.

Table 7-13. Average number of quarters in which a selection of the standard resources were accessed by the learners who did not access advice although it was available in the conditions with different types of advice.

	Feedb	Intv HB	Indc HB	Hist	What	How	Help	Visual
Advice	4.78	6.33	3.00	1.44	0.56	0.78	0.00	5.33
N=9	(3.63)	(2.78)	(1.58)	(1.65)	(0.52)	(0.67)	(0.00)	(3.39)
Alt. Adv.	2.90	6.00	4.10	0.70	0.50	0.90	0.10	5.30
N=10	(2.17)	(3.27)	(2.64)	(2.19)	(0.53)	(1.10)	(0.31)	(3.27)

Table 7-14. Average number of correct answers (and standard deviations) on the explicit and implicit knowledge items of the pre-test and post-test for the users and non-users of advice in the two advice conditions.

	Pre-expl Max=18	Pre-impl Max=8	Pre-tot Max=26	Post-expl Max=18	Post-impl Max=8	Post-tot Max=26	Kn. gain
Advice	8.25	4.09	12.34	10.27	4.56	14.83	2.49
N=85	(2.20)	(1.38)	(2.56)	(2.23)	(1.25)	(2.80)	(3.16)
Alt. adv.	8.12	4.06	12.19	10.43	4.60	14.86	2.61
N=81	(2.35)	(1.26)	(2.76)	(2.03)	(1.27)	(2.48)	(3.31)
Non users	8.67	4.67	13.33	11.00	5.22	16.22	2.89
Adv.	(2.23)	(1.12)	(2.73)	(1.87)	(0.67)	(2.11)	(3.33)
N=9							
Non users	8.10	4.60	12.70	9.30	4.40	13.70	1.00
Alt. adv.	(1.10)	(0.96)	(1.42)	(2.90)	(1.25)	(2.83)	(3.62)
N=10							

In the last table of this section (Table 7-14) data are presented about the test scores of the users and non-users of advice. This indicates that the non-users of advice had a higher pre-test score than the users. However, these differences were not significant. The non-users in the Advice condition also had a (non-significant) higher post-test sore. In the Alternative advice condition, however they had a (non-significant) lower score (and lower knowledge gain) than the ones who used the alternative advice.

In general a comparison of the data of those subjects included in the analyses and the ones excluded do not reveal important differences that could have meaning for the interpretation of the data that are presented in the other sections.

7.7 Differences between players with a high and low knowledge gain

In this section a different view on the data is presented. It is investigated whether players with a low knowledge gain from pre-test to post-test (-1 point or less) behave differently in the game than players who have high gain (7 points or more). A comparison of the access of some of the support tools (feedback, advice, intervention handbook, indicator handbook and visualisations) of these groups of players is made. The other support tools were not included because they were sparsely used.

Table 7-15 shows that in general there are no large differences between the students with a low knowledge gain and those with a high knowledge gain, except for the access of feedback. The difference between the total group scores regarding the access of feedback is significant (t=-2.04, df=53, p=0.047) as was the case in the experiment reported in Chapter 5 (see Section 5.4). Within the three conditions these differences were not significant. So feedback seems to play an important role in learning in the game. This finding will be elaborated in the next section.

Table 7-15. Average number of quarters in which a selection of the standard support tools were used by the learners with a low knowledge gain from pre-test to post-test (-1 points or less) and with a high knowledge gain (7 points or more) for the groups with different types of advice and without advice.

	Feedback	Advice	Intervention HB	Indicator HB	Visualisations
Advice					
Low, N=8	2.88 (3.51)	0.79 (0.30)	5.38 (1.85)	4.75 (1.91)	5.25 (2.96)
High, N=6	3.83 (2.48)	0.82 (0.31)	7.33 (1.63)	3.33 (1.86)	7.33 (2.65)
Alt. advice					
Low, N=7	2.86 (3.33)	0.78 (0.19)	5.43 (2.94)	3.00 (1.53)	6.00 (3.37)
High, N=10	4.60 (2.63)	0.85 (0.20)	5.70 (3.02)	3.50 (1.08)	6.60 (1.78)
No advice					
Low, N=13	3.23 (3.17)	-	5.76 (3.11)	5.23 (2.20)	5.31 (3.01)
High, N=11	5.18 (3.06)	-	5.36 (2.87)	4.55 (1.57)	3.81 (2.60)
Total group					
Low, N=28	3.04 (3.19)		5.57 (2.67)	4.54 (2.12)	5.46 (2.99)
High, N=27	4.67 (2.73)		5.93 (2.73)	3.89 (1.53)	5.63 (2.73)

7.8 The role of the access of resources in the no-advice group

Additional analyses revealed that apart from feedback the frequency of access of the other tools, like visualisations and the handbooks, does not have a relationship with test scores or the level of the business and knowledge indicators in the game in both of the advice groups. In the no-advice group however, there are some interesting relationships. These will be presented in this section. As stated in Section 5.5 caution has to be taken with conclusions based on these additional analyses since there is a possibility that intermediate variables that have not been measured play a role.

Furthermore, the groups that are distinguished based on the different tools are not totally independent.

In Table 7-16 test scores are presented for groups of players who have used resources like feedback, the visualisations, and the intervention and indicator handbook in more than the half of the quarters of game play and for those who used them less frequently. In Table 7-17 and Table 7-18 the level of a subset of indicators at the end of the game is presented for the same groups (all within the no-advice condition).

Table 7-16 shows that there is a significant difference on the score on the explicit knowledge items of the post-test (Anova: F=8.79, df=1, p=0.00) and on the total score on the post-test (Anova: F=6.49, df=1, p=0.01) between those who have consulted feedback frequently and those who did so less frequently. The first group has higher scores.

Furthermore, there is a significant difference on the implicit knowledge items of the post-test between those who have consulted the intervention handbook frequently and those who did so less frequently (Anova: F=6.67, df=1, p=0.01). The first group has higher scores. Table 7-17 shows that there is a difference in market share (Anova: F=4.08, df=1, p=0.046) and in profit (Anova: F=7.19, df=1, p=0.009) in the last quarter of the game between these groups. The group who has consulted the intervention handbook frequently has a significant lower market share and profit than the group who consulted this book less frequently.

There are no relationships between the frequency of use of the indicator handbook, test scores and the level of the indicators. However, there is a relationship between the use of the visualisation tools and the score on the explicit items of the post test (Anova: F=3.94, df=1, p=0.050) and the total score on the post-test (Anova: F=4.01, df=1, p=0.048). The first group has higher scores. The ones who used these tools frequently have a higher test score. They have also a significantly higher score on the customer satisfaction index (Anova: F=3.95, df=1, p=0.050), the product quality index (Anova: F=7.67, df=1, p=0,007) and the level of competence in the R&D domain (Anova: F=7.38, df=1, p=0.008).

These data indicate that the active and frequent use of the additional resources, especially the feedback that is available, the intervention handbook and the visualisation tools leads to higher levels of knowledge for those players who could not use the advice functionality.

Table 7-16. Average number of correct answers (and standard deviations) on the pre-test and post-test for those who used resources often (5-8 quarters) and less often (1-4 quarters) in the No-advice condition

	Pre-total Max=26	Post-explicit Max=18	Post-implicit Max=8	Post-total Max=26	Knowledge gain
Feedback		*		*	
1-4 qua.(N=40)	11.95 (2.99)	9.28 (2.99)	4.28 (1.16)	13.56 (3.69)	1.62 (4.04)
5-8 qua (N=60)	12.73 (2.72)	10.78 (2.04)	4.40 (1.30)	15.18 (2.62)	2.45 (2.86)
Interv. HB			*		
1-4 qua.(N=38)	12.11 (2.79)	10.00 (2.57)	3.95 (1.20)	13.95 (3.03)	1.84 (3.33)
5-8 qua (N=62)	12.61 (2.88)	10.31 (2.56)	4.60 (1.22)	14.90 (3.23)	2.29 (3.41)
Indic. HB					
1-4 qua.(N=55)	12.11 (2.96)	10.00 (2.59)	4.40 (1.12)	14.40 (3.22)	2.29 (3.24)
5-8 qua (N=45)	12.82 (2.66)	10.43 (2.53)	4.30 (1.41)	14.73 (3.15)	1.91 (3.58)
Visualisation.		**		**	
1-4 qua.(N=47)	12.00 (3.26)	9.65 (2.60)	4.22 (1.26)	13.87 (3.32)	1.87 (3.75)
5-8 qua (N=53)	12.79 (2.40)	10.66 (2.45)	4.47 (1.23)	15.13 (2.94)	2.34 (3.04)

* Difference is significant p<0.02 ** Difference is significant p≤0.05

Table 7-17. Average level of some business indicators (and standard deviations) at the end of the game for those who used resources often (5-8 quarters) and less often (1-4 quarters) in the No-advice condition

	MS	CSI	Profit	PQI	JSI
Feedback					
1-4 qua.(N=48)	24.82 (3.55)	7.08 (1.02)	5.58 (2.53)	7.84 (0.95)	7.64 (1.66)
5-8 qua (N=70)	24.53 (3.70)	7.27 (0.96)	5.41 (2.61)	7.91 (1.02)	7.44 (1.67)
Interv. HB	*		*		
1-4 qua.(N=42)	25.58 (3.45)	7.24 (0.99)	6.35 (2.28)	7.98 (0.94)	7.35 (1.90)
5-8 qua (N=76)	24.08 (3.63)	7.17 (0.98)	4.96 (2.61)	7.82 (1.02)	7.62 (1.51)
Indic. HB					
1-4 qua.(N=68)	24.72 (3.43)	7.27 (0.86)	5.47 (2.42)	7.94 (0.92)	7.70 (1.40)
5-8 qua (N=50)	24.55 (3.88)	7.10 (1.11)	5.48 (2.77)	7.81 (1.07)	7.29 (1.94)
Visualisation.		**		*	
1-4 qua.(N=53)	24.20 (4.05)	6.99 (1.01)	5.10 (3.05)	7.60 (1.10)	7.42 (1.73)
5-8 qua (N=65)	25.02 (3.20)	7.37 (0.93)	5.81 (2.04)	8.13 (0.81)	7.60 (1.62)

* Difference is significant $p<0.01$. ** Difference is significant $p \leq 0.05$. MS = Market share, CSI = Customer satisfaction index, Profit = Profit in quarter 8, JSI = Job satisfaction index, PQI = Product quality index.

Table 7-18. Average level of competence (and standard deviations) in the three domains at the end of the game for those who used resources often (5-8 quarters) and less often (1-4 quarters) in the No-advice condition

	Competence in Marketing	Competence in R&D	Competence in Production
Feedback			
1-4 qua.(N=48)	7.54 (1.51)	7.25 (1.41)	5.75 (0.91)
5-8 qua (N=70)	7.55 (1.58)	7.43 (1.33)	5.94 (0.95)
Interv. HB			
1-4 qua.(N=42)	7.70 (1.68)	7.41 (1.37)	5.75 (0.97)
5-8 qua (N=76)	7.45 (1.46)	7.33 (1.36)	5.93 (0.92)
Indic. HB			
1-4 qua.(N=68)	7.63 (1.61)	7.44 (1.27)	5.92 (0.89)
5-8 qua (N=50)	7.45 (1.46)	7.25 (1.47)	5.80 (0.99)
Visualisation.		*	
1-4 qua.(N=53)	7.51 (1.62)	6.97 (1.48)	5.83 (0.91)
5-8 qua (N=65)	7.58 (1.49)	7.69 (1.16)	5.89 (0.97)

* Difference is significant $p<0.01$.

7.9 Summary and discussion

In this chapter data from an experiment are reported in which three versions of KM Quest were used: one with the "standard" advice functionality (with warnings and hints), one in which a different type of advice was given (that did not contain hints, but warnings accompanied by a set of questions) and one that did not contain advice. It was hypothesised that the alternative advice would support a selective and reflective mode of information processing and therefore would lead to more explicit knowledge (than in the other two groups) because it helps players in selecting and organising relevant information (by means of the warnings) and stimulates reflective thought by means of the questions that are represented. Furthermore, it was hypothesised that the advice group would perform better in the game (than the other two groups) because of the warnings and hints that are provided by the advice functionality. Based on the data that are reported in the previous chapter it was hypothesised that players in the no-advice group would gain more implicit knowledge that the other two advice groups.

To test these hypotheses the (implicit and explicit) knowledge gain was measured by administering a pre-test before players entered the game environment and a post-test after completing the game.

To investigate whether (the type of) advice had an influence on game play the players' behaviour in the game was logged in a file together with the data that are generated by the business simulation model.

The first hypothesis could not be confirmed. All three groups had comparable scores on the explicit knowledge items of the post-test. Also, the frequency of access of the advice did not have a relation with the test scores. An unexpected finding was that the length of the delay between game play and post-test played a role. In the group of players with the longest delay the No-advice group had a significant lower knowledge gain than the Alternative-advice group. There was a difference on the explicit but also on the implicit knowledge items of the post-test between these two groups. This seems to indicate that (alternative) advice leads to better retention of both types of knowledge.

In general the second hypothesis could also not be confirmed. There was only a difference between groups in the expected direction on the indicator that refers to the level of competence in the R&D domain. When the frequency of access of the advice was taken into account in the Advice-group there were some significant differences on the customer satisfaction index and the product quality index between those who consulted advice frequently (5-8 quarters) and those who did less frequently. The first group has higher scores. No such difference was found between these two groups in the Alternative advice condition.

There are some indications that the level of prior knowledge plays a role in the relationship between advice and game play. For the Advice group (with warnings and hints) significant correlations were found between pre-test scores and the level of some indicators at the end of the game. However, these correlations still are modest. In the other groups no significant correlations were found between pre-test (or post-test) scores and game indicators.

The third hypothesis that had to do with the implicit knowledge could also not be confirmed. There were no differences in implicit knowledge gain from pre- to post-test between the three groups. All three groups had a small though significant gain in the scores on the implicit knowledge items. It is striking that the pre-test scores were already high compared to the scores in the experiment that is reported in the previous chapter (where the same test items were used). In the current experiment the score was a little bit above 50% correct answers while in the previous experiment the pre-test score was around chance level (33%) and the average post-test score was at the level of the pre-test score in the current experiment. The difference in pre-test scores is probably caused by the difference in the backgrounds of the students. In the previous experiment the students are from Communication Science and in the current study they were from Business Administration. Although this last group did not play comparable simulation games in their regular courses (according to the lecturer), they probably have build up more intuitive knowledge during these courses that is applicable in the test items. One would expect that this difference in background and prior knowledge would also lead to differences in the effectiveness of game play. Based on the data presented in this and the previous chapter it however is hard to say whether this is true because the players in experiment 2 played 12 quarters and the players in the current study played only 8 quarters. An additional analysis of the data in the logfiles of experiment 2 revealed the status of game indicators after 8 quarters of play. This showed that the level of the main business indicators like market share (24.6 in the current study versus 26.2 in the previous one), customer satisfaction (7.3 versus 7.5) and profit (5.4 million versus 5.6 million) do not indicate that the players in the current study were performing better.

Data from the current study contain some indications that the frequency of use of the intervention handbook plays a role in acquiring more intuitive or implicit knowledge. In the No-advice groups there is a significant difference on the implicit items of the post-test between those who have consulted the intervention handbook frequently and those who did so less frequently. The first group has higher scores. In the advice groups this difference was not found.

The fact that there were no differences between the advice and the alternative-advice groups seems to indicate that the hints provided in the advice texts (that were not presented in the alternative advice texts) did not play such a large role as expected. That the players in the alternative-advice group accessed the advice as frequently as the advice group although no hints were available seems to indicate that players use the advice functionality mainly because of the warning system that it contains. This system gives them a quick view of the indicators that need attention. This type of information can also be found by using the measurement system or the visualisations, but than it is more difficult to find the particular indicators. Players in the Advice group use the hints to find information in the intervention handbook about interventions that could be implemented to improve the level of the indicators. Players who do not receive these hints (no-advice or alternative advice) however know where to find this information themselves. This could be deduced from the fact that all groups use the other information resources with almost the same frequency.

Players who cannot use advice and therefore do not have the warning system and the hints have to put in more effort to find the relevant information. Those who do so (within the no-advice group) and frequently use the feedback, intervention handbook or visualisations learn more than those who use these resources less frequently. The first groups have higher post-test scores. It remains unclear however why this effect of the use of these resources is not found within the advice and alternative advice groups. An explanation could be that the differences are caused by the effort that the players have to put in searching for relevant information. Players in the No-advice group have to search for cues that indicate “problems” and for cues about the way to solve these problems. Players in the advice groups do not have to search for the first type of cues because these are provided by the alerts that are given in the advice.

The finding that no differences in explicit and implicit knowledge (gain) were found between conditions could mean that the modes of information processing used by the students in general were not different between groups and that the advice available in different forms (alerts and cues or alerts and questions) did not support the use of a different strategy but mainly supported game performance. This experiment however, as well as the first experiment (reported in Chapter 5) gave several indications that feedback plays an important role in learning with the KM Quest simulation game. The players with a high knowledge gain in general, used this type of support significantly more frequent. Moreover, within the No-advice group the frequency of access of feedback was correlated with post-test scores.

8 Discussion

8.1 Introduction

This thesis is about learner support in an educational knowledge management simulation game called KM Quest (see Chapter 4). It presents empirical data concerning the effectiveness of supports like additional assignments and advice given by the learning environment. Although the fast growth of the use of digital games (on game consoles, personal computers and the Internet) in the last two decades has led to renewed attention to the role of game play in education (see for example Dawes and Dumbleton, 2001, McFarlane, Sparrowhawk, and Heald, 2002; Kirriemuir and McFarlane, 2003; Gee, 2003; Squire, 2004 and Egenfield-Nielsen, 2005) and to scientific research that could be used to design effective educational games, there are still few studies that provide such empirical data. In general however, there is consensus that games can be powerful educational tools and that instructional support is needed to ensure that learning is taking place.

In Chapter 3 the assumption was made that in learning with games different modes of information processing could be distinguished: an unselective experiential (search and apply) strategy and a selective reflective strategy. Both types of information processing lead to different types of learning results.

The experiential mode seems to be a ”natural” way to process knowledge in rich dynamic environments like games, especially when the players have little task relevant knowledge. This mode leads to learning of facts, procedures, instances, examples, and sequences of actions that are applicable in the context of the game. When new abstractions, rules or insights are learned this is mostly implicit, intuitive and context specific knowledge that is difficult to verbalise and transfer to other situations.

The second mode requires more mental effort, structure and selective reasoning than the experiential mode and players switch to this mode only when they get into an impasse because the games goals did not come closer and they don’t have enough cues, instances or action sequences available to guide their actions. When this reflective mode is successful players will develop new explicit insights and strategies that they can apply during the rest of the game or in situations that are comparable to the game situation.

The largest knowledge gain from an educational game is to be expected when players switch between modes and use both an experiential mode of information processing and a reflective mode. This will lead to new intuitive knowledge and to explicit knowledge. Since the experiential mode seems to be the natural way to proceed in rich dynamic games, elements should be added that can support a (switch to a) reflective strategy. The use of tools (inside or outside the game environment) or the help of other people should support the reflective processing mode also when players are not in an impasse. A review of games research revealed that the following tools could be effective in supporting a reflective mode: cooperation and collaboration, debriefing and group discussions, feedback, monitoring facilities, additional assignments, and guidance by means of hints and prompts, a help or advice system.

However, as it is stated in Section 4.6 where the specific supports are presented that are available in the KM Quest learning environment that is used in this study, the role of these instructional supports often is not fully clear. On the one hand they can support the use of a reflective strategy because these elements help players in organising the available information and in focusing on relevant data. By doing this, players do not have to put in a lot of mental effort into these processes and can redirect this effort to reflective thought. On the other hand these tools could also diminish the need to switch to a reflective strategy because the support tools contain enough information and cues to be able to act and react in the game so that players keep using the experiential mode of information processing. This means that players just search (by clicking on resources and following links) in the environment until enough cues are found and than apply the information.

8.2 Central question and data from the experiments

In this thesis research focuses on two of these support elements that can be incorporated into the game itself. So elements that could be added to the learning scenario or the didactical situation and that are not an integral part of the environment in which the game is used, like debriefing and collaboration, are not taken into account. The role of some supports that could be implemented in a game (like feedback and monitoring facilities) seems obvious although there is not much research that grounds this. If no proper process feedback is given and no data are available from previous actions and game states it will be difficult for players to use a reflective strategy. The role of two other elements (guidance and additional assignments) still is not clear.

A certain type of additional assignments (investigation assignments) were reported to have a positive effect when added to a simulation, but these led to a gain of intuitive knowledge (De Jong, Härtel, Swaak, and Van Joolingen, 1996) and thus seemed to support an experiential mode and not a reflective strategy. Therefore further research should focus on a different type of assignments.

Until now there is only one study (Leutner, 1993) in which guidance in a simulation game in the form of advice warnings, led to a gain in explicit knowledge. Further research is needed to clarify the importance of advice.

This leads to the following central question that is the basis of the research reported in this thesis “Do additional elements in the game, like assignments or advice, support the use of a reflective mode of information processing and thereby the acquisition of explicit knowledge?”

Three experiments were conducted to answer the central question. In all three a pre-test was used to measure explicit and implicit knowledge of students before they started using the KM Quest learning environment that is described in Chapter 4. Main element in this environment is a simulation game about knowledge management in which players play the role of knowledge manager in a fictitious company. They play their role for a number of quarters (8 or 12) in the life span of this company. In the game they have a limited budget that can be used to implement interventions that could have an influence on five different types of knowledge processes (gaining, development, transfer, retention and distribution) in three knowledge domains (marketing, production and research & development). By influencing these processes players indirectly influence the level of competence in these domains and this propagates to indicators at the business level like product quality, job satisfaction etc. Finally, these business indicators have an influence on three top-level indicators in the business simulation model: market share, customer satisfaction and profit. The goal of the game is to optimise the level of these three indicators. During the game unexpected events are introduced that could have an influence on certain indicators in the simulation model. Players have to decide whether to react upon these events or not and how to react. To support them in this process several resources are available like a knowledge management model, feedback, advice, visualisations and background information by means of handbooks about the indicators in the simulation model and the interventions that could be implemented (see Section 4.6) After a quarter is finished the business simulation model processes the interventions that the players have chosen and calculates new levels for the indicators. After the game has ended, players received a post-test (which was identical to the pre-test) to assess whether they have gained knowledge during game play. In the first two experiments also a transfer test was administered.

8.2.1 Experiment 1

In a first experiment two groups (one of 16 and one of 12) of master students from Communication Studies of the University of Twente were involved who used different versions of KM Quest. One used the “standard” version and the other used a version in which additional assignments were implemented. There were indications that such tasks are effective in learning with simulations. De Jong and Van Joolingen (1998) concluded that three individual instructional measures can be seen as holding the promise of positively influencing learning outcomes in scientific discovery learning with computer simulations: providing direct access to domain information, providing assignments, questions or exercises, and model progression (when the model is sufficiently complex). De Jong, Härtel, Swaak, and Van Joolingen (1996) found that students who were free to choose, used assignments very frequently in a simulation, and that using assignments had a positive effect on the gaining of intuitive knowledge. This seems to indicate that the type of assignments that were used did not support a reflective mode but an experiential mode.

The assignments used in this study were investigation assignments that prompt the learner to start an inquiry about the relationship between specified variables. Van Joolingen and De Jong (2003) apart from investigation assignments also distinguish specification assignments that ask students to predict a value of a certain variable, explicitation assignments that ask the student to explain a certain phenomenon in the simulation environment, optimisation assignments that ask students to reach a specified optimal situation, and operation assignments in which a certain procedure is applied. These kinds of additional assignments could be effective in simulations with a limited number of variables, but probably are less effective in relatively complex game environments, with a lot of variables and where the relationships between variables and between variables and user actions are less self evident.

In these kinds of environments assignments that focus attention on aspects that might have been overlooked or taken for granted without mindful processing of information (Reiser, 2002), might be more effective, as well as assignments that ask the learner to make generalisations based on their experiences so far.

In the study performed the additional assignments consisted of focus questions and a lessons-learned task (see Section 5.1). The hypothesis was that students using the version with additional assignments will gain more explicit knowledge while playing the game than the ones who did not have these assignments, because the assignments ask players to reflect on their own behaviour and that of “virtual” others and furthermore ask them to make implicit knowledge that was gained while using an experiential mode more explicit (by formulating a lesson learned).

Students could use the additional assignments, but their use was not enforced by the system. Analysis of the logfiles that kept track of the players’ behaviour showed that overall these assignments were actually used in about half of the game quarters. There were no differences found between the two experimental groups on test scores and on game performance. Therefore the main hypothesis that students using the version with additional assignments would gain more explicit knowledge while playing the game could not be confirmed. This could mean that the modes of information processing used by the students in both conditions in general were the same and that the additional assignments did not support the use of a reflective mode. There are indications that the use of the assignments was counterproductive since the frequency of access of the additional assignments did have a significant effect on knowledge gain on the explicit knowledge items. Those subjects who used the assignments less often had higher scores on the explicit knowledge items of the post-test than the ones who accessed them often. This could be caused by the fact that the assignments focused the attention of players mainly on game goals and game behaviour and not on underlying principles.

A comparison of the access of the other support tools in the game by players who had a high knowledge gain (from pre-test to post-test) and those who had a low knowledge gain revealed that the last group accessed feedback significantly more than the first group.

8.2.2 Experiment 2

The second study focused on the role of advice because the first study revealed that almost all players heavily used the advice functionality. Advice was only available in the game when certain indicators in the simulation model got below a threshold value. The advice-icon in the status bar of of the game started blinking if advice was available. When students clicked on this icon a warning was presented together with a list of indicators that were below the threshold value. Clicking on the name of an indicator made a window appear with more information and general hints about the type of interventions that could be implemented to improve the level of the indicator. This window contained links to relevant chapters of the intervention handbook. In 83% of the cases where advice was available the advice functionality was actually consulted by the players. The data from the first experiment however did not reveal whether the use of advice was beneficial for learning. However, a relationship between game performance and the use of advice was found. Frequent users of advice performed better.

A literature review did not lead to many cues about the influence of advice on learning in these kinds of learning environments. A study from Leutner (1993) also used advice in a simulation game. In that study part of the players during the game were provided with warnings if their decisions were likely to lead to problems. Results of the experiments (with 7th grade students and with university students) showed that advice increased verbal domain knowledge, but decreased game performance. Furthermore, the data indicated that system-initiated adaptive advice had short-term effects (measured directly after game play), while learner requested non-adaptive background information had long-term effects (measured by a test that was administered a week after game play).

The role of advice in Leutner's study was to focus the player's attention on important aspects and misconceptions. Mayer (2004) envisions the same role for guidance in discovery learning environments (like simulations and games) in general. He states that pure discovery learning often fails because students may not come into contact with the relevant information. Guidance should prevent this from happening. "The challenge of teaching by guided discovery is to know how much and what kind of guidance to provide and to know how to specify the desired outcome of learning" (Mayer, 2004, p.17). Looking at the two modes of information processing that were discussed in Section 3.4 one could say that guidance offered by advice in a simulation game should support a reflective strategy because it helps students in selecting, organising and integrating knowledge.

To explore the effects of advice on learning an experiment was performed. Two versions of the KM Quest simulation game were used: one with the advice and one in which this resource was removed. It was hypothesized that students in the advice group would gain more explicit knowledge (in line with Leutners findings) and would perform better in the game because they receive hints about possible solutions. This last hypothesis is not in line with Leutners findings, but this is because the type of advice given in the current study is different than the advice given in the experiments performed by Leutner. In those experiments only warnings were provided by the system. In the KM Quest environment warnings are also given, but these are accompanied with general suggestions to improve the status of the specific indicators.

In the experiment 29 master students from Communication Science at the University of Twente participated. Data from the logfiles show that in 77% of the cases where advice was available, it was actually consulted. This finding is in line with the findings of the first experiment. This indicates that the players appreciated the advice functionality, but there are also indications that the effectiveness of the advice given was low. Players in the no-advice condition score equally well on game performance, on the explicit knowledge items of the post-test and on the transfer test. The hypothesis was that advice would support a reflective mode of information processing because it helps students in selecting, organising and integrating knowledge and because it prevents players from missing essential information. Therefore it was expected that players in the advice group would gain more explicit knowledge. This expectation could not be confirmed. It is unclear whether the advice did not support a selective and reflective strategy or that it did support the use of this mode, but that this mode was not effective. There are indications that this latter might be the case. A first indication is that that the players in the advice condition did not gain implicit knowledge while the players in the no-advice condition had a significant gain in this type of knowledge. Since it was assumed that implicit knowledge is gained while using an unselective experiential mode of information processing, this finding seems to indicate that players in the no-advice groups were mainly using this experiential mode and that players in the advice group used a different mode of information processing but that this was not effective. A reason for this non effectiveness could be that players relied too heavily on the alerts and suggestions given by the advice functionality. An indication for this is that the heavy use of the advice when available and of the links between the advice texts and the intervention handbook. This seems to make players "lazy". There are indications that players who are less "lazy", and who are actively searching for information in the game's resources that are not directly linked to the advice, are learning more or performing better in the game.

8.2.3 Experiment 3

Data from the second experiment led to the question whether advice that contains less cues about the type of interventions that could be implemented, would be more successful in supporting a selective and reflective strategy of information processing. Therefore a third experiment was conducted in which three versions of the KM Quest simulation game were used:

- A version in which advice was available when certain indicators are below a threshold value. The content of the advice is described in Section 4.6.5.
- A version in which advice was available when certain indicators are below a threshold value (as in version 1). The content however was different. The advice given does not give cues about possible solutions but tries to stimulate active thinking, problem solving and searching for information by presenting a set of questions.
- A third version in which no advice was available.

It was hypothesised that the alternative advice would support a selective and reflective mode of information processing and therefore would lead to more explicit knowledge (than in the other two groups) because it helps players in selecting and organising relevant information (by means of the warnings) and stimulates reflective thought by means of the questions that are represented. Furthermore, it is hypothesised that the advice group would perform better in the game (than the other two groups) because of the hints that are provided by the advice functionality. Based on the data from the second experiment it was hypothesised that players in the no-advice group would gain more implicit knowledge than the two advice groups.

The students who participated in the experiment were from the Radboud University in Nijmegen. A group of 56 students from the international exchange program who followed a third year bachelor course Knowledge Management that is part of the English Business Administration program. And a larger group of 230 Dutch students who participated in a third year bachelor course Knowledge Management that is part of the Dutch Business Administration program.

The data from this experiment revealed no significant differences between the three groups in explicit and implicit knowledge as measured by the post-test. On both types of knowledge all groups had a significant gain. This is different from the previous experiment where the Advice group did not show a gain in implicit knowledge. An interesting finding was that there was a difference between groups in retention of knowledge when there was a long delay (four weeks) between game play and the post-test while there were no differences when the delay was shorter. The group with alternative-advice had a significant higher knowledge gain than the group with no-advice.

The finding that no differences in explicit and implicit knowledge (gain) were found between conditions could mean that the modes of information processing used by the students in general were not different and that the advice available in different forms (alerts and cues or alerts and questions) did not support the use of a different strategy but mainly supported game performance. However the finding that retention in the long run was higher when alternative-advice was given could imply that there was a difference in information processing but that could not be measured by a knowledge test directly after game play.

On game performance there were also no large differences between the three experimental groups. However, when the frequency of use of the advice was taken into account, there were some significant differences on the customer satisfaction index and the product quality index between those in the Advice-group who consulted advice frequently (5-8 quarters) and those who did less frequently. The first group has higher scores. No such difference was found between these two groups in the Alternative advice condition.

The fact that there were no differences between the advice and the alternative-advice groups seems to indicate that the hints provided in the advice texts (that were not presented in the alternative advice texts) did not play such a large role as expected. That the players in the alternative-advice group accessed the advice as frequently as the advice group although no hints were available seems to indicate that players use the advice functionality mainly because of the warning system that it contains. This system gives them a quick view of the indicators that need attention. This type of information can also be found by using the measurement system or the visualisations, but than it is more difficult to find the particular indicators. Players in the Advice group use the hints to find information in the intervention handbook about interventions that could be implemented to improve the level of the indicators. Players who do not receive these hints (no-advice or alternative advice) however know where to find this information themselves. This could be deduced from the fact that all groups use the other information resources with almost the same frequency.

Players who cannot use advice and therefore do not have the warning system and the hints have to put in more effort to find the relevant information. Those who do so (within the no-advice group) and frequently use the feedback, intervention handbook or visualisations learn more than those who use these resources less frequently. The first groups have higher post-test scores. It remains unclear however why this effect of the use of these resources is not found within the advice and alternative advice groups. An explanation could be that the differences are caused by the effort that the players have to put in searching for relevant information. Players in the No-advice group have to search for cues that indicate “problems” and for cues about the way to solve these problems. Players in the advice groups do not have to search for the first type of cues because these are provided by the alerts that are given in the advice.

Although the hypotheses that were formulated could not be confirmed, this experiment however, as well as the first experiment (reported in Chapter 5) gave several indications that feedback plays an important role in learning with the KM Quest simulation game. The players with a high knowledge gain in general, used this type of support significantly more frequent. And within the No-advice group the frequency of access of feedback was correlated with post-test scores.

8.2.4 Conclusion

The central question was “Do additional elements in the game environment, like assignments or advice, support the use of a reflective mode of information processing and thereby the acquisition of explicit knowledge?”. Based on the data from the experiments presented the answer should be “No”. There were no significant differences found in the levels of explicit knowledge between the groups who had access to these support elements and those who did not.

The underlying idea was that these tools would help players in finding and organising relevant information and that these tools would prevent players from missing essential information. By helping them this way they do not have to put in much mental effort in these processes and this could make that more effort could be spend on reflective thought to find new principles and insights.

The lessons learned assignments in experiment 1 do not seem to support reflective thought and learning but seem to focus the attention of the players on the goals of the game. Most of the lessons learned have to do with these goals and with game play and not with more general content related ideas (see Section 5.3.4).

The focus questions also were counterproductive. This could be due to the fact the effort that is put into answering these questions reduces the effort put into searching for information in the game resources. An indication is that the students in the additional assignments condition in general used the other resources (feedback, visualisations etc.) less frequent than the other group. The differences in frequency of use of these resources however were not significant.

Advice seems to fulfil the role it was supposed to have: helping students in finding and organising relevant information and preventing them from missing essential information. Students use it to get a quick view of the indicators that are low and need attention. Furthermore, they use the hints to search for solutions. However, it appears that most of the students who did not have access to these cues were able to find the relevant information themselves by using the other resources that were available in the environment. These students were able to play the game as effective as the ones who received warnings (and hints) by means of advice. The students receiving advice do not seem to redirect the effort that they do not have to put into selecting and organising information to change to a reflective mode of information processing. Probably this is because the environment contains enough cues to do well in the game and to reach the game’s goals (most students succeed in improving the indicators in the simulation model significantly). Students do not often get into impasses in which they get stuck in the game and have to rethink their strategy. Such types of situations probably could enhance the use of a reflective strategy. This finding about the role of advice supports the warning that Bottino et al. (2005) gave when describing software features that can support children’s cognitive processes while playing games. They stated that backtracking and specific tips are important in constructing a solution strategy but that these features also can be used to reduce effort and to reach a solution by trial and error.

Although the main hypotheses could not be confirmed the experiments did reveal some interesting findings. These will be dealt with in the next sections.

8.3 Influence of support tools

In the three experiments data were gathered about the relationship between the frequency of use of several resources, test scores and the level of game indicators in the last quarter of the game. These data are summarized in Table 8-1. The table indicates that when significant relationships are found, in general these indicate that the more frequent a resource is used the higher the score on the explicit items of the post-test, the total score or knowledge gain. In two cases a relationship is found between the score on the implicit items of the post-test and the use of resources. In the second experiment the group that could not use advice had a higher score on implicit knowledge items and in the third experiment a same kind of relationship was found but only in combination with the use of the interventions handbook. Those in the no-advice group who consulted this book frequently had higher scores on the implicit items.

Table 8-1. *Overview of the significant relationships between the frequency of use of several resources, test scores and the level of certain game indicators in the last quarter of the game in the three experiments (significance level: p<=0.05). Italic subtitles indicate that the relationship is only found in a certain condition.*

Experiment	Feedback	Advice	Intervention handbook	Indicator handbook	Visualisation	Additional assingm.
1 Post test scores	Expl. Items Kn. Gain	-	Expl. Items Total score	-	-	Expl. Items**
1 Game indicators	PQI, CR	MS, CSI, PQI, JSI	MS, CSI, PQI		MS, profit	-
2 Post test scores	-	*No advice:* Impl. Items	-	Expl. Items	Expl. Items Total score	
2 Game indicators	-			Profit		
3 Post test scores	*No advice:* Expl. Items Total score	-	*No advice:* Impl. items Total score	-	*No advice:* Expl. items Total score	.
3 Game indicators	-	*No advice:* CR *Advice:* CSI, PQI	*No advice:* MS**, Profit**	-	*No advice:* CSI, PQI, CR	

All relationships indicate that the more frequent the resource is used the higher the score/indicator. Except for the ones marked with **. In those cases the relationship is reversed.
– Means there were no significant relationships.

An interesting finding is related to the no-advice group in experiment 3. The advice is used very frequently and players use this to find the indicators that need attention and to get cues about interventions that could be used to influence these indicators. Players who can not use advice and therefore do not have the warning system and the hints that are available by means of the advice functionality have to put in more effort to find the relevant information themselves. Those who do so (within the no-advice group) and frequently use the feedback, intervention handbook or visualisations learn more than those who use these resources less frequently. The first groups have higher post-test scores. It remains unclear however why this effect of the use of these resources is not found within the advice and alternative advice groups. An explanation could be that the differences are not caused by the use of the resources per se, but by the goal of and effort put in the search process. The advice groups use the resources searching for cues for solutions. The no-advice groups use them in the same way but also have to search for cues that indicate “problems”.

A study performed by Purbojo (2005) provided additional data concerning one of the supports mentioned above, namely the visualisation tools. He used three versions of the game: one in which data from the simulation model were available in tables in the measurement system and in which the visualisation tools that give a graphical presentation of the data that are in the tables are also available. In the other two versions either tables or visualisations were available as the only source of information. Data from a multiple choice post-test that resembled the one that is used in the studies that are described in the previous chapters did not reveal significant differences between groups using the three versions. There were indications that the group who could only use the tables had a larger knowledge gain than the group that could only use the visualisation tools. The results of the tables and visualisations group were similar to the tables group. The study did not contain data regarding the frequency of use of these tools, or data regarding the level of the game indicators. Although it is difficult to compare the results of the Purbojo study with the data from the experiments reported in this thesis, it seems that the data from Purbojo are not in line with the findings from the second and third experiment that indicate that certain groups that consult the visualisations frequently have higher post-test scores.

One of the resources that is available in the KM Quest game but is not dealt with in this study is the knowledge management model (for a description see Section 4.6.1). Christoph et al. (2005) have performed a study in which they investigated the role of this support tool. They used two versions of the game: one with and one without the knowledge management model. They did not find evidence that the model enhanced learning. There were no significant differences in declarative knowledge and general procedural knowledge on a post-test between the students who could use the model and those who could not. There was only a significant difference on those items that were related to the KM model. Christoph et al. hypothesised that especially students that were weak on metacognitive skills would benefit from the use of the KM model. That is why they measured metacognitive skills by means of a retrospective self-report measurement instrument. Data showed that students that scored low on metacognition had a larger knowledge gain on general procedural knowledge that the ones who scored high on metacognition. However, there was no interaction effect. Students with low metacognition learned more in the version with the KM model, but also in the version where this model was not available. Their main conclusion is that students with low metacognitive skills appear to benefit from KM Quest regardless whether the knowledge management model was present or not. The authors do not give an explanation why the KM model did not seem to support learners in gaining knowledge.

8.4 Learning gain

In all three experiments reported there is a significant knowledge gain when pre-test and post-test scores were compared. So this means that the simulation game that was used was an effective tool for learning in an ill structured domain like knowledge management. However, the post-test scores still were modest. In experiment 1 on the average students correctly answered 48.7% of the questions of the post-test. In experiment 2 this percentage was 50.3 and in experiment 3 it was 56.9. In the studies reported above that used the same learning environment comparable data were found. In the study from Christoph et. al. (2005) the average post-test score was approximately 60% (test was different than the ones used in the experiments in the current study) and in the study from Purbojo it was approximately 45%. These findings indicate that although there is a knowledge gain in all studies, this gain is limited. Several factors could have limited learning like the complexity of the environment and the underlying business simulation model, the characteristics of that model and the game characteristics. Below these factors will be elaborated.

At first sight the learning environment is complicated. Players can use a large set of resources and worksheets and have to deal with a large set of indicators in the simulation model and a large set of interventions that they can implement. However, a good introduction by the lecturer and an "instruction phase" seem to give players enough support to find their way in the environment. The fact that the general Help facility and the "What (to do)" and "How (to do it)" links that are connected to the worksheets are hardly used, while other resources are used frequently, indicate that players seem to know what to do. Furthermore, the finding that most players succeed in improving most indicators significantly indicates that enough information is available to play the game and that the environment is not too complex.

A second factor that could have caused limited learning could be the characteristics of the underlying business simulation model. As stated before the model is very complex because it involves a large set of events, indicators, interventions and relationships between these elements. Furthermore, several features make the situation even more complex. For instance, indicators have a decay function (when nothing happens their values will decrease slowly), some of the relationships are direct and others are indirect (by means of intermediates), and some relationships have a delay (the effect will be visible after a given time period). Information about indicators and interventions and their direct relationships is available by means of the indicator and intervention handbook. Information about the indirect relationships however is not available. So the simulation model to some extent is a black box to the players. The combination of the partial black box with the complexity of the model and the fact that players often implement several interventions at the same time makes it difficult to acquire explicit knowledge about the relationship between interventions and indicators, but also to gain implicit knowledge on these issues.

Game characteristics could also have influenced learning. Unexpected events in some cases interfere with the interventions that players have implemented or limit the effectiveness of these interventions. For instance, when an event is introduced that a competitor successfully launched a new product on the market, market share of the fictitious company "Coltec" goes down despite the interventions of the players in the previous quarters of game play. When players do not see that in this case they just had bad luck, this could mean that they will draw the wrong conclusions regarding the effectiveness of their own actions. Feedback should draw the players' attention to the influence of the unexpected events. Another important game characteristic is the goal of the game. The game's goal is not a learning goal but a performance goal (optimise the level of market share, customer satisfaction index and profit). Players focus on reaching the game's goals and as long as they make progress this focus might prevent them from reflection and from developing new knowledge. When they do not make progress there is a danger that they might attribute this to the wrong causes (as is stated above). Furthermore, the goals of the game are left open (try to reach the highest market share, customer satisfaction and profit). This implies that players do not know whether a market share of 28% or a profit of 7 million is high or not. This might prevent them from putting in more effort or from developing new ideas when they think that their scores are already high.

The final game characteristic that is of importance is the fact that there is no room for experimentation. In KM Quest players do not have the possibility to reverse their actions, to go back and try something else and afterwards to compare the results of these different courses of action. Active experimentation is a necessity to be able to develop new insights, principles or strategies. When experimentation is not possible this limits the effectiveness of a selective reflective mode of information processing.

A last remark about the learning results concerns the measurement of implicit knowledge. In Chapter 5 it was stated that these items were based on the guidelines given by Swaak (1998). In the test a situation was given, an action was described and a set of possible post action situations was given. In each item the textual information was kept to a minimum and a picture or chart was used to present the alternatives. However, one element that was used by Swaak was less salient: time pressure. Swaak asked players to answer as quickly as possible and latency times were recorded. Time pressure was included to prevent deliberate reflective behaviour to take place. In the tests that were used in the experiments reported in the previous chapters students were prompted to answer these items as quickly as possible but response time was not taken into account in the analyses. There is a possibility that some students have taken their time and have not solely relied on their intuitive knowledge to answer these questions. This could mean that the level of intuitive knowledge was overestimated.

8.5 Is it all in the game?

The title of this thesis is “Is it all in the game?”. In this section an attempt is made to formulate an answer to this question. The data discussed above indicate that the main elements of support in the KM Quest simulation game are:

- the availability of relevant background information (by means of the handbooks than can be consulted whenever needed),
- feedback that enables players to compare their own solutions with solutions generated by the system or to value the role that the unexpected events are playing (bad or good luck), and
- the availability of visualisations that help players in ordering the large amount of information that is available in the business simulation model.

Students, who use these resources frequently, learn more and in some cases have higher game scores. These tools are important for learning and as such are essential parts of the game.

On the other hand the learning results are still limited and mainly in conceptual knowledge. To enhance learning and get higher knowledge gains (also in different types of knowledge) probably support is necessary that is not in the game itself but in the setting in which the game is used.

In the past years several authors, like Dawes and Dumbleton (2001), Gee (2003), Kirriemuir and McFarlane (2004) and Jansz and Martens (2005), have stressed the importance of the social aspect of game play. When people think about children playing computer games the prevailing image is that of a boy sitting alone behind a computer screen. This image is too short-sighted because in many (internet) games players play together with others and furthermore after game play much discussion is going on with others about the game experiences and (during or after game play) knowledge and strategies are exchanged between players. Kirriemuir and McFarlane (2004, p. 27) state that there are indications that interaction in (online) communities could contribute significantly to learning related to games play.

So supports that focus on the social aspect of learning like collaboration in teams, classroom discussions during the period the game is played and a debriefing session after the game has ended could be powerful. These supports should support a reflective strategy during the game and reflection after the game is played because players have to make their ideas explicit to be able to discuss with others and to exchange experiences. Furthermore, such supports make it possible to compare strategies and their results, to discuss the role of good or bad luck and could enhance the transfer of knowledge gained while playing the game to “real” life.

Shostak and de Hoog (2004) found an indication that collaborative game play could be beneficial in learning with KM Quest. They found that players who played in dyads had a significant knowledge gain when pre-test and post-test scores that measured decision skills were compared, while students who played alone did not have a significant gain. Collaborative play however does not necessarily lead to better learning results. Several aspects play an important role when playing in small groups like differences in prior knowledge between players (see for instance Gijlers & de Jong, 2005) and the quality of the communication and discussion between players (Purbojo, 2005 and Saab, van Joolingen & van Hout-Wolters, 2005).

As stated in Chapter 2 different types of games can be distinguished (see Section 2.3). A legitimate question is whether the results of the experiments reported in this thesis can be generalized to the use of all these types of games in educational settings. This is hard to say because there is still little research that could support or contradict the findings. There are some indications however that the results could be generalized. Bottino et al. (2005) for instance reported research that focused on the use of puzzle games in primary education that partly supports the findings of this study. They stress the importance of feedback (that supports error comprehension), backtracking, the use of levels of difficulty, and of support for anticipation, memorization and detection of solutions. They do not mention the importance of relevant background information, but probably this is because the games they used are not as complex as KM Quest or other simulation or strategy games. Furthermore, as stated in section 8.2 they stress that in some cases some tools (like specific tips) could reduce the effort that students put in and can promote trial and error behaviour.

8.6 Future research

Research from discovery or inquiry learning with simulations has shown that in these environments students have to perform different types of tasks (formulate hypothesis, design experiments, interpret data etc.) and different types of support are needed to support these different types of tasks (de Jong & van Joolingen, 1998). In the research reported in this thesis the use of supports in general was investigated in relationship to two types of information processing but it was not investigated how different types of support are related to different types of tasks that players have to perform in the game and to different types of cognitive skills that players need to perform these tasks. To develop effective educational games a framework is needed in which guidelines are given that specify what types of support are necessary to perform different types of cognitive tasks in relationship with different types of information processing and learning (unselective experiential learning or selective reflective learning in the game or in social interaction in activities in the broader context within which the game is used (classroom, affiliate groups). To develop such a framework a description is needed of the types of cognitive (or motor) tasks that players have to perform, a description of the types of learning (a first attempt is done in this thesis) and the role of the supports in supporting these tasks and learning needs to be made explicit.

When such a framework is available the next task will be to investigate how supports can be implemented in the game in such a way that on the one hand they really enhance learning and on the other hand that they do not take away the fun and intrinsic motivation that people have to play games.

Further research should also include instruments to measure the mode of information processing that is used by players. In the current study these were not used and the use of certain strategies is inferred based on test scores and data from logfiles. The results show that it is difficult to make these inferences. The data from the third experiment also indicate that it would be good to have a test directly after game play but to have a retention test a few weeks later too.

Another issue for further research has to do with the fact that within games it is hardly impossible to experiment because one can not undo actions and or go back some steps in time (as is the case in pure simulations). It would be good to investigate whether this limits learning by comparing a constrained game situation with a situation where certain constraints are removed (more resembling a simulation) or by comparing one time game play with repeated playing of a game., or by using a set up that is a combination of these two scenarios.

The issues described above are directly related to the research reported with KM Quest. The use of games in educational settings of course is much broader and needs further exploration and experimentation in a systematic way to be able to make claims about their educational use and effectiveness. For this moment however, the game is over.

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Samenvatting

Het onderzoek dat gerapporteerd wordt in deze dissertatie, richtte zich op ondersteuning van het leren met behulp van games. In het bijzonder op het leren met een simulatiespel in het domein van kennismanagement. De grote groei in het spelen van digitale games, op speciale game “consoles”, de personal computer en het Internet, in de laatste twee decennia heeft de belangstelling voor educatief gebruik van games doen oplaaien.

Spel neemt in de ontwikkeling van kinderen een belangrijke plaats in, maar binnen het onderwijs wordt het maar beperkt ingezet als leermiddel, op enkele sectoren na. In de opleiding van militairen wordt al sinds de zeventiende eeuw regelmatig gebruik gemaakt van spellen om bepaalde vaardigheden te leren en te oefenen. Eén van de bekendste militaire spellen, het “Kriegspiel”, werd in 1824 door Baron von Reisswitz ontwikkeld en werd daarna door de Koning van Pruissen aan elk regiment van zijn leger beschikbaar gesteld. In de huidige tijd worden computerspellen binnen het leger op vrij grote schaal gebruikt. Zo worden op een website van Amerikaanse leger (www.dodgamecommunity.com) zestig computerspellen beschreven die binnen de verschillende takken van het leger ingezet worden. Een andere sector waarbinnen spellen regelmatig ingezet worden, is die van de managementopleidingen. Eind jaren vijftig van de vorige eeuw werd het eerste bedrijfssimulatiespel ontwikkeld door de American Management Association. Het werd gezien als een belangrijk middel om het gat te dichten dat werd geconstateerd tussen de formele en theoretische academische opleiding die weinig praktijkgericht was en “on the job” training die vaak zeer specifiek was. Sindsdien worden binnen die sector nog regelmatig spellen gebruikt. Zoals gezegd, is het gebruik van dit middel in de rest van het onderwijs echter beperkt, maar hierin komt de laatste jaren verandering. Zo hebben bekende Nederlandse uitgevers van onderwijsmateriaal, zoals Malmberg, Wolters-Noordhoff en Thieme Meulenhoff, enkele games ontwikkeld die nauw aansluiten bij de door hen uitgebrachte methodes en heeft de Koninklijke Bibliotheek binnen het project “Het geheugen van Nederland” het initiatief genomen tot de ontwikkeling van games die gericht zijn op het primair en secundair onderwijs. Deze games zijn met name gericht op het oefenen van bepaalde vaardigheden in een aansprekende context, en voor een kleiner deel, op het opdoen van nieuwe kennis en vaardigheden.

Games kunnen voor het onderwijs interessant zijn omdat leerlingen (soms in samenwerking met anderen) actief, gemotiveerd, bezig zijn met het oplossen van uitdagende problemen. In die zin sluiten ze aan bij de opvattingen over onderwijs zoals die naar voren komen in theorieën over constructivistisch leren, gesitueerd leren en collaboratief leren. In deze theorieën wordt benadrukt dat het opdoen van kennis een actief sociaal proces waarin betekenis wordt gegeven aan ervaringen die worden opgedaan bij het oplossen van gesitueerde realistische problemen.

Belangrijk voordeel van het gebruik van games ten opzichte van traditioneel onderwijs is dat leerlingen vaak sterk geïnvolveerd en gemotiveerd zijn en zich richtten op lange termijn doelen. Games kunnen dus enerzijds de leerlingen motiveren om iets te leren en aan de andere kant kunnen ze ervoor zorgen (mits ze goed geconstrueerd zijn) dat de leerlingen gemotiveerd bezig blijven. Deze motivatie komt enerzijds voort uit de aansprekende context en het plezier dat ze aan het spelen beleven, en anderzijds uit het feit dat leerlingen het gevoel hebben controle over het (leer)proces te hebben, omdat ze zelf beslissingen kunnen nemen en de loop van het spel kunnen beïnvloeden.

Verder kunnen er situaties aan bod komen waarin je normaal gesproken niet de mogelijkheid krijgt om nieuwe ideeën of strategieën uit te proberen omdat bijvoorbeeld, de consequenties van de handelingen die de studenten moeten verrichten te ingrijpend of kostbaar zijn om er mee te kunnen experimenteren.

Leren met games
Literatuuronderzoek leert dat er weliswaar veel is gepubliceerd over het gebruik van games maar dat veel publicaties beschrijvend van aard zijn en dat er weinig wordt gerapporteerd over leerresultaten en de effectiviteit van het middel (al dan niet in vergelijking met andere leermiddelen). Voor zover deze data wel beschikbaar zijn, zijn ze vaak niet eensluidend. Uit de verslagen is ook niet altijd goed op te maken wat de verschillende auteurs onder het begrip game verstaan. In deze dissertatie wordt de volgende definitie gehanteerd: “Games zijn competitieve, gesitueerde, interactieve (leer)omgevingen die zijn gebaseerd op een set van regels en/of een onderliggend model; waarin met in acht name van een aantal beperkingen en onder onzekere omstandigheden een uitdagend doel moet worden behaald”.

In de literatuur wordt vaak gesproken over simulation games, en in het Nederlandse taalgebied wordt ook de term spelsimulatie regelmatig gebruikt. Dit geeft al aan dat de begrippen game en simulatie raakvlakken hebben. Het belangrijkste verschil tussen games en simulaties is gelegen in het ontbreken van een competitie-element en toeval/verrassingselement in simulaties. Verder is het doel in simulaties over het algemeen anders van aard. Doel is vaak om de onderliggende principes (die zijn vastgelegd in het simulatiemodel) te ontdekken. De speler heeft in simulaties in een bepaald opzicht meer vrijheid dan in games, in die zin dat hij bijvoorbeeld zelf bepaalde doelen kan stellen, minder rekening hoeft te houden met beperkte resources of met de consequenties van zijn acties. In games kunnen acties over het algemeen niet teruggedraaid worden en gaat het spel telkens verder vanaf de veranderde situatie die is ontstaan door de acties van de spelers en het systeem. In simulaties kunnen de spelers dezelfde situatie vrij eenvoudig nog een keer doorlopen en hebben ze meer mogelijkheden om te experimenteren (“Wat zou er gebeuren wanneer ik .....?”).

Voor zover er in de literatuur over games leerresultaten gerapporteerd worden, hebben deze met name betrekking op het ontwikkelen van nieuwe kennis en vaardigheden op de gebieden van wiskunde en management. Verder zijn er enkele indicaties dat games kunnen leiden tot veranderingen in leersstrategieën, attitudes en in praktisch handelen. Een interessante studie aangaande dit laatste aspect ging over een spel dat bedoeld was om het handelen van kinderen met diabetes te beïnvloeden. Geconcludeerd werd dat er veranderingen optraden in het gedrag van kinderen, maar dat hun kennis aangaande diabetes niet significant was toegenomen. Dit lijkt er op te duiden dat er wel leren heeft plaatsgevonden maar dat dit niet tot uiting komt op een kennistoets.

In hoofdstuk 3 wordt hier verder op ingegaan en wordt de veronderstelling utgesproken dat er bij het gebruik van games twee vormen van informatieverwerking onderscheiden kunnen worden, die ieder tot verschillende leerresultaten leiden. Een “unselective experiential mode” die vooral leidt tot feitenkennis, handelingspatronen, en instanties die bruikbaar zijn in de gamecontext. Wanneer abstracties of principes geleerd worden is dit meestal in de vorm impliciete kennis die situationeel is en moeilijk onder woorden te brengen. De andere vorm is een “selective reflective mode” die, wanneer ze succesvol is, kan leiden tot expliciete kennis in de vorm van nieuwe inzichten, regels en strategieën. De grootste leerwinst bij het gebruik van games valt te verwachten wanneer spelers beide “modes” gebruiken.

Verwacht wordt echter, dat leerlingen in rijke dynamische contexten, zoals games, vooral een “unselective experiential mode” zullen gebruiken en slechts onder bepaalde omstandigheden (bijvoorbeeld als ze vast lopen) over zullen schakelen naar de “selective reflective mode”. Om het gebruik van deze laatste mode te ondersteunen (ook op momenten dat spelers dit niet spontaan zullen doen) zullen er elementen aan het spel of de leersituatie toegevoegd moeten worden.

Centrale onderzoeksvraag
Het onderzoek richtte zich op twee elementen die aan een spel zelf toegevoegd kunnen worden waarvan, op basis van de bestaande literatuur, nog onduidelijk of zij het leerproces kunnen ondersteunen, namelijk advies en extra opdrachten. Elementen die aan de leersituatie toegevoegd kunnen worden zoals “debriefing” en het samenwerken met anderen, werden buiten beschouwing gelaten. De centrale onderzoeksvraag is: “Ondersteunen elementen, zoals advies en extra opdrachten, die aan een spel toegevoegd worden het gebruik van een “reflective mode” van informatieverwerking en daarbij de acquisitie van expliciete kennis?”. Om deze vraag te beantwoorden werden drie experimenten uitgevoerd waarbij gebruik werd gemaakt van een pretest – posttest design. In de tests waren vragen opgenomen die expliciete kennis beoogden te meten en items die gericht waren op het meten van impliciete kennis. Verder werd het gedrag van de spelers vastgelegd in logfiles waardoor het mogelijk werd een relatie te leggen tussen het gedrag van de spelers en testresultaten.

De spelomgeving: KM Quest
In de onderzoeken werd gebruik gemaakt van het spel KM Quest. Dit is een collaboratief internetgebaseerde simulatie spel dat is ingebed in een leerscenario dat bestaat uit vier fasen. Het is ontwikkeld om studenten en managers (in groepjes van maximaal 3 personen) een mogelijkheid te geven om actief problemen op te lossen en kennis op te doen in het domein van kennismanagement. Het spel is gesitueerd in de context van een fictieve “product leadership” organisatie. De spelers spelen ieder dezelfde rol van kennismanager binnen het bedrijf en hebben de taak om de kennishuishouding van het bedrijf zodanig te optimaliseren dat het bedrijf een zo hoog mogelijk marktaandeel behaalt, een zo hoog mogelijke “customer satisfaction index” en winst. De spelers spelen deze rol gedurende 12 kwartalen. Kern van het spel is een case beschrijving met statische informatie, en een onderliggend “business model” dat gebruikt wordt om het gedrag van een groot aantal bedrijf- en kennis procesindicatoren te simuleren, en om nieuwe gegevens te genereren op basis van de interventies die de spelers in elk kwartaal in de bedrijfscontext implementeren. Spelelementen die in KM Quest zijn opgenomen zijn: competitie tussen spelers, onverwachte gebeurtenissen (elk kwartaal wordt één onverwachte gebeurtenis geselecteerd uit een bestand van meer dan 50 gebeurtenissen), beperkingen zoals een gelimiteerd budget om interventies uit te voeren, en het niet kunnen terugdraaien van acties.

Om de spelers te ondersteunen bij het oplossen van problemen zijn een aantal ondersteunende elementen in de spelomgeving geïmplementeerd, zoals een richtinggevend systematisch kennismanagement model (met gezamenlijke werkdocumenten), feedback, advies, handboeken met belangrijke informatie, en mogelijkheden om op het eigen gedrag terug te blikken. Om communicatie en samenwerking (met behulp van het Internet) te ondersteunen zijn elementen in de leeromgeving opgenomen zoals een chatbox, monitor faciliteiten, forums, een stem “machine”, e-mail notificatie, “groupcall”, etc. Deze elementen ondersteunen zowel synchrone als asynchrone communicatie tussen groepsleden.

Het eerste onderzoek
In het eerste onderzoek werd onderzocht of het toevoegen van extra opdrachten aan de spelomgeving KM Quest een selectieve en reflectieve manier van informatieverwerking ondersteunde en daardoor leidde tot een hogere mate van expliciete kennis.

Er werden twee versies van KM Quest gebruikt die beide afweken van de hierboven beschreven opzet op de volgende punten. Er was geen sprake van een teamspel: de spelers speelden alleen. Dit omdat uit ander onderzoek was gebleken dat de kwaliteit van de samenwerking en de communicatie sterk van invloed was op het verloop van het spel en de leeruitkomsten. Verder was de aanvangswaarde van een groot aantal indicatoren in het business simulatie model verlaagd. De reden hiervoor was dat daarmee de condities werden geschapen voor het selecteren van meer interne problemen die te maken hadden met het niet optimaal verlopen van een aantal kennisprocessen. In een situatie waarin deze processen wel goed verlopen zoals in de aanvankelijke game set-up, worden er door de game-engine vooral veel externe gebeurtenissen (events) geselecteerd die betrekking hebben op externe omstandigheden. Deze events bleken in voorgaand onderzoek voor de spelers moeilijk te duiden en daarmee niet erg geschikt om als eerste spelsituaties te gebruiken. Een laatste afwijking betrof het selectiemechanisme van de gebeurtenissen. In de oorspronkelijk opzet van de game was de volgorde van de events niet vastgelegd maar afhankelijk van de status van bepaalde indicatoren in het business simulatie model en de reeds eerder ingevoerde interventies. In de gehanteerde set-up waren de events voor alle spelers dezelfde zodat mogelijke verschillen in leerresultaten en "game performance" achteraf niet toegeschreven zouden kunnen worden aan verschillend in (de sequentie van) gebeurtenissen waarmee de spelers geconfronteerd werden. In beide versies waren de volgende ondersteunende elementen aanwezig: het kennismanagement model en bijbehorende werkbladen, feedback, advies, "just-in-time" achtergrond informatie, visualisaties en informatie over het eigen handelen en de status van de business model indicatoren in voorgaande kwartalen.

In de ene conditie vormde bovenstaande beschrijving de "standaard" situatie in de andere conditie waren hier elementen aan toegevoegd in de vorm van extra opdrachten. Deze opdrachten hadden tot doel de aandacht van de spelers te vestigen op elementen die ze mogelijk over het hoofd hadden gezien bij het event in het voorgaande kwartaal, en op hun eigen handelen en de rationale daarachter in dat kwartaal. Ze bestonden uit twee elementen: een vraag die betrekking had op de mogelijke oplossing van het probleem in het voorgaande kwartaal en een opdracht om op basis van de ervaringen zover, een "lesson learned" te formuleren die voor hen zelf of voor andere spelers van belang zou kunnen zijn. Deze extra opdrachten waren vanaf kwartaal twee beschikbaar via een link in de krant van het bedrijf ("Coltec news"). De spelers konden deze opdrachten maken, maar het maken ervan werd niet afgedwongen door het systeem. De verwachting was dat de spelers in deze conditie meer expliciete kennis zouden opdoen, omdat ze ondersteund werden in het gebruik van een reflectieve manier van informatie verwerken.

Aan het onderzoek werd deelgenomen door 28 studenten van de opleiding Toegepaste Communicatiewetenschappen van de Universiteit Twente. Voor deze studenten was deelname aan het spel een verplicht onderdeel van een master cursus Kennismanagement in een lerende organisatie. Er werd gebruik gemaakt van een pre-test om voorkennis te toetsen. Deze toets bestond uit 26 meerkeuzevragen. 18 hiervan hadden tot doel om expliciete kennis te toetsen over begrippen die in het spel gebruikt werden, over stappen in het kennismanagement model en over relaties tussen interventies en indicatoren. Acht items waren gericht op het toetsen van impliciete kennis. Bij deze opgaven werd een situatie geschetst en werd een interventie beschreven. Daaronder stond een grafiek weergegeven met drie lijnen. Vervolgens werd gevraagd om aan te geven hoe de betreffende indicator zich zou ontwikkelen en welke lijn bij de betreffende situatie past. Na de voortoets speelden de spelers het spel in een aantal sessies. Nadat ze het spel beëindigd hadden, volgde een natoets die dezelfde was als de voortoets. Vervolgens kreeg men een transfertoets die thuis gemaakt mocht worden. Deze toets bestond uit een case beschrijving van een ander type bedrijf met een aantal gebeurtenissen. Spelers moesten deze gebeurtenissen analyseren en aangeven hoe ze hierop zouden reageren als kennismanager van het betreffende bedrijf. Het cijfer dat op deze toets behaald werd, telde mee in de beoordeling voor het vak. De score op de voor en natoets niet. Tijdens het spelen werden allerlei gegevens vastgelegd in een logfile zodat naderhand nagegaan kon worden welke elementen in het spel door de spelers geraadpleegd waren en wat de status van de indicatoren in het simulatiemodel was in de verschillende kwartalen.

Uit de testresultaten bleek dat beide groepen een significante leerwinst hadden geboekt, maar dat er geen verschillen waren tussen de scores van beide groepen op de natoets en de transfer toets. Ook werden er geen significante verschillen tussen beide groepen gevonden wanneer gekeken werd naar de hoogte van een set van indicatoren uit het business simulatie model aan het eind van het spel.

Uit de logfiles viel op te maken of de extra opdrachten ook daadwerkelijk gebruikt werden. Daaruit bleek dat vijf van de 16 studenten in deze conditie, nooit een “lesson learned” had geformuleerd en dat vier nooit een vraag hadden beantwoord. Wanneer een vergelijking werd gemaakt tussen degenen die de vragen en opdrachten regelmatig gebruikt hadden en degenen die dat niet hadden gedaan, bleek dat de eersten significant lager scoorden op de natoets. De extra opdrachten bleken contraproductief te zijn. Een verklaring hiervoor zou kunnen zijn dat de spelers zich door deze opdrachten en vragen extra gingen richten op het behalen van de doelen van het spel en minder op de onderliggende ideeën en op het kennismanagement model.

Nadere analyse van de gegevens in de logfiles bracht aan het licht dat vier informatiebronnen frequent gebruikt werden: feedback, advies, de visualisaties en het interventie handboek. Advies bleek, gemiddeld genomen, in 83% van de gevallen dat het aanwezig was ook daadwerkelijk “geopend” te worden. De andere drie bronnen werden ongeveer in helft van alle kwartalen geraadpleegd. Alle andere beschikbare informatiebronnen werden slechts zelden aangeboord. Er waren geen significante verschillen in gebruik van de bronnen tussen de studenten in de twee condities.

Wanneer een vergelijking gemaakt werd tussen studenten met een hoge en een lage leerwinst, bleek dat de eerste groep de informatiebronnen meer frequent gebruikte (behalve het advies) en dat het verschil in gebruik van feedback zelfs significant was. Dit was de aanleiding om te onderzoeken of de frequentie waarmee bepaalde informatiebronnen werden gebruikt, samenhing met de hoogte van de testscores en met de hoogte van de indicatoren in het simulatiemodel. Bij deze analyses werden de studenten uit de twee condities samengenomen omdat er tussen deze toch geen verschillen bestonden en werden de spelers opnieuw ingedeeld in drie groepen op basis van de frequentie van gebruik. Er moet wel voorzichtigheid betracht worden bij het trekken van conclusies uit deze analyses, omdat de mogelijkheid bestaat dat intermediërende variabelen, die niet gemeten zijn, een rol spelen. Zo zou het kunnen zijn dat het gebruik van bepaalde bronnen samenhangt met bepaalde persoonlijkheidseigenschappen of met intelligentieniveau. Dit zou er toe kunnen leiden dat geconcludeerd wordt dat er een relatie is tussen het gebruik van feedback en de leerwinst die is behaald, terwijl er in werkelijkheid sprake is van een relatie tussen intelligentieniveau en leerwinst. Verder is het zo dat de groepen, die op basis van het gebruik van verschillende bronnen onderscheiden worden, niet geheel onafhankelijk van elkaar zijn. Het zou kunnen zijn dat degenen die feedback regelmatig raadplegen ook het interventie handboek regelmatig gebruiken. Het is dan moeilijk om eventuele verschillen toe te schrijven aan het gebruik van de ene of de andere informatiebron. Een correlatie analyse bracht aan het licht dat gebruik van feedback en interventiehandboek inderdaad met elkaar correleerden. De andere correlaties waren niet significant.

Het gebruik van feedback bleek samen te hangen met de score op de items die expliciete kennis beoogden te meten. Met name het verschil tussen degenen die feedback raadpleegden in 2/3 van de kwartalen of meer en degenen die dat deden in 1/3 of minder was significant. Waarbij de eerste groep hoger scoorde. Bij de game indicatoren was er tussen deze twee groepen een verschil in de hoogte van de “Product quality index” en het competentieniveau in de R&D afdeling. Degenen die feedback vaak raadpleegden hadden hogere scores. Wat betreft het gebruik van het interventie handboek is het beeld hetzelfde bij de testscores en bij de game indicatoren was er een verschil bij de “Customer satisfaction index”.

Zoals gezegd, werd het advies, wanneer dit beschikbaar was, zeer frequent geraadpleegd. Het is dan ook moeilijk een vergelijking te maken op basis van frequentie van gebruik omdat bepaalde groepjes erg klein waren. Desondanks bleek dat degenen die het advies in minder dan 33% van de gevallen dat het aanwezig was, raadpleegden op een aantal indicatoren in het spel, significant lagere waardes hadden dan degenen die advies vaker raadpleegden.

Aangaande het gebruik van de visualisaties werden er geen verbanden gevonden met de hoogte van de testscores. Wel was er een verband tussen de hoogte van het marktaandeel en visualisatie gebruik. Degenen die de visualisaties weinig gebruikten hadden een lagere score dan de andere twee groepen.

De conclusie is dat het gebruik van extra opdrachten niet tot meer expliciete kennis heeft geleid. Wel zijn er aanwijzingen dat frequent gebruik van informatiebronnen zoals feedback en het interventie handboek samenhangt met een winst in expliciete kennis. De winst in dit type kennis zit met name in kennis over concepten die in het spel gebruikt worden, en slechts in beperkte mate in kennis over de relatie tussen interventies en indicatoren. Desondanks weten de meeste spelers de hoogte van indicatoren in het spel substantieel te verhogen. Dit zou kunnen duiden op het gebruik van impliciete kennis. Op de tests is echter geen sprake van een significante winst in impliciete kennis. Het zou kunnen zijn dat spelers toch succesvol zijn in het spel doordat ze de informatie die beschikbaar is in bronnen zoals advies, feedback en het interventiehandboek direct toepassen zonder deze te interpreteren en te waarderen. Dit laatste zou er de reden van kunnen zijn dat de toename in expliciete kennis niet heel erg hoog is. Sinds het advies de bron is die het meest geraadpleegd wordt, en dit ook de meest directe aanwijzingen bevat aangaande de selectie van relevante informatie, is het interessant om te onderzoeken of het verwijderen van deze bron leidt tot andere leerresultaten of een andere manier van spelen. Dit werd onderzocht in het tweede onderzoek.

Het tweede onderzoek

In het tweede onderzoek werden twee versies van KM Quest met elkaar vergeleken. Eén die vergelijkbaar is met de versie zonder extra opdrachten uit het eerste onderzoek, en één waarin dezelfde informatiebronnen aanwezig waren, behalve het advies. Advies in KM Quest is sowieso, niet altijd beschikbaar, maar alleen wanneer bepaalde indicatoren onder een drempelwaarde komen. Er begint dan een icoontje te knipperen en wanneer spelers daarop klikken met de muis, dan verschijnt een waarschuwing met de namen van de indicatoren die onder de drempelwaarde terecht zijn gekomen. Wanneer ze vervolgens op de naam van de indicator klikken, verschijnt er een tekst waarin, onder andere, verwezen wordt naar categorieën van interventies die gebruikt zouden kunnen worden om de waarde van de betreffende indicator te beïnvloeden.

De veronderstelling is dat advies er voor zorgt dat spelers essentiële informatie niet over het hoofd zien en hen helpt bij het selecteren van, en focussen op informatie die belangrijk is. Op deze manier kan het een selectieve en reflectieve manier van informatie verwerken ondersteunen, wat zou moeten leiden tot meer expliciete kennis. Aan de andere kant zou het er ook toe kunnen leiden dat spelers juist minder reflectief te werk gaan omdat de waarschuwingen en hints, die in het advies gepresenteerd worden, de spelers al op het goede spoor zetten zonder dat ze zelf actief informatie hoeven te zoeken en zonder dat ze zelf hoeven in te schatten of bepaalde informatie, onder de gegeven omstandigheden, relevant is of niet.

De opzet van het onderzoek was dezelfde als bij het eerste onderzoek, De tests werden op enkele punten aangepast, maar waren in grote lijnen dezelfde. Aan het onderzoek werd deelgenomen door 29 studenten van de opleiding Toegepaste Communicatiewetenschappen van de Universiteit Twente. Voor deze studenten was deelname aan het spel een verplicht onderdeel van een master cursus Kennismanagement in een lerende organisatie.

Uit de toetsresultaten bleek dat beide groepen een significante leerwinst hadden geboekt op de expliciete kennisopgaven en dat de Geen-advies groep ook een significante winst had bij de impliciete kennisopgaven, terwijl de Advies-groep daar geen winst boekte. Het verschil in score tussen beide groepen op de impliciete kennis items van de natoets is bijna significant (p=0.051). Wanneer gekeken wordt naar de hoogte van de indicatoren in het simulatie model zijn er aan het eind van het spel nauwelijks verschillen tussen de twee groepen te vinden.

Verder bleek dat er niemand was, in de Advies groep, die het advies niet gebruikte. Gemiddeld was er advies beschikbaar in 9.3 van de twaalf kwartalen en werd het geraadpleegd in 7.1 kwartalen. Dat betekent dat het zeer frequent geraadpleegd werd, net als in het eerste onderzoek. Verder bleek dat net als in dat onderzoek feedback, het interventie handboek en de visualisaties door beide groepen frequent gebruikt werden en dat het Indicator handboek significant vaker werd geraadpleegd door de Geen-advies groep.

Een vergelijking tussen de spelers met een hoge leerwinst en een lage leerwinst leverde een ander beeld op dan bij het eerste onderzoek. In dit geval gebruikten de genen met een lage leerwinst de verschillende informatiebronnen, over het geheel genomen, meer dan degenen met een hoge leerwinst. Dit verschil werd met name veroorzaakt door de spelers in de Advies groep. Daar waren degenen met een lage leerwinst zeer frequente gebruikers.

Net als bij het eerste onderzoek werden analyses uitgevoerd waarbij werd nagegaan of er een verband was tussen de frequentie waarmee bepaalde informatiebronnen werden gebruikt, en de hoogte van testscores en game indicatoren. Bij deze analyses werden de twee experimentele groepen samengevoegd en werden de spelers opnieuw in drie groepen ingedeeld op basis van de frequentie waarmee bepaalde bronnen werden aangeboord. Zoals hiervoor opgemerkt moet de nodige voorzichtigheid in acht worden genomen bij het trekken van conclusies uit deze analyses, mede omdat de groepsindelingen niet onafhankelijk zijn van elkaar. In het tweede onderzoek bestonden er significante correlaties tussen het gebruik van de verschillende informatiebronnen. Alleen het gebruik van het indicator handboek bleek niet met het gebruik van de andere bronnen te correleren.

De analyses bevestigden de resultaten van het eerste onderzoek niet. Er werd geen verband gevonden tussen de frequentie waarmee feedback geraadpleegd werd en de hoogte van toetsscores en/of indicatoren in het spel. Voor het gebruik van het interventiehand boek gold hetzelfde. Het gebruik van het indicator handboek bleek samen te hangen met de score op de items die expliciete kennis beoogden te meten en met de totaalscore op de natoets. Met name het verschil tussen degenen die het indicator handboek raadpleegden in 2/3 van de kwartalen of meer, en degenen die dat deden in 1/3 of minder, was significant. Waarbij de eerste groep hoger scoorde. Aangaande het gebruik van de visualisaties werden dezelfde verbanden gevonden. Hierbij was echter het verschil tussen de groep die visualisaties raadpleegde in 5-8 kwartalen en de groep die dat deed in 0-4 kwartalen significant (in het voordeel van de eerste groep). Voor de totaalscore op de natoets was ook het verschil tussen de groep die visualisaties raadpleegde in 9-12 kwartalen en de groep die dat deed in 0-4 kwartalen significant.

De hypothese dat advies een reflectieve manier van informatieverwerking ondersteunt en daardoor leidt tot meer expliciete kennis kon niet bevestigd worden. Opmerkelijk is dat de Geen-advies groep een leerwinst boekte op de impliciete kennisopgaven en de Advies groep niet. Gezien de assumptie dat impliciete kennis met name wordt verworven wanneer een onselectieve ervarende manier van informatie verwerken wordt gebruikt, lijkt dit er op te duiden dat de spelers in de Geen-advies groep deze manier van informatie verwerken regelmatig gebruikten. Het feit dat de Advies groep geen toename in impliciete kennis liet zien, kan er op duiden dat in deze groep deze manier van informatie verwerken minder gebruikt wordt. Het kaner op te duiden dat deze spelers een reflectieve manier gebruikten, maar dat deze niet effectief was, gezien het feit dat ze niet meer expliciete kennis hebben verworven. Het zou kunnen dat de effectiviteit laag was, omdat spelers minder cognitieve inspanning leverden, en zich in hoge mate lieten leiden door de waarschuwingen en hints die in het advies gegeven werden. Er zijn aanwijzingen dat spelers die zelf actief op zoek gingen naar informatie die niet direct is verbonden met het advies, bijvoorbeeld in het indicator handboek, meer expliciete kennis verwierven. Dit leidt tot de vraag of een andere vorm van advies waarin bijvoorbeeld geen hints werden gegeven, tot andere resultaten zou leiden. Dit werd onderzocht in het derde onderzoek.

Het derde onderzoek

Het derde onderzoek was in feite een replicatie van het tweede met een derde conditie, waarin een andere vorm van advies werd gegeven. Het advies in deze conditie bestond wel uit de waarschuwingen dat bepaalde indicatoren onder een drempelwaarde zijn terechtgekomen (zoals beschreven bij het tweede onderzoek), maar gaf vervolgens geen hints aangaande bepaalde categorieën van interventies die geïmplementeerd zouden kunnen worden. In plaats daarvan, werd een lijst met een aantal vragen weergegeven die de spelers aan het denken zouden moeten zetten. De lijst met indicatoren waarop de waarschuwingen betrekking hadden, verschilde elk kwartaal. De lijst met vragen was telkens dezelfde.

De veronderstelling was dat deze vorm van advies een reflectieve manier van informatie verwerken beter zou ondersteunen, doordat het ervoor zorgt dat essentiële informatie niet gemist wordt en de spelers aanzet tot reflectie door middel van de vragen, wat zal leiden tot meer expliciete kennis dan bij de andere twee groepen. Verwacht werd dat het “traditionele” advies, zoals ook gebruikt in onderzoek 2, zou leiden tot hogere waarden op de game indicatoren als gevolg van de waarschuwingen en hints die beschikbaar zijn. Tenslotte werd verwacht dat de Geen-advies groep meer impliciete kennis zou vergaren dan de andere twee groepen (zoals het geval was bij het tweede onderzoek).

Aan het onderzoek werd deelgenomen door 286 studenten Bedrijfswetenschap van de Radboud Universiteit in Nijmegen. Deelname aan het spel was een verplicht onderdeel van een bachelor cursus Kennismanagement. De algemene set-up was dezelfde als die bij onderzoek twee, op twee punten na. De spelers speelden acht in plaats van twaalf kwartalen, en de transfer test werd niet afgenomen. Verder werd de grote groep opgedeeld in drie subgroepen, die ieder in verschillende tijdsperioden (achter elkaar) het spel konden spelen. De reden hiervoor was, dat er geen ervaringen waren met dergelijk grote groepen spelers, en de kans groot geacht werd dat er systeem crashes op zouden treden wanneer alle personen tegelijk zouden spelen. Gevolg van het spelen in drie tijdsperioden is wel dat de tijdspanne tussen het spelen van het spel en de afname van de natoets niet voor iedereen dezelfde was. Aangezien de spelers binnen elke conditie verdeeld waren over de drie tijdsperiodes werd verondersteld dat de invloed hiervan voor alle drie de condities dezelfde zou zijn.

Uit de analyses van de logfiles bleek dat het advies over het geheel genomen frequent gebruikt werd, maar dat ongeveer 10% van de spelers het advies icoon nooit heeft aangeklikt, hoewel er wel advies beschikbaar was. Omdat deze spelers geen gebruik konden maken van de steun die het advies hen kon bieden, zijn zij buiten de analyses gelaten. Hun gegevens werden in een aparte paragraaf besproken.

Ook in dit onderzoek bleek dat alle groepen een significante leerwinst hebben geboekt. In onderzoek 2 bleek dat alleen de Geen-advies groep een leerwinst boekte op de impliciete kennisopgaven. In dit derde onderzoek werd dit gegeven niet gerepliceerd. Alle drie de groepen boekten een kleine, maar significante, leerwinst op deze items. Over het geheel genomen werden er geen significante verschillen gevonden tussen de drie condities op de scores op de natoets.

Zoals gezegd, was de tijdspanne, tussen natoets afname en het spelen van het spel, niet voor iedereen dezelfde. Toen de resultaten van de drie groepen uit de drie verschillende tijdsperiodes met elkaar vergeleken werden, bleek dat in de Geen-advies conditie, de groep met de langste tijdspanne, een significant kleinere leerwinst boekte dan de groepen in de andere tijdsperioden. Het verschil met de Alternatieve-advies groep in dezelfde tijdsperiode was ook significant. Kennisretentie lijkt dus minder wanneer er geen advies beschikbaar is.

Een analyse van de hoogte van de game indicatoren aan het eind van het spel leverde geen significante verschillen tussen groepen op, behalve bij competentieniveau in de R&D afdeling. Een post-hoc analyse liet zien dat de Advies groep hier hoger scoorde dan de Geen-advies groep. Binnen de Advies groep waren er op enkele indicatoren verschillen tussen degenen die het advies regelmatig gebruikten, en degenen die dat minder frequent deden. Dit lijkt er op te duiden dat de hints die gegeven werden in het advies van betekenis zijn om het beter te doen in het spel. Over het geheel genomen werd het advies in 78% van de gevallen dat het beschikbaar was, ook daadwerkelijk geraadpleegd. In de Alternatieve-advies groep lag dit percentage zelfs nog hoger: 82%. Dit is opmerkelijk, omdat de vragen die in het advies waren opgenomen telkens dezelfde waren. Blijkbaar waren de waarschuwingen, die wel telkens verschilden, voor de spelers genoeg reden om het advies te blijven raadplegen. Binnen de Alternatieve-advies groep werd geen verband gevonden tussen de frequentie waarmee het advies geraadpleegd werd, en de hoogte van game indicatoren, zoals het geval was bij de Advies groep.

Wat betreft het gebruik van de andere informatiebronnen zijn er geen grote verschillen tussen de spelers in de drie condities, behalve in het gebruik van het Interventie handboek. Dit werd door de Advies groep vaker gebruikt dan door de Geen-advies groep. Dit werd waarschijnlijk veroorzaakt door de directe links die er zitten tussen de advies teksten en het handboek.

Wanneer een vergelijking werd gemaakt tussen studenten met een hoge en een lage leerwinst, over de drie condities heen, bleek dat de eerste groep, net als in het eerste onderzoek, feedback meer frequent gebruikte. Nadere analyses wezen uit dat binnen de Geen-advies groep, een verband bestond tussen de frequentie waarmee feedback gebruikt werd en de hoogte van de score op de expliciete kennis items en de hoogte van de totaalscore op de natoets. Een zelfde verband werd gevonden tussen deze scores en het gebruik van de visualisaties. Meer frequent gebruik hangt samen met hogere scores. Dezelfde samenhang geldt voor het gebruik van het interventie handboek en de score op de impliciete kennis items.

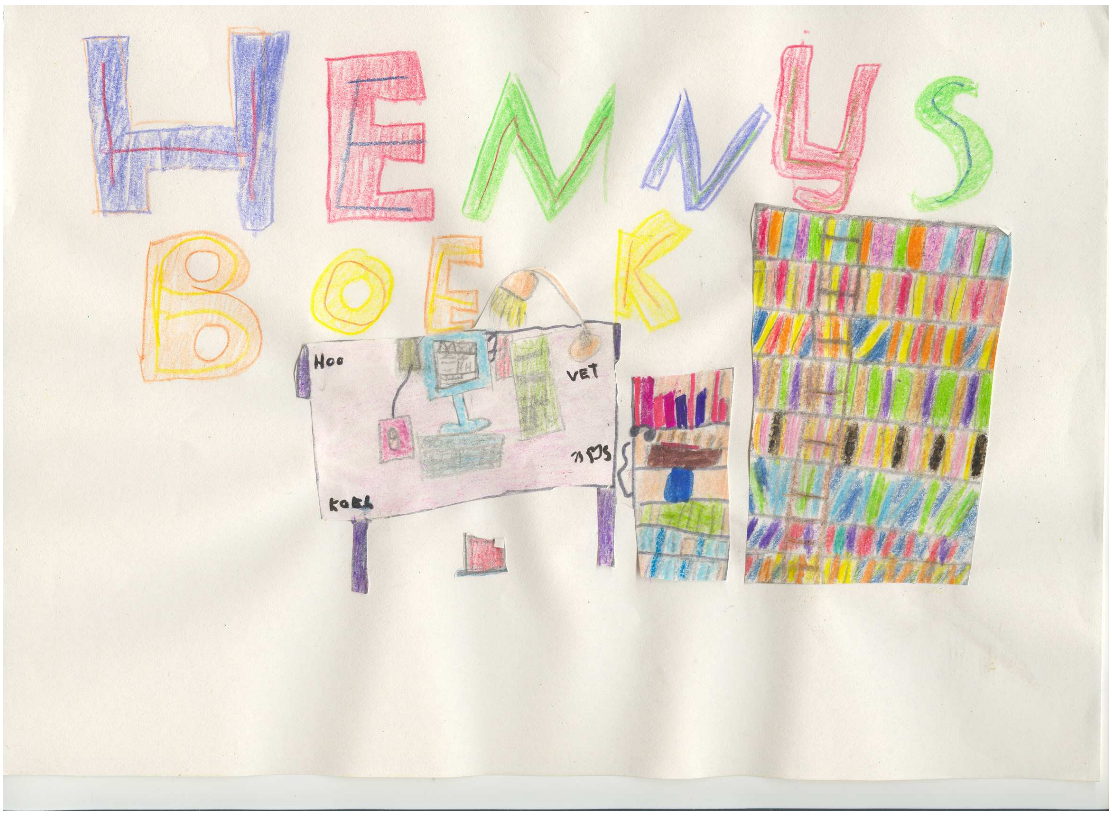
Het feit dat er geen verschillen werden gevonden tussen de verschillende condities lijkt er op te duiden dat de manieren van informatie verwerken die de spelers gebruikten in het algemeen niet van elkaar verschilden. Het advies, in welke vorm dan ook, lijkt geen veranderingen in manier van verwerken te bewerkstelligen, en lijkt alleen van invloed op de prestaties binnen het spel.

Conclusie

In alle drie de onderzoeken werden significante leerwinsten geboekt door de spelers. En als zodanig kan de conclusie getrokken worden dat een game een bijdrage kan leveren aan kennisacquisitie in een domein als kennismanagement. Er werden in de onderzoeken geen aanwijzingen gevonden dat de implementatie van ondersteunde elementen in het simulatiespel, zoals extra opdrachten en advies, leiden tot een toename in expliciete kennis. Deze elementen lijken een reflectieve en selectieve manier van informatie verwerken niet te ondersteunen. De extra opdrachten bleken zelfs contraproductief.

Het onderzoek leverde wel aanwijzingen op dat het gebruik van een aantal informatiebronnen in het spel verband hield met het verwerven van kennis. Zo bleek in twee onderzoeken, dat degenen met een hoge leerwinst meer gebruik maakten van feedback dan degenen met een lage leerwinst. Verder werden er verbanden gevonden tussen de toets scores en de frequentie waarmee feedback, het interventie handboek en de visualisaties werden geraadpleegd, met name wanneer er geen advies beschikbaar was. Een hoge frequentie was gerelateerd aan een hoge score. Dit leidt tot de aanbeveling om in educatieve games in ieder geval te zorgen dat relevante achtergrondinformatie beschikbaar is, en dat ze op elk moment dat de speler dat wil, geraadpleegd kan worden. Een tweede aanbeveling is om te zorgen voor een goede vorm van feedback die gerelateerd is aan de handelingen van de speler en niet alleen aan het resultaat van zijn handelingen. Goede feedback in games is met name van belang omdat in veel games toeval en onverwachte gebeurtenissen een belangrijke rol spelen. Op basis van feedback zou de speler in staat moeten zijn om na te gaan welke effecten toegeschreven moeten worden aan zijn eigen handelen en welke aan toeval of andere factoren die hij niet in de hand heeft. Het opnemen van advies in een game wordt niet aanbevolen. Het onderzoek wees uit dat advies weliswaar zeer veel werd gebruikt, wanneer het aanwezig was, maar dat spelers zonder advies over het algemeen ook prima uit de voeten konden en evenveel leerden. Er zijn zelfs indicaties dat het advies spelers “lui” maakt.

Het onderzoek heeft zich gericht op ondersteuning die in het spel zelf geïmplementeerd kan worden. In de literatuur wordt echter ook gewezen op het belang van elementen die in de leercontext kunnen worden opgenomen. Het samen spelen met anderen, het voeren van discussies met anderen en het nabespreken van wat er in het spel gebeurd is, kunnen reflectie bevorderen en kunnen de ontwikkeling van expliciete kennis bevorderen. Belangrijke ondersteuning zit dus niet alleen in het spel zelf maar ook in de leercontext. It’s not all in the game!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