DECIDE-IT

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Executive Summary

This is version 1.0 of the methodological manual that explains how to use the DECIDE-IT game to train decision making in business contexts. At the time of writing this manual the decide-it game is not in its final version. Anyway the general structure of the game has been designed and a good theoretical framework for training decision making has been identified. As a result, the contents of this document may appear quite general with few practical examples and references to actual game sessions. More practical example will come in the second version of this manual when the final version of the game will be ready.

The document is structured as follows. The first section introduces the basics of Educational Games and Simulations. This section is a fundamental one since is at the base of the methodology explained in this manual, that is the game based learning methodology. The second chapter focuses on Dynamic Decision Making and how it is applied in the DECIDE-IT game. This section is essential to understand what kind of decision making decide-it is aimed at training.

Summary

1 Educational Games and Simulatinos

Educational games and simulations are becoming increasingly used as supporting tools for training. They're often said to allow experiential exercises meaning that they provide learners with "parallel" worlds where they can apply their knowledge, skills, and strategies in the execution of their assigned tasks. Examples range from engineers diagnosing problems in a simulated industrial plant to children learning basic science and math principles. To highlight the need for the entertainment component in an educational game Zyda (2005) defines serious games as 'a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives'.

The use of simulations and games for educational purposes can be traced back to the use of war games in the XVII century where the goal was to improve skills such as tactic and strategic planning. Since the XVIII century, they have been used as simulation tools in the military planning of major world powers. Starting from the late 1950s, the use of simulations has extended also to business and medical education, and games and simulations are found in language, science education (mathematics and physics) and vocational training. But only recently the educational potential of games has become a research field with an increasing number of academic publications on "Serious Games" (Michael and Chen, 2006). So what emerges to be the distinctive characteristic of Serious Games, with respect to games in general, is that in addition to be entertaining they also have some educational purpose. And here lays most of the difficulty in the design: how to make a game that is both engaging and educational ? How to ensure that some kind of knowledge is conveyed through the gameplay ?

Anyway there's a subtle difference between Games and Simulations that is worth pointing out. While games have well defined rules and goals set, simulations in contrast are open-ended evolving scenarios with many interacting variables. The goal for each participant is to take a particular role in managing the mechanics of the above system, and experience the effects of their decisions. The state of the system can take different directions, depending on the actions and reactions of the players. Simulations are often referred to as Sandbox Game, meaning that the goal is a lot more loosely defined. One of the main problems faced during the design phase of an educational simulation is the level of fidelity of the model and the boundaries of the real world domain modeled. A good simulation environment should be complex enough to capture relevant aspects of the reality. But too much complexity in a simulation game can impair the learning process and can lead to uncontrolled results. Too much simplicity can bore players making the simulation appear trivial and without educational value.

The availability of computer simulation for educational purposes has been mainly due to the increased availability of cheap and powerful computers on the market, which took place in the late ‘90s.

1.1 Architecture, purposes and design criteria

The architecture of games and simulations can analyzed with respect to two main aspects. On the one side we have interactive aspects and on the other we have functional aspects.

Interactive aspects are those related to user interface design, usability accessibility etc. sometimes called surface structure (van Ments, 1984). Example of interactive aspects concern the layout of UI elements like buttons, sliders, icons, graphic elements, their functioning, the number of operations that are required to perform some actions in the game etc. Interaction with a game or simulation can be described as a process in which bidirectional transfer of information happens between the user and the system. When the user input some information into the system taking some actions, we have a transfer of information from the user to the system. When the system changes status and it displays new information on the user interface, we have a transfer of information from the system to the user. Interaction is the basic mechanism through which the entire game experience is conveyed and a good interaction design is crucial for exploiting the full potential of a game design.

Functional aspects refers to the deep underling mechanisms and logic that govern the game or simulation. The functional aspects are somehow hide and must be learned through the interaction with the surface structure of the game or simulation. Functional aspects are also important because they determine the cognitive and metacognitive capabilities that are necessary to play with the game or simulation. An important difference between games and simulations, from the perspective of learning, is that simulation are more oriented to the solution of ill-defined problems while games are usually based on well-defined static problems. Ill-defined problems are those in which goals are not posed in a clear explicit way and there isn’t a unique valid solution. Most of the problems in the real life are ill-defined. Due to these characteristics, giving feedbacks to participants of a training course based on simulation can be problematic or at least require the tutor or facilitator to carefully map the actions of the player to the changes of the simulated system and this can be a non-trivial task.

For the learning with games and simulation to be effective one more ingredient is necessary which is immersivity. An immersive game or simulation can be defined as one that make the player put the same commitment that he/she usually put in real life situations. This ensures that learning outcomes are effective and long lasting.

1.1.1 Educational Games

As mentioned before the difference between games and simulation is that games usually have a well-defined structure with goals, playing rules, cores, penalties for unpermitted actions and a set of instructions to execute the play, such as commands, actions and computer keys (Gredler, 1992). Games can be designed to be single player o multiplayer and in the latter case they can be collaborative or competitive in nature. The structure of the game can be leveled based on the educational content and passage from one level to the successive can be determined based on the score of the previous level.

1.1.1.1 Purposes

Educational games may serve different purposes: (a) to acquire new knowledge and skills (b) to practice and/or consolidate already-acquired knowledge and skills, (b) to asses gaps or weaknesses in current knowledge or skills, (c) to enhance and develop links among concepts and principles. Games can also be used along with traditional in class learning to add motivation and to vary the educational scenario. But games can also be used as “stealth” diagnosis systems especially for children.

1.1.1.2 Design Criteria.

A well designed educational game should possess two main characteristics. Should be challenging and engaging as any entertaining game so that players are motivated to play over and over. It should be designed in a way that players can advance in the game and be rewarded only if they apply the knowledge and skills that are the objective of the training.

There are some design principles that if applied can lead to a successful educational game and can be summarized in the following design rules. Advancing in the game should allowed only to players that demonstrates to possess the correct knowledge and skills. Instead many games reward knowledge extrinsically, for example putting multiple choice questions along a normal game. Example are puzzle games that at the end of a game level present some questions about mathematics or general science that are unrelated to the mechanics of the game.

So the mechanics and the gameplay should be designed around the educational content that we want to convey. Just to give an example, if I want to design a game about geometry, I have to design the game in order that at some point to advance further I need to calculate the area of a circle or other geometrical shape.

A game should also be tailored to the target group for what concern difficulty and knowledge level. For this reason it is important to put the level of difficulty as one of the optional parameters that can be decided before a game session starts. More in general the game should allow a certain level of customization to adapt it to the need of end users. An important aspect of game design is also the feedback provided to the participants that on its turn is linked to the level of explicitness of knowledge. Sometimes in educational games, and especially in simulations, knowledge is acquired in an implicit manner so that one is able to pass a game level but he/she doesn't know how he/she achieved that. In these cases feedbacks from the game can help to gain awareness of the implicit knowledge acquired during the gameplay.

1.1.2 Simulations

Simulation, unlike games, don't have predefined goals, rules and roles but are sand boxes in which players can experience cause-effects relations by freely experimenting with the system. The goal is not winning or gaining the highest possible score but learning how the simulated system works by experimenting with a computerized model. The most prototypical example of simulation is the flight simulator in which players can have the experience of controlling an aircraft in each of the critical phase of flying (take off, landing etc). In a flight simulator players don't have a specific goal. They can take off from an airport and land again after few minutes or make a longer trip flying to a city hundreds of miles away. Simulations are widely used to teach scientific subjects like physics chemistry and mathematics. In this case simulation are like virtual laboratory where abstract notions can be practiced in a safe and comfortable environment.

1.1.2.1 Purposes

Computer simulations can be used for many different purposes. They are extensively used both in the industrial and scientific fields for two main purposes. First, they can be used in the design phase of a product to test its capabilities and drawbacks. Secondly they can be used to study scientific phenomena that is difficult or expensive to reproduce in a real laboratory.

Using computer simulations is particularly advantageous also for educational purposes (Feurzig & Roberts, 1999). The aim of a computer simulation is to represent a scientific theory in a sort of "working version" that reproduces the underlying phenomena. In a sense, computer simulation allows players to play with the scientific knowledge. Indeed, computer allow for the contextualization of knowledge. It is important to create a context in which examples of the theory that you are intending to teach can be performed and practiced. In that respect, an agent based simulation of the FRL theory allows us the ability to create an infinite number of specific contexts in which the knowledge can be experienced and practiced.

1.1.2.2 Design criteria

The criteria adopted in the design of a simulation can vary a lot depending on the training goals and the level of the training course. One of the most important criteria is the level of realism that one wants to achieve in the simulation. For hard skill training a high level of realism is recommended since practice should be performed in an environment that should be as much as possible similar to real life situations. In other types of training realism is not needed and sometimes even not advisable because details of the simulation may distract learners from higher level aspects and mechanism that are the focus of the training. An example where high realism is needed is diagnostic simulation, in which students goal is to find treatments for a disease and the patient's pattern of symptoms, general health conditions must be simulated based on real data. On the contrary, some business simulation doesn't require to be based on real data if one just wants to teach principles of general management and relationships among marketing, sales, inventory etc.

Another important aspect to be considered in the design of a simulation is the level of complexity that is strictly linked with the motivational level of players. A too simple or too complex simulation can bring motivation down and make the training boring or frustrating. On the other hand tweaking the level of complexity is not a simple task due to individual differences that characterize a group of learners.

1.1.2.2 Advantages

There are some advantages in using simulations for training purposes that games have not, at least those based on discrete, predefined problems. One is that simulations are inherently more similar to real world situations and contexts than, for example, multiple choice games. This is a point in favor of transferability of knowledge and skills to real world context. Another advantage of simulations is that they require learners to employ procedural instead of declarative knowledge. For example I may be able to explain by words how to drive a car (declarative knowledge) while at the same time being unable to really drive it. More in general simulations can provide useful information about students' attitudes and strategies in problem-solving.

2 Dynamic Decision Making

In the previous section we had an overview of educational games and simulations in general without reference to any topic in particular. In this section instead we will focus on Dynamic Decision Making that is a field of research that studies decision making in complex dynamic environments with the use of games and simulations. We will explain why this theoretical framework has been chosen as a base for building a new methodology for training decision making in the business context. Most of the issues discussed in this section are fundamental in the application DECIDE-IT as a game based methodology.

As described in D3.1 decision making is a vast field of research with a lot of facet. Many aspects of decision making are still to be revealed and clarified by future research. In building the methodology for the DECIDE-IT training kit we have carefully considered the outcome of the needs analysis document and the current trends in the business decision making research. As a result the methodology and theoretical background is based Dynamic Decision Making (DDM).

2.1 Decision making in complex dynamic environments

A growing line of research in business decision making and decision making in general is about how human take decisions in real life context that are well known to be inherently complex and dynamic at the same time. While many classical laboratory studies about decision making try to create simple and static situation that are easily controlled and can be better analyzed, a different approach is adopted by DDM research. In this case computer simulations are used to recreate some of the complex and dynamic situations of real life to study how people behave and decide in such contexts. As highlighted in the previous sections one of the advantages of using computer simulations is that complexity and dynamicity can be weighed out to match the desired goals of the experiment or training. Moreover behavior can be recorded and traced better than in real world settings. DDM belongs to a relatively new approach in studying decision making called Naturalistic Decision Making (NDM) that emerged in the beginning of the 90s to overcome the limitations of classical decision making studies done in laboratories with static structured situations. NDM research received a great deal of support from researchers coming from the military, industrial and health sectors, that is people who were interested in real decision making problems.

In the next paragraph we'll try to define more precisely what a complex dynamic environment is.

2.2 Complex and dynamic enviroments

It is fundamental here to clarify what we mean for complex and dynamic environments or situations to avoid the confusion that could arise if one adopts an intuitive definition. The definition of complexity that we refer to is the one that emerges from research in system dynamics. System dynamics is an approach to the study of natural phenomena that is based on the concept of system. A system is a group of interacting elements that can be considered as a whole (see fig. 1). The complexity of a system is produced by the interaction of its elements over time. It is important to highlight that even if the elements of a system are very simple ones their interaction can produce a very complex behavior.

Fig.1 Abstract representation of system: a group of interacting elements that give rise to complex behaviors

Just to give a more concrete example of what a system is and how complex its behavior can be let’s take the example of the ping pong game. The elements of a ping pong game are: two players, two rackets, a ball and a table. Interaction between the players, balls and the table is governed by the laws of physics. Interaction between players is governed by the rules of the game. It is interesting to notice that both the laws of physics and rules of the game are not so complicated in themselves as are the elements of the ping pong game. But describing a ping-pong match in details is a very difficult task because of the complexity that emerges from the interaction of its elements.

Another example that is closer to the business world is that of stock management. The stock management system of a company can be described in a simplified manner as composed of three main elements: customers, inventory and production system. Inventory and production system are part of the same company system that, from the point of view of customers, can be considered a single element, but in analyzing the stock management system we will consider them as separate elements. Now let's have a look at the interactions between these elements. When customers put orders to the company a certain amount of stock is withdrawn from the inventory which level of stock decreases. The inventory manager interact with the production unit giving the production target that is the amount of items to be produces to keep the level of stock at an adequate level. The production unit receive production targets and adjust production rate accordingly.

The goal of an inventory manager is to keep enough stock in the warehouse to satisfy customer orders but at the same time limit it in order to avoid overstocking that could cause problems like reaching the maximum storage capacity or increase expenses due to management of big quantity of stock. It is important to notice that the production of goods require times so that if the inventory department is short in stock and commands an increased amount of items to the production its request will not be satisfied immediately but need a certain amount of time to take effect. As we'll see in the next paragraph, stock management systems are not easy to manage and the dynamic behavior that arises from the interaction of the three simple elements described above can be rather complex.

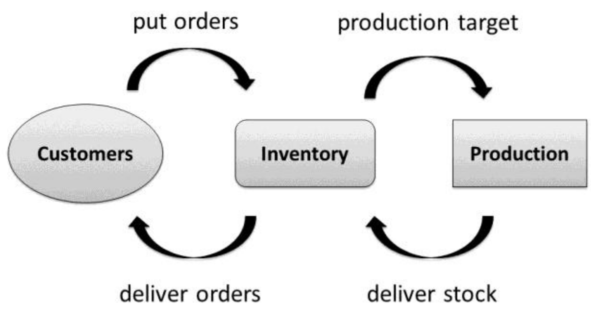

Fig.2 Example of simplified stock management system

2.3 Human performance in DDM: the misperceptions of feedback

At this point one question arises that is relevant for a training course on dynamic decision making: how is human performance in DDM tasks ? As many studies has demonstrated (Diehl & Sterman, 1995; Klabbers, 2003; Moxnes, 2004; Sterman, 2000) human performance in complex dynamic tasks is very poor. The most common explanation of this poor performance is attributed to the "misperceptions of feedback". Put it simply, what causes problems in managing systems like the stock management system described above is the fact that most people ignore time delays and nonlinearities in complex systems and are thus unable to recognize some behaviors of the system as results of their previous actions and decisions on it. There are some simple experiments that show this in a very effective way. Suppose you have a bath-tube with a certain level of water inside. Suppose you open the water so that you have an inflow and you also open the drain so that you have an outflow. Now suppose that you regulate the inflow according to the following graphs (look at the square shape line) for about 16 minutes.

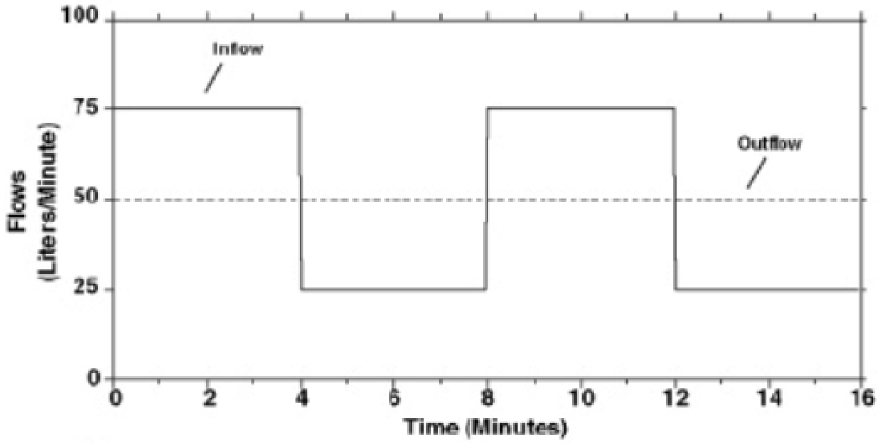

Fig.3 The bath-tube problem (see text for details)

What will happen to the level of water in the bath-tube ? For many people this is a difficult task not easy to solve. But it's interesting to notice that this is an example of stock system common to many problems in many fields as exemplified in the following table:

Table 1. Examples of stock-management systems

System	Stock	Supply Line	Loss Rate	Acquisition Rate	Order Rate	Typical behavior
Inventory Management	Inventory	Goods on Order	Shipments to Customers	Arrivals from supplier	Orders for goods	Business cycles
Capital investment	Capital Plant	Plant under construction	Depreciation	Construction completion	New contracts	Construction cycles
Equipment	Equipment	Equipment on order	Depreciation	Equipment delivery	New equipment orders	Business cycles
Human Resources	Employees	Vacancies & trainees	Layoffs and quits	Hiring rate	Vacancy creation	Business cycles
Cash Management	Cash balance	Pending loan applications	Expenditures	Borrowing rate	Loan application rate	?
Marketing	Customer Base	Prospective customers	Defections to competitors	Recruitment of new customers	New customer contacts	?
Hog farming	Hog stock	Immature and gestating hogs	Slaughter rate	Maturation rate	Breeding rate	Hog cycles
Agricultural commodities	Inventory	Crops in the field	Consumption	Harvest rate	Planting rate	Commodity cycles
Commercial construction	Building stock	Buildings under development	Depreciation	Completion rate	Development rate	15-25 year cycles
Cooking on electric range	Temperature of pot	Heat in coils of range	Diffusion to air	Diffusion from coils to pot	Setting of burner	Overcooked dinner
Driving	Distance to next car	Momentum of car	Friction	Velocity	Gas and Brake pedals	Stop-and-go traffic
Showering	Water Temperature	Water Temp. in pipes	Drain rate	Flow from showerhead	Faucet settings	Burn-then-freeze
Personal energy level	Glucose in bloodstream	Sugar and starch in GI tract	Metabolism	Digestion	Food consumption	Cycles of energy level
Social drinking	Alcohol in blood	Alcohol in stomach	Metabolism of alcohol	Diffusion from stomach to blood	Drinking rate	Drunkenness

Table 1. Examples of stock management systems

The solution to the previous bath-tube problem is presented in the following picture.

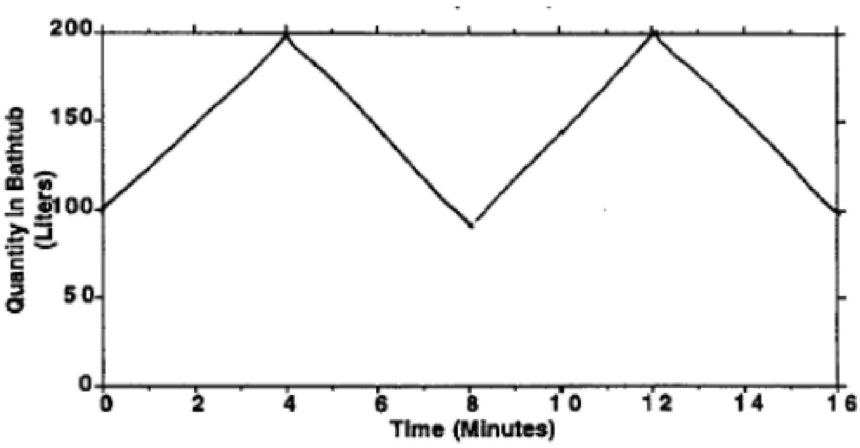

Fig. 4 Solution to the bath-tube prolem

As can be seen in this picture the square shape policy of inflow regulation gives rise to a ramp shape variation in the level of water that is not the immediate answer of many people asked to solve the problem.

Now as Qudrat-Ullah pointed out (2006) humans are not inherently incapable of solving problems in complex dynamic environments as demonstrated by experts performing well after years of practice in complex problem domains. So the question arises of what is the best method to learn decision making dynamic complex environments.

2.4 System dynamic approach to business processes

Now that we have introduced the topic of decision making in dynamic complex environment we can focus on the importance of this framework in the business context. To do that we'll describe a classical study by Diehl and Sterman (1995) that shows very well how business processes and human decision making can be analyzed in term of system dynamics. For a detailed explanation of the experiment we suggest to refer to the original article. For the purpose of this document we just ask the reader to get an intuitive understanding of the work. The purpose of this study was to map the effects of time delays and feedback loops on performance in a stock management task with a computer simulation. Participants managed the production of a firm that sells a generic kind of commodity. The firm receives order from customers and deliver goods that is withdrawn from the inventory thus reducing the stock level. Orders varies in a stochastic manner and participants were asked to minimize the cumulative costs. Costs derived from two factors: the discrepancies between the stock level and its target value, and the cost associated with changes in production rate. So to put it simply the goal of participants was to keep the stock level as close as possible to the target value fixed at the beginning of the game. The inflow of inventory is determined by the production output while the outflow is determined by sales. The delays and feedback loops involved in this experiment are shown in fig. 5

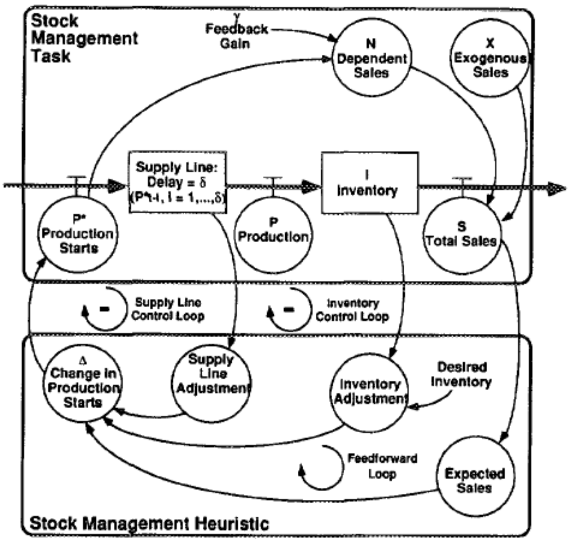

Fig.5 Delays and feedback loops in a stock management task (Diehl&Sterman, 1995)

Two main variables were manipulated in the simulation. One was the delay in the production system, that is the time necessary for the change in the production rate to take effect. The other variable was a gain effect on sales produced by an increased production, that is the more the firm produces the higher the sales. The experiment was performed with two groups of participants in two conditions, one with delays and positive feedback loop between production and sales, and the other one without delays and feedback loop. Results are shown in fig. 6.

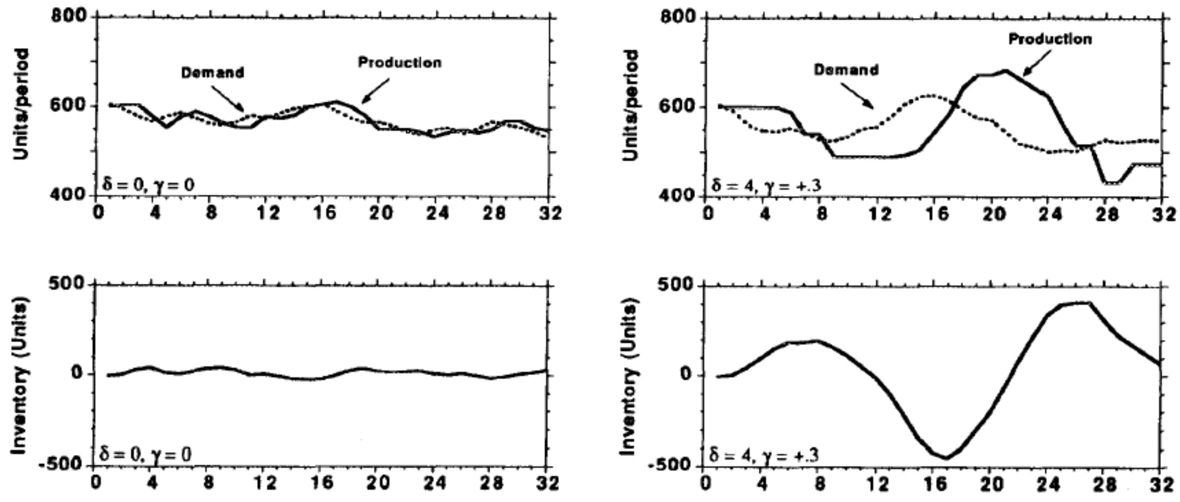

Fig.6 Results of the experiment on delays and feedback loops in business (Diehl & Sterman, 1995)

As can be seen in fig. 6 on the left part, when there weren't delays and feedback loops in the stock management system people performed quite well in the task of regulating production in order to satisfy the demand and as a result the stock level was kept around a stable value. When instead delays and feedback loops were introduced (fig.6 right side) the task became much more difficult and people performed poorly. It is important to notice experiments like this has been replicated even with managers and executives of large companies and results are very similar indicating that the misperception of feedback is common to both experts and novices.

So, as this experiment demonstrates we humans are severely impaired in managing complex dynamical systems where there are delays and feedback loops. As Sterman illustrates in his award winning book "Business Dynamics" (2000), most of the systems in our world can be characterized as dynamical systems made of parts interacting with feedback loops and delays, and this not only applies to business but also to social and natural phenomena. Thus the importance of knowing and learning how to manage such kind of system.

3 DECIDE-IT game: structure and purposes

In chapter one we have illustrated how games and simulations can be used for educational purposes. In chapter two we have described the system dynamic approach to decision making in business. In this chapter we will describe the DECIDE-IT game and how it tries to combine the principles of educational games with the theoretical framework of Dynamic Decision Making. At the time of writing this manual the DECIDE-IT game has not yet been tested and is not in its final version. But the design is nearly complete and there have been some initial tests that will be useful to ground our discussion on how to train decision making with it.

3.1 The business simulation under decide-it

The purpose of the DECIDE-IT simulation engine is that of reproducing the general business dynamics of an online retail company. To build the simulation we have been greatly inspired by the above cited work from Diehl and Sterman. The structure of the model company and economic environment is shown in the figure below.

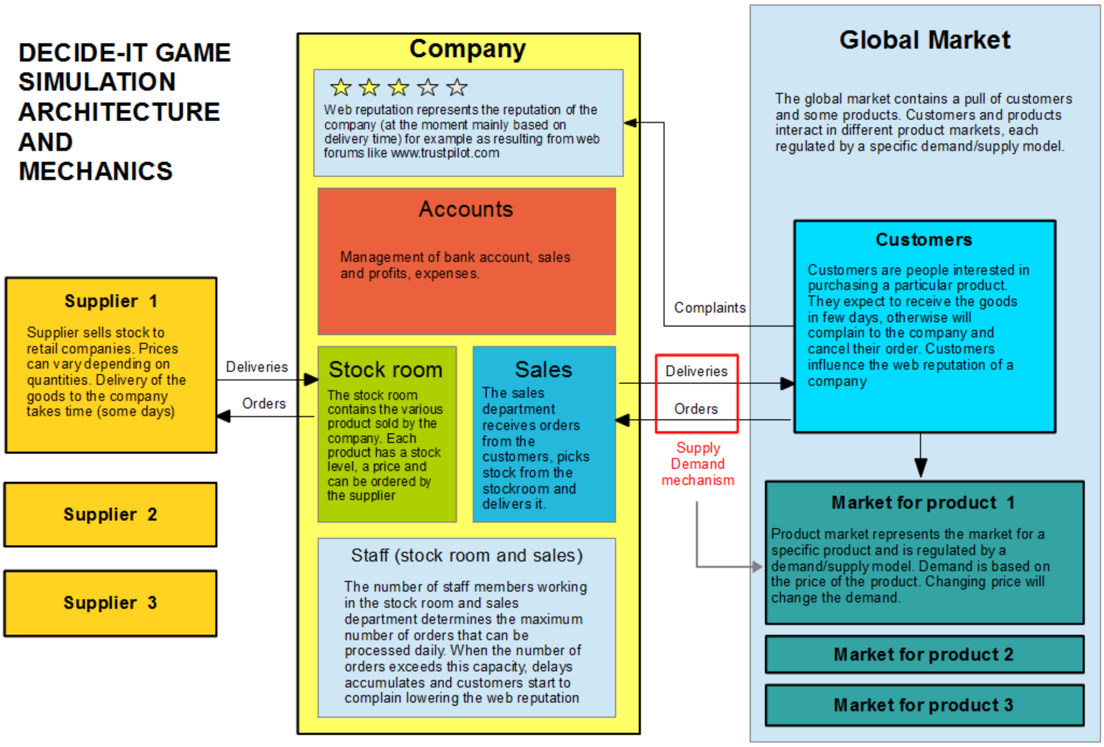

Fig. 7 Basic scheme of the DECIDE-IT simulation

The company is supposed to be an online retailer of products for hobbyists. Essentially this virtual company buys product from some suppliers and sell them to consumers through its commercial web site. There are three types of products that can be managed in the game each with a different retail and supplier price and a different initial quantity in stock. The company has a back account with a certain amount of money that can be used to buy goods from the suppliers. The bank balance varies depending on the expenses and income and when it goes in debt the game overs. Expenses are due to salaries of the staff and buying goods from the suppliers. Income are due to selling products on the website.

Order arriving at the company are processed by the staff of the sales department that take the stock from the warehouse and deliver it to the customers. The main goal of the player is to control the level of stock in the warehouse buying the right quantities to satisfy market demand and trying to minimize overall costs.

Fig. 8 shows the game interface that the palyer/s can use to manage the company.

Fig.8 Game interface of the first version of the game

One thing player should pay a lot of attention to is customer satisfaction. If customers don't receive their order in time they will complain and leave a bad mark on an internet rating system that will affect future performance of the company. Indeed customers before buying goods from the company are supposed to check the web reputation of the firm on specialized web sites. The lower the web reputation the less order the company will receive. Apart from web reputation, the amount of order arriving each day is dependent from a demand supply rule hardwired in the system.

The interface is divided into eight panels. For details we suggest to refer to the game manual, here we just briefly describe information contained in each of them. The time panel at the top marks the current days of the simulation and allow player to stop and resume the game. The bank panel gives information about the current amount of money available. The accounts panel show current and cumulated expenses and income, and total revenues. The sales and marketing panel shows the current situation for what concerns incoming orders, processing of orders, delays and customers satisfaction(number of complaints and web reputation). The products panels on the right convey information about products (amount in stock, supplier price, retail price) and have two buttons one for ordering products to supplier and one to change the retail price. The chant panel can be used in the multiplayer game session if the players want to communicate each other.

3.2 Training purposes of the game

In this section we want to highlight some of the main training purposes that can be achieved with the use of the current version of the game. As stated previously the game hasn't been tested so we can't provide information relative to the efficacy of a training conducted with it. A more complete version of this manual will come with the second version when it will be integrated with the improved features of the game and with information derived from the experimental trials.

3.2.1 Resource management

The game presents several aspects of resource management as an important facet of decision making. One of the resources that needs to be manages is money. The availability of a limited amount of money in the bank account forces players to adopt a wise policy in buying goods from suppliers, not only in the quantity of stock but also in the kind of products that he purchases. Buying too much of a product that is not sold means wasting money and can lead to a condition in which we have no money to buy the product that we need and a warehouse full of stock that is unsold.

A second kind of resources that needs to be managed is staff. The payer can't hire new staff at least in this version of the game, so staff is considered a limited resources. What the player should pay attention to is to avoid overcome the maximum workload of staff because this will lead to delays in the processing of orders and delays in deliveries which in turn will lead to decrease in web reputation. So the price policy of the product that could virtually increase sales as much as wanted should be planned wisely based on staff resources available.

The third kind of resource that must be carefully considered is time. Time is needed to receive order from the supplier and to decide how many pieces of any product is needed. The trade-off between these two aspects if fundamental.

3.2.2 Time delays

As explained in the section dedicated to the Dynamic Decision Making one of the pitfalls of decision making in complex dynamic environments is the misperception of feedbacks due to time delays. The DECIDE-IT game include the modeling of different types of delays that are common in the business context. One of the main delays that players need to consider is the time that passes from orders to the suppliers and receiving the goods from them. When the stock level of a particual product is getting low I should carefully consider the time needed to get new stock from the supplier and the time that it takes the stock level to get to zero pieces. For example if I sell 20 items of a product per and I have 160 pieces in stock and it takes one week to get new stock I have only one simulation day to decide if buying new stock or not. And as we said before buying new stock is not a trivial task because it must consider the amount of money available and the situation of other products. If I don't consider time delays I may find myself in a bad situation in the future (a lack of stock for example, or complaints and bad reputation) that typically is attributed to other factors (lack of money or time for example).

3.2.3 Feedback loops

Feedback loops are the second main problem that people encounter in managing complex dynamical systems. What seems problematic about loops is recognizing that the state of the system at some point in time could be linked to actions performed much earlier which triggered a negative or positive feedback loop that led to the current state. Even when recognized, the reinforcement mechanisms of loops are difficult to break.

Let's give an example taken from the DECIDE-IT game. At some point in the game one can find the company with a very low amount of incoming order and low profits. A careful analysis shows that a negative feedback loop was triggered by a bad resource management. Stock was getting low and was not order in time to the supplier because there was not enough money. A period of out-of-stock for some products led to delays in order processing. Delays produced an accumulated amount of order to process. Due to the limited amount of staff available the maximum workload was reached which in turn led to delays in delivering. Some customers complained and left a bad rating. Bad rating led to decreased sales.

Decreased sales means less money and less money means les capacity to buy new stock which close reinforces the negative loop.

3.2.4 Understanding system structure and functioning: mental models

The previous example about feedback loops gives us a chance to explain the general training strategy of DECIDE-IT. The game is an occasion for players to experiment situations that are prototypical of real life situations. The advantage of the game with respect to real life is that players, with the help of a tutor or facilitator, can reflect on what happened and try to figure out what went wrong by analyzing every aspect of the system, and map their actions to the consequences in the game.

An important step in the learning process is the analysis and transformation of the players' mental models of the system. In this respect the role of the tutor is of great importance. According to the Dynamic Decision Making paradigm, the success in managing a complex system derives from applying the concepts of system dynamics and in creating a useful mental model of the system that needs to be controlled. But the natural tendency of our cognitive system is to perceive situations in simple and static way ignoring long term consequences and nonlinearities. The goal of a training in dynamic decision making is twofold. First getting familiar with the functioning of simple dynamical systems showing how faulty is our natural tendency to model situations in a static manner. We can call this the awareness phase. Second goal is to learn the basic principles of system dynamics and use this principles as building blocks to aid the construction of mental models that are more close to how a system works.

3.3 How to teach DDM with decide it and the ABA technique

Applied behaviour analysis (ABA; Cooper, Heron et al) can provide a useful framework for both guiding the design of educational games and conducting the basic research necessary to find out how to teach successfully via games. This claim is based on the foundation of ABA in behavioural science, the success of ABA programmes wherever they have been implemented (lindsley, 1992b), and the observation that ABA teaching programmes are structured similarly to successful, engaging games (see (Linehan, et al) for a detailed discussion of this point).

ABA is an approach to learning based on the findings of behavioural science. Teaching is typically delivered on a one-to-one basis, where the tutor is seen as a coach, rather than a lecturer. The structures of ABA programmes are heavily influenced by the observation that learning is maximized when high performance targets are set, and teaching is focused on the individual (See Lindsley, 1992b). Unlike in traditional education, the passing criterion in ABA is not, for example, 40%, but typically somewhere around 90%. If the learner does not reach this stringent passing criterion, they are required to repeat that particular part of the programme until they do reach it. If they fail to reach criterion a number of times, they are required to repeat previous, more basic learning outcomes, to demonstrate that they understand the underlying concepts or skills, before being presented with the more complex task once more. The result is that the tutor is always sure that the learner has a fluent understanding of the subject matter before moving on to more advanced topics.

Of course, the core reason for proposing ABA as a framework for guiding educational game design, is because there is a great deal of empirical support for the effectiveness of behavioural teaching programmes wherever implemented, from university modules (Saville, 2006) to secondary school (Olympia et al, 1994), primary school (Lindsley, 1992b), and challenging populations (Christopherson & Mortweet, 2001). Behavioural teaching methodologies have been particularly successful as early interventions for children diagnosed with autistic spectrum disorders (Lovaas, 1987).

Interestingly, ABA programmes are structured in a way that is strikingly similar. Specifically, the ABA tutor defines each individual learning outcome that the student needs to improve on, and defines the rewards for reaching that target. The student practices the behaviour until the specified target is met. Once performance targets have been met, the student obtains the pre-defined reward and the student must undertake a new, more complex task. Students record their own performance under supervision of teachers on specially designed charts. From viewing these charts, students have constant access to feedback on their performance relative to previous sessions. Thus, it appears that ABA is a very successful form of teaching, which is structurally very similar to an entertaining computer game.

In [Linehan et al] we discussed the basic processes necessary to undertake when using ABA to guide the design of educational games, which in turn was based heavily on (Cooper, Heron, & Heward, 2006 and Catania, 1998). We will provide a brief summary of each below. Figure ? illustrates how these processes interact in an ongoing programme.

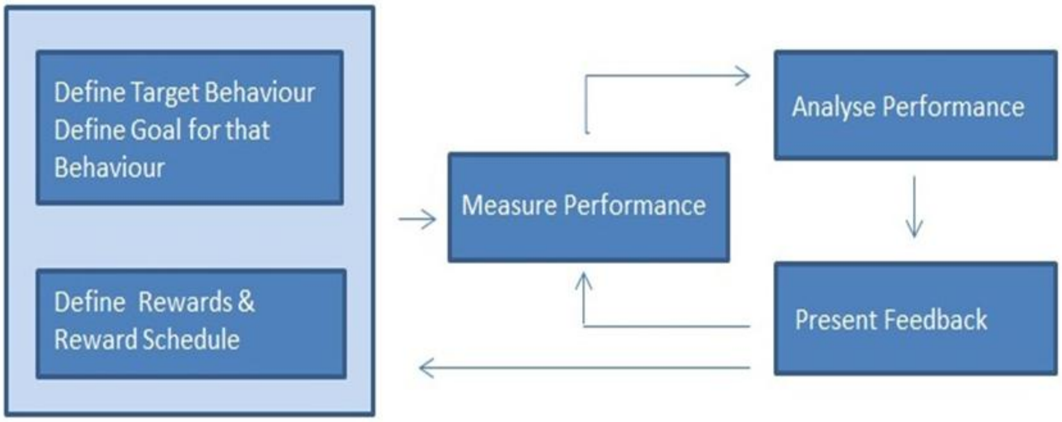

Figure 1. Illustration of how the different processses interact during an ongoing ABA teaching programme.

2.4.1 Defining hierarchies of learning outcomes

The most basic and important step is to clearly define the intended learning outcomes of the programme. If training is to be automated, with no tutor input, these outcomes must be defined as clearly, objectively observable behaviours, and it must be possible to provide a specific definition of when a learner has and has not reached that learning outcome. Crucially, it must be possible for a computer to evaluate, from simply recording and analyzing a player's behaviour, whether they have learned or not.

The designer must clearly define not only the ultimate learning outcome of the programme, but also the series of steps that learners must reach on their way to that goal. In this way, a hierarchy of learning outcomes is created, where knowledge of the simplest concepts and processes are taught first, and performance is built methodically. Once the player has passed a challenge and demonstrated knowledge of a particular concept, they are immediately presented with a more complex challenge that builds upon that newly acquired information. If learners do not reach a learning outcome, they are required to repeat it until they do. If repeated failures are observed, learners are required to repeat the tasks lower on the hierarchy related to that task. This necessity for re-training in component skills is why a logically structured hierarchy is essential to any ABA programme. It also helps the educational game designer understand what should happen when a player is repeatedly unsuccessful.

2.4.2 Defining mastery criteria

When a learning outcome is decided upon, an acceptable mastery criterion for that outcome must also be defined. Mastery criteria are essential to the way that entertainment games work and are also a key component of ABA. Specifically, learners are expected to demonstrate excellence at each learning outcome before they are allowed to advance to the next lesson. This is how the tutor (or in this case, the game) knows that learning has occurred. The passing criteria in ABA are typically somewhere near 90% - it is not acceptable to advance upon receiving a grade of 40%, as it is in traditional education (such as Higher Education in UK & Ireland).

2.4.3 Measuring, recording, and analyzing performance

Measurement refers to the process of assigning numerical values to observed behaviour. In traditional educational settings, success is measured by reporting the number of tasks that have been performed correctly and the number that have been performed incorrectly. ABA programmes rely not only on accuracy, but also on temporal aspects of performance. Measures of performance that include temporal components have been demonstrated as more accurate method for judging how comfortable, or fluent the learner is with the material [13].

Closely related to the process of measuring behaviour, is that of recording those measurements in a way that is easy for both the learner and instructor to understand and use. Behaviour analysts record every single instance of every target behaviour during an ongoing programme. In the context of a game, every single action that a player takes within the game is important and must be recorded in a way that is easy for the game software to analyse.

The key metric used by behaviour analysts in analyzing the success of learners is the change in their behaviour over time. Essentially, once a learning outcome has been defined, the behaviour analyst continually measures the learner performing that behaviour and examines whether or not the performance of the learner is approaching the desired outcome. Appropriate feedback is given based on this analysis.

2.4.4 Delivering feedback

Feedback is presented to learners in most educational programmes in order to give them information regarding how closely their current level of performance matches their goals. The intention is to guide the learner towards excellent performance. Interestingly, the process whereby performance-related feedback alters the behaviour of learners has attracted huge amounts of attention from behavioural psychologists for the past 70 years (Skinner, 1938; Skinner, 1953; Skinner, 1974). The type of feedback delivered (reinforcement or punishment), the timing of when feedback is delivered (schedules of reinforcement; Ferster et al, 1957), the operation of different schedules simultaneously (concurrent schedules) and methods for adapting schedules based on performance (i.e. the matching law; Herrnstein, 1961) have all been investigated in order to understand how to maximize the attention and motivation of learners (Catania, 1998).

The findings of the science of behaviour are directly relevant to the design of educational games; especially since game software must organize learning in a similarly objective and empirical manner to a behavioural scientist. Games that capitalize on the empirical science of learning will have a higher probability for success than those that ignore it. By using ABA as a guide for designing educational games, the designer is ensuring that they take best advantage of the already established body of data assembled through the science of learning.

2.4.5 Adapting to player performance

Both games and ABA programmes are built on the assumption that the challenges presented should be appropriate to the learner / player’s skill level. There should always be the opportunity for reinforcement, regardless of the level of ability that a learner initially demonstrates (Kiili, 2005). In order to ensure that this is the case, educational games must be able to analyse ongoing performance and adapt in a way that encourages further engagement. This appears to be quite a challenge, but can be done quite effectively if the previous steps have been taken carefully.

Firstly, clearly defined goals, each representing components of the ultimate target behaviours, mean that present behaviour can always be compared to a relevant goal. If goals are met quickly, the player should advance at a fast pace. If goals are not met after repeated attempts, the player should be required to repeat the simpler component tasks, as described earlier. In this way, the player will always be striving towards achievable goals and the game will not present any challenge without providing the player with the skills required to pass it.

Secondly, as the player advances through the game at a quick pace, the game can recognize this and begin presenting rewards on a leaner schedule. The increased scarcity of rewards functions to sustain behaviour (Catania, 1998). Thirdly, using an algorithm known as the matching law (Herrnstein), the game can evaluate the relative reinforcing strength of the various rewards on offer. This information can be used in a variety of different ways, depending on what effect on player behaviour is necessary. For example, they can offer proportionally more of the more attractive rewards (adapting to individual differences), reduce the frequency of those rewards over time (leaning the schedule), or adjust the amount of work required to achieve each of the available awards, in order to ensure that players are motivated to experience each element of the game.

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