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How the Inclusion of Time Creates Complexity in Dynamic Decision-Making Environments

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Abstract

This report discusses the factor of time in decision-making and how time can be taken into account in simulation gaming. This discussion is based on recent definitions and classifications of time. We will reflect on these classifications and argue why embedding a richer time conception would increase the application domain of simulation gaming in the organizational context. Finally, we will theorize on the implications of continuous processing in simulation gaming. The results of the report hint that continuous gaming provides a very intense and meaningful learning environment and context.

Keywords: time, decision-making, complexity, experiential learning, business gaming, simulation gaming.

1. Introduction

The discussion of this report aims at broadening the concept of time in the field of computerized simulation gaming. We feel that this kind of discussion is very current and relevant because of at least two reasons. First, there are environmental changes that affect the whole decision-making procedure in organizations. Secondly, the present views on technology-supported learning highlight the importance of environments which represent authentic activity and complexity in the learning context (see, e.g. Bednar et al., 1992; Duffy and Cunningham, 1996; Jonassen, Peck and Wilson, 1999). In this report the emphasis is on the first reason but also the second one can be recognized indirectly.

The topic is relevant also from the point of view of the trends in the present video gaming market. Vast majority of commercial computer and video games are being developed to take advantage of the internet and/or real-time gaming (see, e.g., games like Harry Potter and the Prisoner of Azkaban – http://harrypotter.ea.com/hppoa/; The Sims – http://thesims.ea.com/; Microsoft Flight Simulator 2004: A Century of Flight – http://www.microsoft.com/games/flightsimulator/; Rise of Nations – http://www.microsoft.com/games/riseofnations/; City of Heroes – http://www.cityofheroes.com/; Civilization III – http://www.civ3.com/; or almost any of the new best selling games).

This report offers some explanations why real-time gaming (or continuous gaming) seems to be so fascinating from the entertainment point of view. At the same time the report provides some classifications that can be taken into consideration when designing interactive, time bound simulation games. Most of the examples of the report are from the business gaming context but the principles described here are as well applicable in any other gaming context.

This report is structured as follows. We will first briefly discuss the changes that have taken place in the organizational decision-making environment. After the environmental discussion we will concentrate on the time dimension of organizational work and decision-making. This is done by introducing three recent classifications of time: Mapping Activities on Time (Ancona et al., 2001), Functional Roles of Time (Lee and Liebenau, 1999), and Dimensions of Temporality (Lee, 1999). After having introduced these classifications we will analyze what are the implications of the different classifications of time for simulation gaming. We also discuss how decision-making differs between the different game processing alternatives. Before introducing conclusions we theorize about continuous gaming as an experiential learning experience and complexity in the context of continuous gaming.

Our conclusions are that the continuous processing element of gaming is capable of helping the participants to see how the different business processes elaborate, emerge and are linked together.

2. Changes in the organizational environment

Businesses today often operate in competitive environments that are increasingly turbulent and unpredictable (Drucker, 1997; Eisenhardt and Brown, 1999; Beer and Nohria, 2000). Karin and Preiss (2002) note that business processes have various interactions, which have changed as the business world has moved from a static to a dynamic environment. Interactions have become more bi-directional (compared to mono-directional) and they extend over a longer period of time and often deal with external situations. Market conditions that change with time are influenced by more environmental factors than before. This has brought about drivers for the business processes (Karin and Preiss, 2002), like multi-modal inter-process interactions and dynamic, time-dependent business processes.

Figure 1 (Karin and Preiss, 2002) shows a diagram of an iterative managerial process. It includes intake of information, analysis, decision and action. This creates a decision loop where information is transmitted once in a decision period, instructions are given and for the remainder of the period the actions taken do not change. Figure 2 (Karin and Preiss, 2002) shows the same decision loop as a continuous dynamic process, where information is continuously gathered, decisions continuously reviewed, and the ensuing courses of action change continuously.

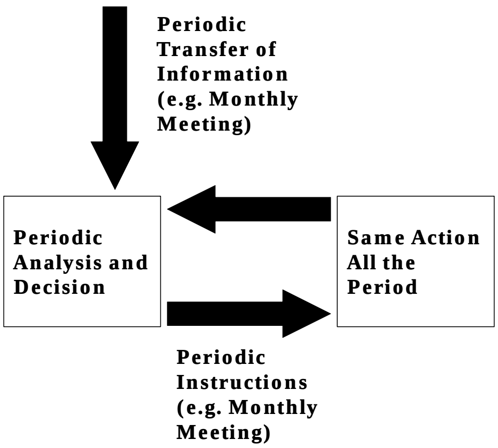

Figure 1: An iterative managerial process (Karin and Preiss, 2002)

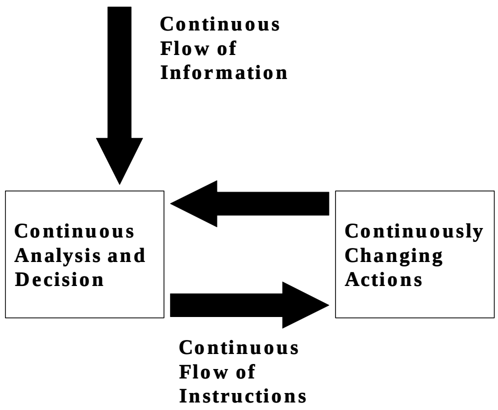

Figure 2: A continuous dynamic managerial process (Karin and Preiss, 2002)

Karin and Preiss (2002, p. 65) verbalize the change in the environment:

> *When Figure 1 applies to business situation, the business model is piecewise static. Static because over one decision period the operational plan does not change, piecewise because at the end of a decision period the plan changes suddenly. When Figure 2 applies, the business model is dynamic – for example, suppliers to supermarkets that are required to replenish stock at least twice a day, according to sales data. Such a supplier continuously monitors the sales at all branches of the client supermarket… The variables in this example, such as quantities to be stocked, are both continuous and dynamic. Continuous, because the values take continuous values, and dynamic, because the values of the variables change with time.*
>
> *In the past, the scenario above could have been expressed by a discrete and static variable. Imagine that the supplier takes orders once a month to supply goods to a customer order in only four lot sizes: small, medium, large and extra large. The variable describing the quantity to be supplied is then a discrete variable, having only four possible values. It also is static, since once specified it remains unchanged for a month.*

The above example distinctly defines the difference between batch-processing and continuous processing in simulation gaming. It also has similarities with different organizational models. As external forces associated with environmental turbulence and the timing of organizations' responses under such conditions have become crucial to firm survival (Scott Morton, 1991; Waller et al., 1999) there is no reason why organizations would necessarily continue in their present form. While bureaucratic organizations once dominated many aspects of society, most of them are in the process of being reshaped along with the changing demands and challenges of the world around them (Morgan, 1989). Ghoshal et al. (1999) state that machine-like systems or control are not helpful in a situation where the most important corporate resources are not financial funds in the hands of the top management but the knowledge and expertise of the people on the front lines. As a result, newer forms of organization appear that are much more like networks than hierarchical structures. The organization is much more like a network of interaction than a bureaucratic structure (Morgan, 1989).

Morgan (1997) introduces a continuum describing the relationship organizations have to their environment. Morgan argues that when the change in environment becomes the order of the day, open and flexible styles of organization and management are required. Table 1, modified from Morgan, illustrates extreme patterns of organization and management in organizations experiencing different rates of environmental change (the original Morgan table includes four different classes of change rates; we have included only the two extreme classes).

Nature of environ-ment	Stable environment: technological and market conditions well understood.	Highly unpredictable: rapid technological advance and boundless market opportunities.
Organi-zation of work	Clearly defined jobs arranged in hierarchical pattern. Interdepartmental communication and coordination are often poor, and people have a myopic view of operations: no overall grasp of the situation facing the enterprise as a whole.	Deliberate attempt to avoid specifying individual tasks; jobs defined by the individuals concerned through interaction with others. An organization of interrelated subsystems. Individuals belong to groups or departments that belong to larger organizational divisions. Stresses the importance of being able to scan and sense changes in task and contextual environments, of being able to bridge and manage critical boundaries and areas of interdependence, and of being able to develop appropriate operational and strategic responses.
Attitude towards the environ-ment	*More or less ignorant about the role of the environment: a closed system that can be designed as clearly defined structures of parts. Goals predetermined, not designed for innovation => Great difficulty in adapting to changing circumstances. May lead to: "Wrong thing well" or "Right thing too late".*	*Open systems best understood as ongoing processes rather than as a collection of parts. Attention devoted to understanding the business environment defined by the interactions with customers, competitors, suppliers, and so on.*
	MECHANISTIC ⟵⟶	ORGANIC
	Organizations as Machines; Taylorian View	Sociotechnical View; Organizations as Open Systems

Table 1: Extreme patterns of organization and management in organizations experiencing different rates of environmental change (adapted from Morgan, 1997).

The dominant method of running business games has been batch-processing. In batch-processing the game participants create a 'budget' for the next term to be simulated. Then the simulation is run as a black box, meaning that the participants cannot see the processes taking place within the simulation. All they can see are the results from the simulation. For us batch-processing follows the mechanistic view of organizations. The batch-processing decision-making process is a budgeting process, where the top level corporate decision-makers make the decisions on behalf of the whole organization.

Continuous processing – or real-time processing – means that data will be maintained on-line and data will be updated as events occur. Thus, the participants are able to follow operations as soon as they take place. They are also able to enter decisions when ever they choose to. Furthermore, decisions can be made on a one by one basis and no batches are needed. In continuous processing the participants can be part of the business processes which evolve as the time proceeds. The decision-making may start from the operational level. The dynamics between different organizational tasks and functions can be explicit as the participants are able to see every phase in each process.

Next we will introduce some classifications of time and then later discuss these classifications in the context of gaming.

3. Classifications of time

A key element in organizational decision-making is time, or the progress of time and the ability to live with it. In that sense it is surprising how little has been written about time in the field of management and organization. By 1988 Bluedorn and Denhardt (1988) find only three major reviews of time and organization. The small amount of research on time is striking since time is a key point in understanding organizations (Lee and Liebenau, 1999). Time is often considered as natural and taken-for-granted, requiring no explanation. However, there has been a clear understanding that time is closely related to organizational productivity and that time can be viewed as a resource to be managed. Time is considered one of scarce resources, one to be measured and manipulated in the interest of organizational efficiency and effectiveness. One of the most difficult problems in organizational management is to bring objects to the right place at the right time. Bluedorn and Denhardt (1988) quote Moore [1](p. 8):

> *Thus one element of temporal ordering is synchronization. Other activities require that actions follow one another in a prescribed order; thus sequence is a part of temporal order. For still other activities, the frequency of events during a time period is critical; thus rate also is one of the ways that time impinges on social behavior.*

Bluedorn and Denhardt (1988, p. 304) argue: *The problem of rate, sequence and synchronization are central to the understanding of time as an organizational resource*.

Today many groups in organizations must adapt their pacing of task behaviors quickly to changes in time resources[2] . Barkema et al. (2002) found out that besides the speed of organizational processes and activities, also the pace of activities is an important factor. Different organizational processes require different paces and the management challenge is to discover and manage the optimal temporal progression of various processes. Also, time is not

[1] Moore, W. (1963). Man, Time and Society. Wiley, New York.

[2] Note that determining time as a resource is not without problems – e.g. you cannot buy extra time - but here we have used the terminology by Bluedorn and Denhardt (1988). Lee and Liebenau (1999) also call time a resource

evenly distributed. For example, project work groups steadily increase attention to time as deadlines near (Waller et al., 2002; Gersick, 1989). We will next introduce three different classifications of time. These classifications will later be used when we analyze the implications of time to simulation and gaming.

Mapping activities to time

We will now introduce an underlying structure for how activities can be mapped on time. This categorization creates the basis when we want to assess gaming tasks and events in simulation gaming environments. For this we use the classification by Ancona et al. (2001) who divide variables of time (variables through which the time phenomena can be described) in three categories. These categories are Conceptions of Time, Mapping Activities to Time, and Actors Relating to Time. Here we concentrate in the second category, **Mapping Activities to Time**, which has clear implications for the decision-making in time depended environments like continuously processed simulation games.

In the **Mapping Activities to Time** category activities or events are mapped to time. Examples include rate, duration, allocation, scheduling, and entrainment. Many variables in this category involve an explicit and deliberate creation of order. These variables are divided into five subcategories. We will now treat those subcategories that are relevant to decision-making in a simulation gaming environment. We will also later in this report discuss how these subcategories relate to batch-processing and continuous processing. Although the term is not mentioned, Ancona et al. actually describe a succession of dependent events as business processes.

In **single activity mapping** the concern is on how an activity is positioned on the continuum – its scheduling. The focus is on the rate at which the activity occurs on the time continuum; how long the activity lasts. Figure 3 shows how single activities can be mapped on time (1a and 1b). Both of the cases in Figure 3 have a specified duration. In case 1a, the activity occurs early and has a constant pace. In case 1b, the activity occurs later and has a more irregular pace of completion. A typical example of this kind of increasing intensity is a situation where a deadline approaches and a workgroup is motivated to pay more attention to time (Gersick, 1989).

In **repeated activity mapping** (Figure 3; 2a, 2b, and 2c) an activity is repeated multiple times. In a simple repetition or cycle the activity takes place and begins again (case 2a). More complex forms of repetition include characteristics like the rhythm with which the activity is repeated, the frequency of that repetition, and the interval between repetitions of the activity (cases 2b and 2c).

In **single activity transformation mapping** (Figure 3; 3a, 3b, and 3c) a qualitative transformation changes the old activity into a new one. In case 3a, a transformation occurs at the temporal midpoint and alters the form of activity. In case 3b, an imposed deadline forces an increasing pace of activity as the deadline approaches. In the transformation process there can also be development patterns, which have a form of different stages (e.g. a lifecycle) (case 3c).

In **multiple activity mapping** (Figure 3; 4a, 4b, and 4c) activities have a relationship between each other. In this kind of construction, the concern is the amount of time that must be distributed among multiple activities. Another variable connected to multiple activities and their mapping to time is ordering or the sequence of activities. When two activities conflict, one activity may be rescheduled. In some instances, synchrony is based on a relationship between starting and ending times with no overlap (case 4a). Activity mapping can also involve perfect synchrony or concurrence, where the activities occur at the same time (case 4b). Synchrony can also indicate a relationship between an activity's beginning and end times but with overlap among activities (case 4c). People in a polychronic culture value engaging in several activities or events at the same time. Conversely, people in monotonic cultures prefer to engage in one activity at a time (Bluedorn and Denhardt, 1988). By jointly holding a polychronic view of time, members of a given culture see the world and interact in a particular manner. A polychronic group maps many activities simultaneously on its temporal map, whereas a monochronic group maps these activities sequentially, one following another (Waller et al., 1999).

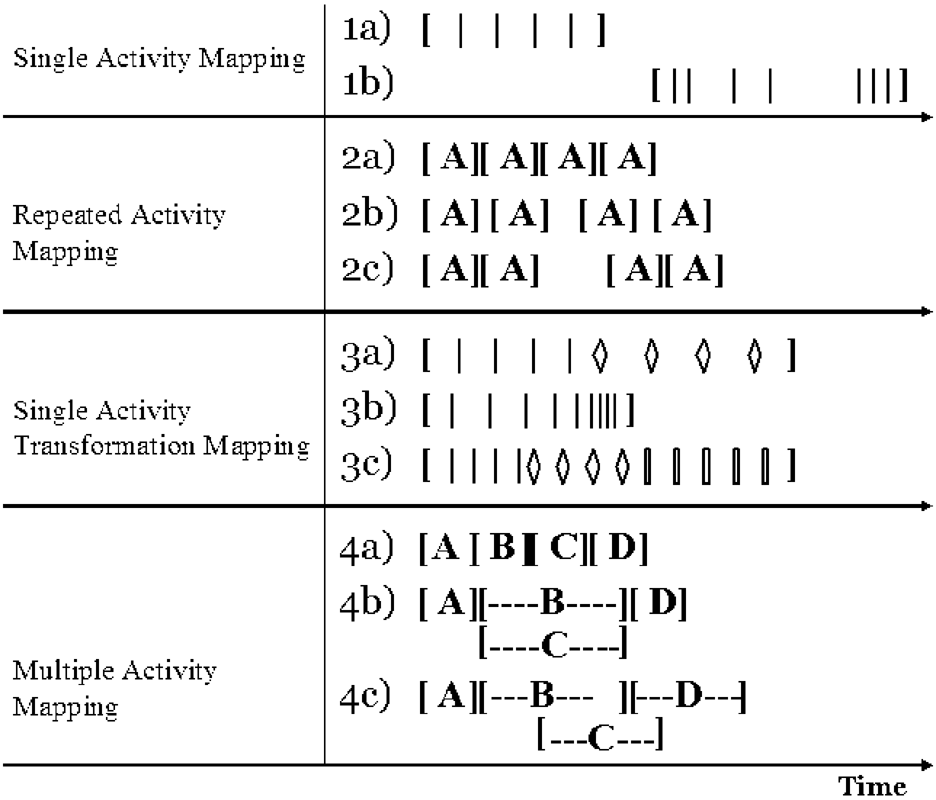

Figure 3: Mapping activities to time (adapted from Ancona et al., 2001).

Functional roles of time

We further give a second classification of time, the functional roles of time (Lee and Liebenau, 1999). Here we can find two separate roles for time. When time takes the role of an **independent variable**, the focus is on the impacts of temporal factors on various organizational processes. Here the study concentrates on various temporal factors affecting various aspects of individual, group or organizational behavior. For instance, how does time pressure affect individual problem-solving performance? Time can also play the role of a **dependent variable**, when we raise questions of how various organizational factors affect the way individuals conceptualize, experience and use time, and how those factors may alter the temporal patterning of behavior. The application of the functional roles of time is discussed more in detail later in this report.

Dimensions of temporality

As the last concept on temporal issues, we briefly introduce the six dimensions of temporality of business processes (Table 2; Lee, 1999). Without going into details it is quite obvious that batch-processing and continuous processing in games differ from each other in respect of all these dimensions. To take one example, the sequence dimension, batch-processing gives the participants a possibility to adapt to a monochronic way of working, thus performing one task at a time. In continuous processing the work is more polychronic, demanding attention to be given to several tasks in parallel. However, this matter is discussed more in detail later in this report.

Dimension	Definition
Duration	The amount of time spent to complete a task or an activity.
Temporal location	The location of activities and tasks at particular points over the continuum of time; when they take place.
Sequence	The order in which activities and tasks take place.
Deadline	The fixed time by when work is to be done.
Cycle	The periodic regularity in which work is completed repeatedly.
Rhythm	The alternation in the intensity of being busy.

Table 2: Six dimensions of temporality of business processes (Lee, 1999).

Implications of time vs. processing methods

We acknowledge the need for learning tools which represent realistic and complex models of reality, are authentic, facilitate continuous problem solving and meaningful learning, and embed learning in social experience. The classifications explicated earlier shape our conceptual model of how realism should be acquired and embedded in simulation gaming environments.

The problem with batch-processing is put forward by Feinstein et al. (2002, p. 736):

> *The greatest weakness of these games is their inability to provide the learner with a dynamic environment. Time, in essence, stands still while the teams are implementing their decision strategies. Then, time jumps forward at the end of each round. Although players are under a time deadline and decision time might be included in the adjustment of variables, players cannot observe the impact interactions of their decisions with external and competitor variables until the round is complete. Further, creating what-if scenarios is extremely difficult. Decisions are made based upon what happened in the last rounds, not what is happening at the time.*

However, Feinstein et al. do not hypothesize with the possibility of continuous gaming but, instead, suggest continuous event computer simulations as training devices. Rather few scholars discuss continuous processing as a game processing alternative and even fewer scholars discuss examples of these. Examples of authors theorizing continuous processing are Churchill (1968), Patz (1990), Thavikulwat (1996), and Lawrence (1997). Some authors giving real examples of computerized continuously processed games are Chiesl (1990) and Gray (1995). See Lainema and Makkonen (2003), for a discussion on most of these.

The time dimension of organizational activities is problematic in traditional batch-processed business games because in batch games processes are hidden, as all the participants can see is aggregate level information from the last run period. The time dimension of decision-making is not realistically embedded. This means that both the process view and the time bound nature of decision-making are missing. Batch-processing describes decision-making as a process where information is perfect and the time used in reacting to changes has no significance.

Batch-processed games are tools that most often function on the strategic decision-making level, representing centralized decision-making on the highest level of an organization. This is a mechanistic view of organizations as systems that can be designed as clearly defined structures of parts. Also, batch-processing represents stagnant momentary views. This presents some problems from the point of view of representing the learning context in an authentic way as batch-processing does not introduce the complex, time bound nature of real world organizational functioning.

Applying continuous processing in gaming gives possibilities to present organizations as open systems which emphasize the nature of organizations as ongoing processes within its environment rather than as a closed collection of parts. In reality also the diminishing time available for decision-making forces organizations to act without perfect information about the background factors. Continuous processing gives opportunities of representing business processes on transaction specific level. We will now elaborate more on the differences between batch- and continuous processing. Following we will make a synthesis of the different time classifications.

Synthesizing the mapping activities to time classification

From the temporal point of view batch-processing offers a cyclical process which normally has a constant pace, though the pace can sometimes also be made shorter or longer between the activities. Referring to Ancona et al.'s (2001) temporal classifications, batch-processing corresponds to the repeated activity mapping of Figure 3, represented here as Figure 4.

a) **[A][A][A][A]**

b) **[A] [A] [A] [A]**

c) **[A][A]   [A][A]**

→ **Time**

Figure 4: Repeated activity mapping, possible in batch-processing (Ancona et al., 2001).

Based on the different **Mapping Activities to Time** category Ancona et al. (2001) create propositions which describe the distinction between the two possible decision-making categories relevant to simulation and gaming. One proposition is based on mapping a repeated activity to time. They state that (p. 524) *here the goal is to do the same thing over and over in an organization, often at the same time each year. An example would be budgeting... When this process is finished, other activities replace it, but the same process is repeated the following year in a predictable, cyclical manner.* The important focus is on replicating the same process in each iteration of the activity, in a manner consistent with a cyclical view of time. Ancona et al. then state another proposition: *A task described by repeated activity mapping is highly congruent with a culture based on cyclical time* (Ancona et al., 2001, p. 524). Present business games represent this kind of a cyclical process.

When Ancona et al. (2001) move to multiple activity mapping, they note that a level of complexity is added since this category must include the temporal characteristics of each activity, as well as the interplay across activities. In this case activity maps are short-term projects that need to be done as soon as possible. The maps describe how time is allocated to the most pressing projects. Mapping includes multiple activities that are all fast paced and have short-term time horizons and short cycles. The interdependence of activities in multiple activity mapping sometimes requires rescheduling of activities, allocation of time across activities, and ordering of the activities to ensure the correct prioritization of work across projects. Based on this argumentation they, again, give another proposition (p. 525): *A task described by multiple activity mappings that contain fast-paced, short-term, short-cycle activities that are frequently rescheduled and reallocated is highly congruent with the individuals having a high sense of time urgency, a present time orientation, and a short-term time horizon*. Present batch-processed business gaming seldom – if ever – present this kind of organizational environments.

However, continuous processing is also able to represent all the other activities described in Figure 3. Some examples:

- Single activity mapping: we have received a big order which should be delivered by the delivery due date. As this date approaches, we have to pay increasing attention to ensuring that our production will meet the deadline.
- Repeated activity mapping: raw material purchases in continuous processing can take place like in a) and b) classes of Figure 3. Usually an organization aims at maintaining its raw material purchases constant, but in the times of a sudden demand in finished products the purchases have to be hastened.
- Single activity transformation mapping: an example could be the process of transforming the raw materials to semi-finished products and then to finished goods.
- Multiple activity mapping: besides the materials process, in continuous processing the participants also have to take care of funding, selling activities, productivity follow-ups, and so on. These different activities do not necessarily follow the same pace: some may be non-stop activities; some may require attention at long intervals.

We find support for our aim of representing the flow of time and business processes from Teach (1990). He notes that while business simulation designers like to comment on how realistic their games are, the truth is that very few simulations are even close to reality. Teach finds two reasons for this. First, shackling of decision-making to the reporting or accounting cycle (pp. 114-115):

> *How realistic is it to have simulated clock stop, to have perfect financial and operations statements be made available, and to have all the marketing research that was requested, regardless of its difficulty, be made available at the end of the last day of the period? Another ridiculous situation is that every firm receives their data at the same time and no further competition takes place until all participants make either new decisions or have repeated old ones, again all at the same moment of time.*

The above statement by Teach supports the concept of continuous processing which makes the flow of time transparent/explicit. The second reason Teach finds concerns the aggregate level information of business gaming. Teach's comment on this supports directly the aim of representing business processes and transaction specific level of information (p. 115):

> *If one quizzes a simulation participant who has not had previous business experience about an invoice, it becomes apparent that few have any comprehension of the importance of such a document, or even its very existence…. A famous quote states, "I know one half of my advertising dollars are wasted, but I just don't know which half." This statement has no relevance to current business simulation players. Business simulation players never develop the concept that company sales are the result of many individual transactions, and that manufacturing is a complex, but controllable process. Today's powerful desktop computers and the availability of easy-to-use database software make transaction-based simulations a real possibility.*

Synthesizing the functional roles of time classification

Our next comment on the time aspect is based on the two **functional roles of time** by Lee and Liebenau (1999), introduced earlier. In continuous processing time is an independent variable as it flows independently of how the participants of the game act during the game. Time is conceived as **clock time** and time determines or influences the behavior of the participants. Thus, we could well examine the effects of clock time on various behavioral phenomena. Lee and Liebenau note that differences in human time orientations may cause organizational integration to be problematic unless it is properly recognized and managed. For example, the members of both production and sales departments tend to have short time orientations. In contrast, scientists in an R&D department have longer time orientations. Another example; the greater the time pressure, the more vigorous the search for alternatives becomes, and selective perception is the most acute where time pressure is the highest.

In batch-processed games, this is not exactly the case. In batch games time is probably also regarded as an independent variable, but not in the clock time sense but more as a concept of social time (Lee and Liebenau, 1999). Time may exist in many variations according to the individual in question. Lee and Liebenau use the concept of **event time** (Clark, 1985[3]) as an opposite to clock time. Event time flows unevenly and discontinuously, and contains varying levels of contingency. Event time is not absolute and individuals may have their own time by this definition. Considering this, it would seem that continuous processing and batch-processing also provide a different kind of learning experience.

Synthesizing the dimensions of temporality classification

Re-referring to Lee (1999), it is quite obvious that batch-processed and continuously processed games differ from each other in respect of the six dimensions temporality of business processes (Table 2):

- **Duration dimension**: Continuous processing probably gives generally less time to be spent to complete tasks and activities, making the experience more time urgent and maybe also forcing the time horizon of the participants to be shorter. This is not a direction without problems as it will cause problems on the higher levels of decision-making. This is also the reason why the execution of continuously processed learning environments must be halted every now and then during the training sessions to give the participants an opportunity to thoroughly analyze the situation and properly create new plans to be implemented on a mid- and long term basis.
- **Temporal location**: In continuous gaming events and tasks take place both simultaneously and in succession, thus, there is no clear temporal structure of events and decision-making as often is quite clearly in batch games.
- **Sequence**: In continuous gaming the sequence of activities is more complex, as already described earlier and will further be discussed in section *Complexity in continuous gaming*. Batch-processing gives the participants a possibility to adapt to a slightly more monochronic way of working, where tasks are performed more in a manner of one task at a time, although functional management tasks are integrated on a general (strategic) level to one set of decisions. In continuous processing the work is more polychronic, demanding attention to be given to several tasks in parallel. Thus, the game events, resources and information are managed continuously; their flow is not intermittent as in batch-processing.

[3] Clark, P. A. (1985). A Review of Theories of Time and Structure for Organizational Sociology. In Bacharach, S. B., and Mitchell, S. M. (eds.) Research in the Sociology of Organizations, pp. 35-80, Greenwich, CT: JAI.

- **Deadline**: In continuous gaming the nature of deadlines differs from the deadlines in batch games. In batch games the only deadline is the deadline for the whole decision batch, defined by the game operator. In continuous gaming the deadlines are clock bound and set partly by the decision makers (for example, in the sales orders the players promise a certain delivery time for their customers and are then bound to deliver their goods according to this) and partly by the environment (the customers may order when ever they decide and then the players need to answer to his in time). This is a key difference between batch- and continuous processing.
- **Cycle**: In batch games the periodic regularity in which work is completed is clear; it is the period of simulating one cycle from decisions to results. In continuous gaming the cycles, again, are simultaneous, successive, their frequency may be very fast, and they are not necessarily regular. Again, this is a key difference between batch- and continuous processing.
- **Rhythm**: In continuous processing the alternation in the intensity of being busy may vary considerably. In batch-gaming the intensity is probably more stable.

4. Decision-making in the processing alternatives

In this section we will explain more concretely our experiences on the time aspect of REALGAME (Lainema and Makkonen, 2003), a continuously processed business game we have experimented with. The following conclusions and arguments are based on some 40 REALGAME gaming sessions, both in university and business organization settings.

From the temporal point of view batch-processing offers a cyclical process which normally has a constant pace. Referring to Ancona et al.'s (2001) temporal classifications, batch-processing corresponds to repeated activity mapping of Figure 4. Continuous processing, as time bound processes, is also able to represent all the other activities described in Figure 3. Our own interpretation of the time aspect is described in Figures 5 and 6. Figure 5 describes the batch-processing process. Each black square representing a task – an aggregate level of a task in this question (like planning a raw material purchase budget for a period). During the decision-making period the participants plan an aggregate level decision for each of these functions/tasks. Then these decisions are fed into the simulation model. During the simulation, these aggregate figures affect each other and as a result, the simulation model gives out some end values to be used during the next decision-period.

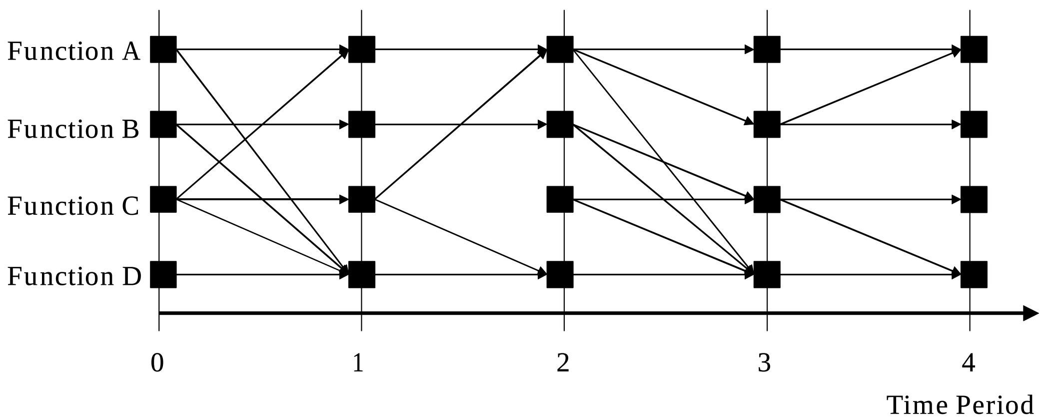

Figure 5: Participant decision-making tasks (aggregate level of tasks) in batch-processed games: one decision during each period within one decision-making task.

Figure 6 describes decision-making in a continuous game (compare to Figure 3). When the game is on, decisions are made continuously. These decisions are possible on the atomic, transaction specific level. Furthermore, there may be several simultaneous similar kinds of decisions. For example, the player continuously scans the raw material inventory. Whenever any of the raw materials inventory values needs supplement, a raw material order is made. These single, basic level decisions trigger other events or decisions. For example, a raw material order triggers a payment after the payment time (thus, the order is marked in the accounts payable and later this leads to a cash transaction) and an inventory value increase after the transportation time.

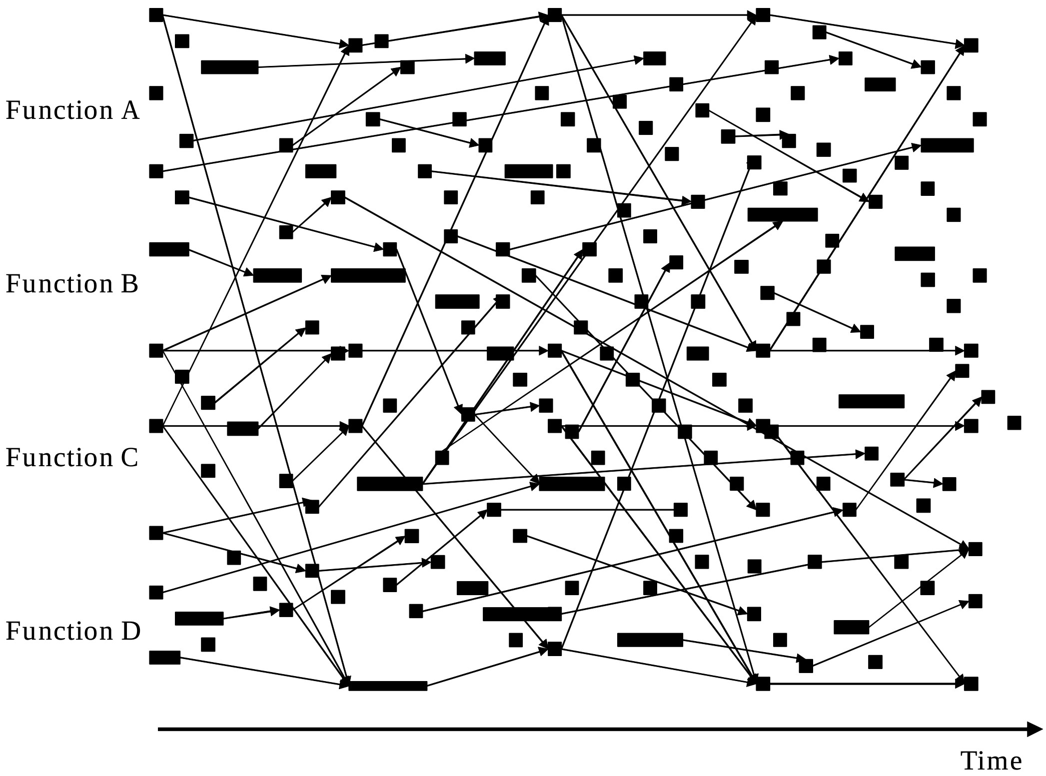

Figure 6: Participant decision-making tasks (transaction level tasks) in a continuous game: possibly several separate decisions on each functional decision-making level executed continuously during the game run.

The main difference between the two modes is that the continuous model reveals the process nature of business operation, explaining in a transparent form each particular phase within a certain business process.

REALGAME offers a bottom-up view on business activities instead of just a top view of business activities by introducing decision-making on the operational level. In the business game this means different phases of game clock speeds (see Lainema and Makkonen, 2003). Table 3 replicates some of the characteristics of organizations as open systems from Table 1 and explains how these characteristics are show in REALGAME.

Characteristics of continuous processing	**How shown in REALGAME**
Close to an open system view: best understood as ongoing processes rather than as a collection of parts.	The order and structure of participant operations and decisions according to which the game should be played is not fixed. **Events take place continuously and some of them in an unexpected order**. For example, the participants are not able to know in advance when customer orders take place. Furthermore, several processes are ongoing at the same time, each evolving according to its own phase: each customer transaction from order to delivery and payment; material flows from suppliers through manufacturing to delivery; product quality development/erosion as a dimension of time, cash flow development as a function of almost all the tasks taking place throughout the game company internal and also external environment, and so on.
Decentralized decision-making, also on the operational decision-making level, close to the actual action.	The game represents decision-making on the very operational, transaction specific level (meaning handling single customer transactions; not aggregate): ordering raw materials, answering to customer orders, sending deliveries, selecting delivery methods, turning on/off production tasks/cells, and so on.
Continuous; the view is continuously evolving representing the process nature of business operations, on a transaction specific level.	Instead of momentary states at the end of fixed decision-making periods, continuous processing presents the flow and evolution of processes from the very first step to the last one, not missing intermediate phases. For example, the players can witness how their raw material purchases – as a function of time – are transported from the supplier to the inventory, are taken from the inventory to be used in production, are transformed while flowing through production cells to more developed semi- and final products, and end up in the inventory waiting to be delivered to the customers.
Process, bottom-up.	Business processes (materials handling processes but also processes which deal with sales, product development, monetary transactions, and so on) form the core business activity. Aggregate information can be produced based on the processes (from bottom to the upper levels), but the participants are always able to return to the transactional level of information.
Process -> Outcomes.	As the game builds on processes and the transactional level of operations, the participants are able to see the chain from decisions/events to their outcomes. Thus, this connection is transparent or visible, not a black box as in batch-games. However, to be able to form a conceptual map of the game processes the game participants need to observe the game events and conclude the actual structure of the processes. This demands pattern recognition from the part of the participants.

Table 3: The characteristics of continuous processing in REALGAME.

5. Continuous gaming as experiential learning

Experiential learning is the traditional view of learning used to argue about business gaming. In gaming the participants act as decision-makers and see the consequences of their decisions. Gaming represents learning which is based on multiple circular cause-effect relationships and in which time is accelerated so that the link between a decision and its outcomes becomes explicit. In REALGAME this includes intricacies of time delays and spatial scattering of decisions. The participants face here-and-now concrete experience and learning is based on feedback processes.

Then, how does REALGAME fit into this picture? There probably is no doubt that REALGAME is an experiential learning environment: it provides experience and feedback. REALGAME, however, is radically different from conventional business games in respect of the nature of this experiential cycle and in respect of what kind of experiences it provides. **First**, during the game execution the cycle of experience in REALGAME does not include clear *separate* phases of Concrete experience, Reflective observations, Abstract conceptualization, and Active experimentation (Kolb, 1984), but there are several cycles taking place simultaneously. In a conventional business game there is a more clear experiential cycle in the form of separate phases of Mental models, Strategy and decision-making, Virtual world (the business game model), and Outcomes and evaluation (Isaacs and Senge, 1992). Each of these phases mainly takes place separately from each other, although mental modeling, strategy and decision-making become intertwined during the process (Figure 7). In REALGAME there are several experience cycles going on at the same time (Figure 8). For example, while the players have sent new sales offers to the market (i.e. phase Decision-making; have not yet received any information about the reception of those offers) they may at the same moment be experiencing the results of an old marketing investment (i.e. Outcomes and evaluation). This may be one reason for the observation that the participants immerse very deeply in REALGAME playing, according to our experience and interpretation more deeply than they use to do in conventional business gaming (Lainema and Nurmi, 2003).

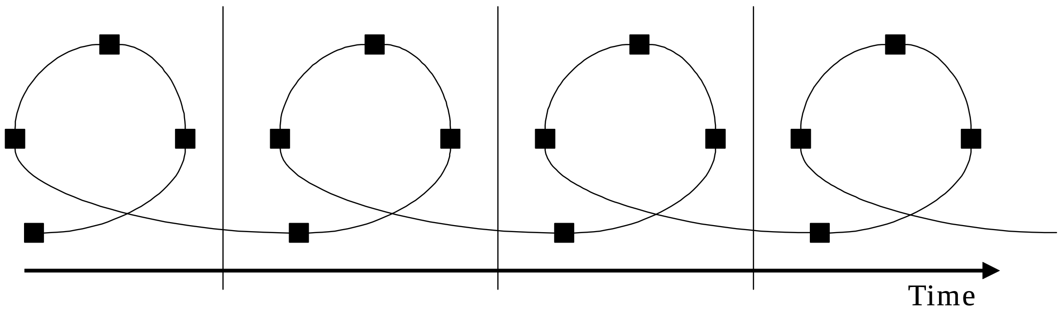

Figure 7: The experiential learning cycle in a batch-processed game.

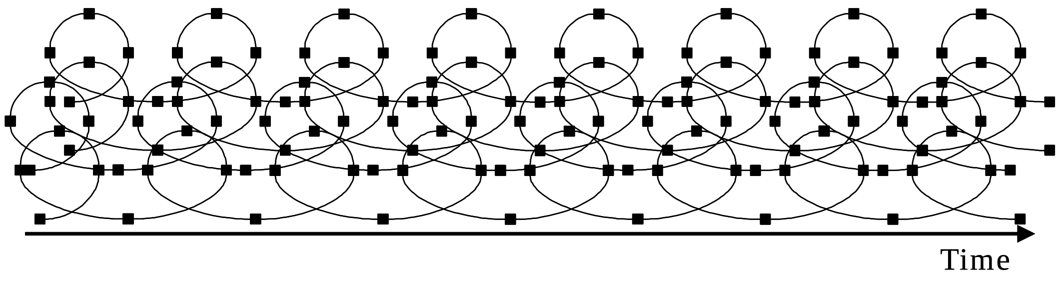

Figure 8: The experiential learning cycle in a continuously processed game.

Second, the flow of these experiential cycles is independent, thus, time flows independently of how the participants of the game act during the game (in Figure 7, the cycles are paced according to the decision periods; in Figure 8 the cycles are mainly dependent on the flow of time). Time is conceived as *clock time* and time determines or influences the behavior of the participants (Lee and Liebenau, 1999). If differences in human time orientations may cause organizational integration to be problematic (as Lee and Liebenau, 1999, suggest) then this might also be the case of the REALGAME experience compared to batch-gaming. The greater the time pressure, the more vigorous the search for alternatives becomes, and selective perception is the most acute where time pressure is the highest. This certainly would suggest that the learning experience is very different between the two modes.

In batch games time is probably not regarded in the clock time sense but more as a concept of social time (Lee and Liebenau, 1999). In batch-games time is probably experienced more as *event time* which is an opposite of clock time. Event time flows unevenly and discontinuously, and contains varying levels of contingency. This seems to indicate that continuous processing and batch-processing also provide a different kind of learning experience.

Another issue concerns REALGAME as part of an **organization's learning process**. Here we do not see that much difference between the two processing modes. Whatever the processing method, the role of the learning environment is the same. An experiential learning environment should function as a shared frame of reference where participants can test their mental models, to see relationships between various business decisions and potential outcomes. The insights gained from experience with these activities may be transferred to an organization when participants face situations that remind them of similar challenges faced in the simulation. Experiential environments should foster shared understanding of complex organizational processes and systems.

6. Complexity in continuous gaming

Complexity has not been a research topic in our studies. However, complexity is an issue, which regularly pops up in the comments of the game participants when they describe the game environment. Complexity is almost always mentioned in a positive manner. We believe that complexity is a topic more relevant in the context of REALGAME than in the context of traditional business games. This originates both from REALGAME's transaction specific level of information and the continuous nature of the game.

Today organizations are routinely viewed as dynamic systems of adaptation and evolution that contain multiple parts which interact with one another and the environment. Systems thinking teaches us that what we label cause and effect are but temporary states in a web of interactions whose second- and third-order consequences come often back to haunt us. Members of learning organizations will have to envision dynamic conceptions of time/space where B leads to A or both are contingent on C. This is a relational picture that does not translate neatly into words (Mirvis, 1996). Kim (1993) argues that most efforts at mapping mental models result in static representations of phenomena which are usually highly dynamic and nonlinear. In this section we discuss why the artefact of the thesis might be somewhat different from conventional business games from the point of view of complexity.

Senge (1990) divides complexity into two types: detail complexity (e.g., many variables included in a decision situation) and dynamic complexity (situations where cause and effect are subtle, and where the effects over time of interventions are not obvious). Dynamic complexity can be found in situations where the same action has dramatically different effects in the short and the long run. REALGAME is a **continuous dynamical system which includes causality**. This kind of dynamical system includes **dynamic complexity** (situations where cause and effect are subtle, and where the effects of interventions over time and space are not obvious) (Senge, 1990). But REALGAME may include also detail complexity. We will first discuss the detail complexity issue.

The level of **detail complexity** in REALGAME depends on two factors: the specific game configuration in use and game clock speed. Through configuration the game model detail complexity can be altered considerably. Besides the production layout structure complexity can be increased by increasing the number of: market areas; customers; raw materials needed in the production; finished products produced; workers and machinery needed in each production cell; available transport methods; and so on. Even a very complex model - in respect of the number of details - can be easy to manage if the clock speed is slow. Thus, a back side of this same detail complexity is the clock speed. The faster the clock speed becomes, the more difficult it becomes to manage the details.

Here we would like to note that this combination of details and speed needs to be kept within manageable gaps, to give the participants the possibility of attaining new learning levels. Just to mention one example of REALGAME detail complexity, a REALGAME company typically after simulating some half a year of business operations may have around 5,000 rows of cash transactions in the cash flow table. Because of this huge amount of detailed cash events information the participants may face problems analyzing the reasons for the present cash situation.

Most cases in policy resistance arise from **dynamic complexity**, the behavior of systems that arises from the interactions of the agents over time (Sterman, 2001). Where the world is dynamic, evolving, and interconnected, we tend to make decisions using mental models that are static, narrow, and reductionist. The elements of dynamic complexity that are most problematic are feedback, time delays, and non-linearity. We believe that to improve our ability to learn about and manage complex systems, we need tools capable of capturing the feedback processes and time delays which are sources of dynamic complexity. A learning tool must enable us to understand how these structures create a system's dynamics.

Dynamic complexity can be found in situations where the same action has dramatically different effects in the short run and the long run. Senge (1990) mentions that the real leverage in most management situations lies in understanding dynamic complexity, not detail complexity. Examples of dynamic complexity mentioned are: balancing market growth and capacity expansion; developing a profitable mix of price; improving quality; lowering total costs; and satisfying customers in a sustainable manner.

In REALGAME, dynamic complexity arises from the characteristics of the game illustrated already in Figure 6. Dynamic complexity usually exists also in conventional business games but its nature is different from that found in REALGAME. In batch games the results of different situations/actions/events is calculated based on aggregate values. The simulation model uses the decision budget values as input and calculates the results from these based on some simple – though hidden – algorithms. Both the input and output are on an aggregate level. Single transactions are "hidden" within the aggregate values. The result is that normally the imaginary transactions – if visible at all – represent an average transaction. Thus, the model is not able to illustrate exceptional transactions which may have a significant and interesting role in a continuous model.

In REALGAME all the aggregate values are based on "real", existing, atomic level transactions. This means that the participants are able to drill down to the atomic level of events and analyze each transaction separately. This makes it possible to see reasons, for example, in difficulties in delivering or selling certain products during a certain time limit to specific customer in a certain market are.

This characteristic of REALGAME also makes the relationships between cause and effect less mechanical than in batch games. In batch games stochastic elements are based on simulation model arithmetic, but in REALGAME the players themselves may cause stochastic behavior, like when they “forget” to order raw materials, change the production cell to produce the product in demand, or deliver customer order in the order back log. Thus, the continuous transaction specific nature of REALGAME gives a new dimension in respect of change elements in the game environment.

To illustrate what we mean, we will discuss one example of business activities, sales promotion investments. In batch-gaming the game participants invest in sales promotion, the simulation is run, and then the participants are expected to analyze and make conclusions about the effect of the investment to their sales (Figure 9). This sounds quite a simple procedure though, of course, matters are not quite this simple as there are many intervening decisions and the results are often very difficult to link to the sales promotion investments. However, the process is basically of the type of input-process-output-analyze.

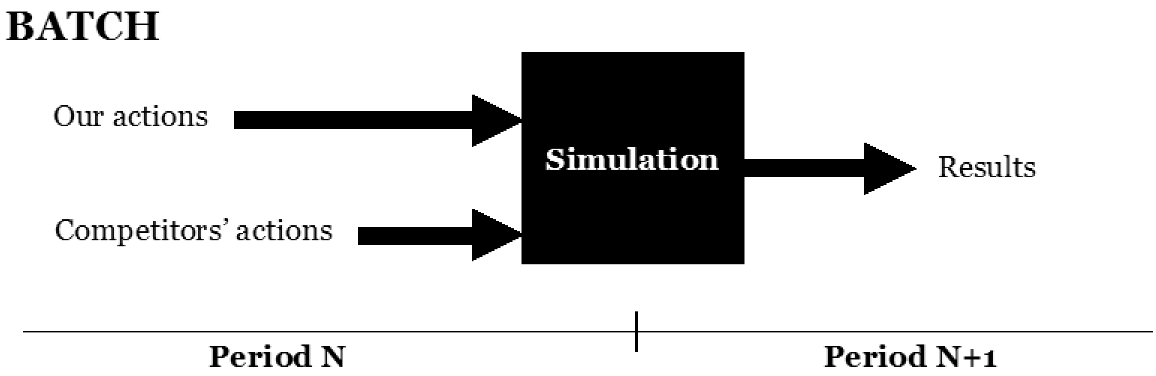

Figure 9: The characteristics of competitive investments in batch-processing.

In continuous processing, the process of investing and analyzing sales promotion is not at all straightforward. This is because of the continuous nature of events taking place. For example, companies may launch their sales promotion campaigns of different scales at different times. This kind of situation is much more complex than the one in batch-processing and becomes quite impossible to be analyzed thoroughly in the given time. Figure 10 illustrates the operation in question in continuous processing. Different companies launch their campaigns at different times, with different frequencies and with different sums (the length of the bar illustrating the amount of money invested). In the reports of the game the participants can mostly see the aggregate scale of each company’s investment but not at all that easily the point of time and dispersion of the investments. Considering all this and the fact that new investments normally do not take effect immediately, analyzing the different components and drawing exact conclusions about the whole structure is not possible. All that can be concluded is an approximation of the situation. For example, consider the situation in Figure 10 between companies 6 and N. Both of them have invested an equal amount but the investment of company 6 has had more time to take effect. Looking only at financial reports of the companies at the end of the time scale does not reveal a difference between the companies. Still, in general the investment of company 6 would have been more effective by the end of the time scale (but probably this effect ends before the effect of N’s investment).

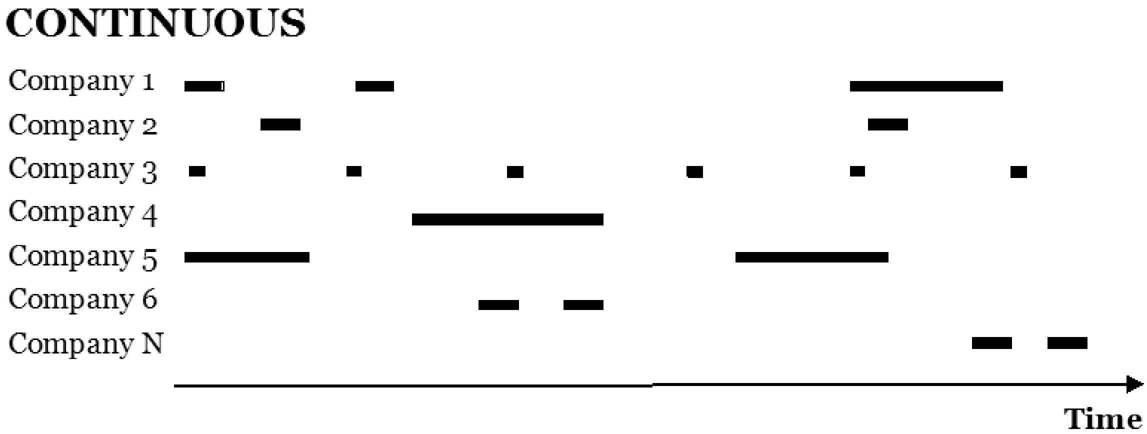

Figure 10: The characteristics of competitive investments in batch-processing and continuous processing.

Sales promotion activities are not the only type of activity functioning the way we described in continuous processing. Actually all time dependent activities affecting the competitive situation have the very same characteristics, like offers (when an offer is launched) and product development.

Senge (1990) argues that besides of seeing interrelationships rather than linear cause-effect chains, there is another issue essential for systems thinking. Also, seeing processes of change rather than snapshots is important. Here batch and continuous processing are very different. In batch processing the participants can see only a static view of the state of their company after each simulated period (see Figure 7 describing the periodic structure of a batch game). In continuous processing the view to the business model is transparent.

The value of continuous processing and dynamic complexity for the learning experience is still vague. However, the inclusion of these elements to the learning environment should be in line with the new views on learning which encourage the use of complex learning environments by arguing that students cannot be expected to learn to deal with complexity unless they have an opportunity to do so (Cognition and Technology Group at Vanderbilt University, 1992).

We have to further comment one more aspect of batch gaming. Actually, REALGAME is a batch game, but the batches are executed once an hour in simulation time. Thus, we could also think REALGAME as a highly accelerated batch game where one decision period lasts one hour simulation internal time. Following this reasoning, we could argue that batch gaming would produce similar learning experience as REALGAME if only a batch game's cyclical input-process-output cycle was accelerated considerable. However, this is not the case, as in REALGAME the events still take place on the transactional level.

As a conclusion about the dynamic complexity in REALGAME we can comment that though the basic nature of dynamic complexity between batch and continuous games is the same (cause and effect are separated in time and place), in REALGAME the number of causes and effects is much higher and are influenced more by participant actions. How useful this is from the point of view of helping participants to discover trigger points separated in time and place, remains to be studied in the future.

7. Conclusions

When assessing REALGAME, we have made explicit the underlying assumptions about time and organizations. These assumptions frame the learning environment. During the debriefing the participants feed back their experiences in forms that should be compatible with the design characteristics. This is critical when we want to assess the learning environment. The assessment of REALGAME is preliminary. Assessing learning in games is a difficult task (see, for example, Burns et al., 1990). We also want to remind what Gosenpud (1990) has found: The learner often learns things not intended by the designer, and often this unintended learning is more valuable because it is relevant to the learner. Evaluation, defined by the designer, may miss the real worth of the experiential experience because what is valuable for the learner is defined by the learner and may have nothing to do with the designer's intention. In addition, in experiential learning intended outcomes are often vague since the focus of learning is usually on very complex, abstract phenomena.

Very few business games that would include pure continuous processing have not been constructed before. But how significant is this new feature? There is some speculative literature about the effects of continuous processing which emphasize its possibilities, but as this is new research ground there is no prior research on the topic. Future research has to be done within this area. Based on observations and interviews from our previous research on REALGAME playing (Lainema and Nurmi, 2004; Lainema, 2004) we can conclude that continuous gaming provides a very intense and meaningful learning environment and context. Continuous gaming seems to maintain task-orientation well over long periods of training. The continuous processing element helps participants to see how the different business processes elaborate, emerge and are linked together, thus facilitating the formation of rich mental models, linking across different business studies, and representing the complexity of business operations.

We have noticed that what is learned through playing the game is not easy to recognize. The game participants clearly regard the gaming experience as useful, but they have difficulties in expressing what the concrete benefit from the session was. According to the participants' interviews and questionnaire answers the game helped them to construct a holistic view of the functioning of a manufacturing company, and to see the interdependencies between different business operations. In other words, the game introduced a process view of business to the participants (Lainema and Nurmi, 2004; Lainema, 2004).

Weick (1979) has commented that, as consensus grows, the views appear to be so self-evident that alternatives are rarely discussed. Then, for whatever reason, the phenomenon suddenly becomes examined in a new context which requires new units of analysis, leading in turn to the formulation of new perceptions and definitions. Batch-processing especially in business gaming seems to be this kind of self-evident phenomenon which rarely has been challenged. Continuous gaming seems to pop up every now but there is no continuity in the study of this phenomenon. Nevertheless, the simulation gaming community should have a more experimental and curious attitude towards new application possibilities. Continuous processing clearly represents one respectable possibility to take the simulation gaming discipline further.

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