Using casual loop diagramming to represent the factors affecting learning for students using a business simulation game

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Abstract

The paper explores the interactions and dynamics associated with students' learning about business strategy using a computer-based simulation game. Developed from student interviews, a causal loop diagram is presented which distills the relationships between the key learning variables. The diagram demonstrates that reinforcing behavior is at work in the learning process, with students being caught up in either a virtuous or vicious cycle of learning. A key determinant of the path followed by students is module design which is inherently linked to both students' motivation to play the game and their understanding of the associations between strategizing and resulting business performance.

Keywords: Simulation, learning, business strategy, causal loop diagram.

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Introduction and Background

Computer-based simulations are an interactive means of teaching business strategy to students in university business schools. The potential benefits of the approach include greater levels of student participation in study and a fuller appreciation of the dynamic complexities involved in running a business. However, attaining positive learning outcomes for a participating student cohort is far from guaranteed when adopting this approach. Previous research shows that games are not self-teaching and some students can become caught in a *single-* or even *zero loop* mode of learning (Moizer et al., 2006). This article seeks to explore the causal feedback mechanisms at work when a computer-based business strategy simulation game is used as a vehicle for promoting learning.

Moizer et al. (2006) argue that when teaching business strategy using a computer-based simulation game, its integration within the broader module design is critical. An effective module design is an important determinant of whether students follow a zero, single or *double-loop* learning mode (see Argyris and Schön, 1974 and Snell and Man-Kuen Chak, 1998 for an exposition of loop learning concepts). A number of issues relating to the integration of business strategy simulation games into module design are highlighted. These findings are supported within the broader simulation and gaming literature. For instance, the selection of an appropriate game, in terms of both the type of technology and the complexity of the simulation is important. A number of authors indicate that whilst high levels of complexity and verisimilitude can be achieved for a simulation game, simple games that students can master easily are often more appropriate for many student groups (Lane, 1995; Low, 1980; Burns and Gentry, 1998). Other issues identified by Moizer et al. as being potentially central include whether assessment is used formatively or summatively, how students are encouraged to learn on reflection, and how teaching is orientated towards the development of strategic thinking capabilities amongst students. Whilst all of these factors are important, and are widely referred to in the literature, there is arguably less understanding of the full causal relationships between module design and learning. In particular, there is a need to recognize that there are intervening variables captured within this relationship. Furthermore, these variables are embedded within *causal feedback loops*. *Causal loop diagrams* are an established means of mapping out these feedback mechanisms and tracing through the consequences of decisions and actions (see Sterman, 2000 for an overview of causal loop diagramming).

Through using causal loop diagramming, the intention of this study is to extend the authors' earlier work in order to gain a more complete picture of how the variables associated with student learning are interrelated. Readers interested in the literature relating to learning in the context of simulation games are referred to these earlier studies (see Moizer et al. 2004; 2006).

In the next section of the paper, the context within which the study was undertaken is described. Following this the research objectives and methods used to conduct the research are outlined. Results are then presented and discussed with reference to relevant literature. From these results a causal loop diagram is developed and explained. The final section of the paper discusses the benefits and limitations of both the study results and the method of enquiry used. Possible avenues for further research are also outlined.

Study Context

The Business Strategy Game (BSG), developed by Thompson and Stappenbeck (1998) is used to support the learning of business strategy within the University of Plymouth Business School. It is the student's use of this game that provides the focus for this study. The BSG is a total enterprise management game which simulates the high level decisions of businesses serving the global marketplace for athletic footwear. The simulation takes the form of a game which is interactive and allows participants to take on the role of Directors who manage this global concern. Participants form individual businesses and compete against each other for market share.

Decisions are made by the respective businesses over a sustained playing period which equates to several simulated years. Participants are required to submit a series of business decisions which cover activities such as the production, marketing and distribution of athletic footwear to worldwide markets. Decisions are high-level and strategic, and have a simulated time-frame of one year. The decisions are processed on an administrator's spreadsheet, and the simulation game then rolls on to another year's play. A score based on a number of performance metrics (profit, market share, capitalization, sales volume, *etc*) is determined. This results in the groups moving up or down a business league table. For this study, the BSG was run over eight decision periods with final year undergraduates reading for either marketing or business degrees.

Research Objectives and Methodology

The intention of this study is to extend previous research, in order to explore the causal feedback mechanisms associated with learning from playing a computer-based business strategy simulation. The supporting objectives are to:

- identify the key variables associated with learning in this gaming domain; and
- structure the cause-effect relationships between variables using feedback loops.

The broad research approach adopted was inductive in nature. The purpose was to allow a conceptual feedback model to emerge from qualitative insights gained from business simulation game users. Hence, the study does not aim to fully validate and empirically test a model. Rather, the emphasis is on presenting a model to stimulate discussion about the interaction of learning variables. This work will enable future deductive research investigation to be undertaken employing quantitative measurement.

In order to achieve the objectives of the research, a study was designed which consisted of three major phases:

1. Learning input phase

During this phase, students were introduced to the BSG through a briefing session. They were informed of the intended learning outcomes of the exercise, how the game functioned and how to play it. They were provided with a player's manual to enable them to begin using the game. Prior to, and during the gaming period students also attended a series of lectures on corporate strategy. Earlier lectures were used to ground the students in the subject of strategy, with later course lectures focusing more upon contextual issues in strategy. Interim feedback on the progress made by the playing teams was available after each 'yearly' gaming round.

2. Data collection phase

Data was collected through a series of debriefing sessions which were run at the game's completion. These sessions took the form of meetings with each of the twelve teams of students that took part in the simulation. The purpose of these meetings was to stimulate a student-led discussion which focused on the learning efforts that took place through playing the simulation, and the key factors influencing that learning. The data collection approach was qualitative in nature, and utilized a semi-structured interviewing approach (see Thorpe et al., 2002). Discussions were up to 30 minutes in length, and were recorded and transcribed for full analysis. The approach adopted for data analysis broadly followed the guidelines of Marshall and Rossman (1989) and Miles and Huberman (1994).

3. Model building phase

The output from the data collection phase was a set of 12 interview transcripts which were coded and reduced to produce a meta matrix

(Miles and Huberman, 1994) summarizing the key issues highlighted during each of the interviews. By comparing and contrasting the themes emerging from the reduced interview data it was possible to identify important variables that appeared to be linked to learning within the student groups. An understanding of how these key variables were interrelated also emerged. Hence, the data gathered facilitated the development of a conceptual model representing the key causal elements of the learning process. Particular emphasis was placed on representing how these elements reside within causal feedback mechanisms.

Results and Discussion

Key learning variables

Analysis of the debriefing interviews indicated that approaches to planning and team decision-making processes used were key drivers associated with learning. There was strong evidence that the planning process of five of the six groups that had demonstrated more effective learning involved 'purposeful change'. In four cases, the groups had developed formal plans and/or objectives during the early stages of the game but later switched to a more emergent approach, developing well considered responses to the evolving gaming environment. In one case, an initial emergent approach was discarded in favor of a more formal planning approach. In the case of all other groups (none of which exhibited evidence of significant learning), planning and purposeful change were far less evident. In most cases, groups adopted an experimental or responsive approach. Overall, this evidence appears to support the view that an association exists between learning and purposeful change in the strategies adopted. Evidence also exists to suggest an association between learning and an attempt by groups to strategize and apply formal planning (at least in the initial phases of the game). This lends some support to the findings of other researchers. Hornaday and Curran (1996) (who identify an association between formal planning and the performance of business simulation teams), argue that learning plays a key role in this relationship. They propose that the planning process forces the team to learn more about the simulation. Their superior understanding of the simulation is the most likely cause of their better performance. In the real world, the authors argue that the chief benefit of formal planning is the learning that takes place amongst implementers, equipping them better to respond to changing circumstances. In this study, the learning resulting from the formal planning activities of four of the teams appears to have equipped these teams with greater understanding of the game and the confidence to implement the designed or 'purposeful changes' witnessed. Thus, it may be concluded that in these cases, initial engagement in formal planning enabled the designed change to occur. This process of formal planning and designed change facilitating learning can be considered in the context of the construction of mental models. Schaub and Strohschneider (1992) contend that complex simulations require careful knowledge acquisition and the construction of a coherent and sufficiently correct mental model as a prerequisite for action. What appears to distinguish more effective learners in this study is their ability not only to create a mental model of the simulated business but also to change this model over time. In the cases where there is limited evidence of learning, there is very little evidence of the development of a shared mental model of the business. For teams exhibiting strong evidence of learning, the development of such models appears in the majority of cases to have arisen from the initial planning undertaken by the teams. In the case of the one team that changed from an emergent approach to a more formal planning approach, the experience of running the company appeared to provide the basis for the development and subsequent change in their mental model of their company. Wellington and Faria (1996), who highlight the important interactions between planning and implementation in a gaming context, state that formal planning often emerges from actions already occurring, as appears to be the case with this team.

The extent to which the student groups enjoyed playing the game appeared to have a moderate association with learning. As Walters et al. (1997) report, dissatisfaction with a business game can greatly diminish its potential as a learning tool. Three of the teams that exhibited limited learning did not enjoy the gaming experience. In fact, they perceived it to be a waste of their time. Their 'motivation' to engage fully with the game was low. The lack of summative assessment linked to the playing of the game was cited as a major reason for this. It is worth noting that in all three cases, levels of self-reported learning were low. There has been debate about the value of summative assessment of gaming participation. Some authors argue that a summative assessment of the gaming experience is an important aspect of module design (Base, Ruies and Sharpe 1986; Herz and Merz, 1998). However, others suggest that there is little or no value in using graded assessment as a motivating device (Wolfe and Roberts, 1986; Faria, 1986). The fact is that most research studies concerning the delivery of classroom based simulation games incorporate grading systems that are utilized as a matter of course. This indicates that implementers of business simulation games are either led by the expectations of their students towards summative assessment, or have designed their games' delivery in such a way that this type of assessment plays a significant motivating role. Whilst some of the other groups raised concerns over the lack of summative assessment, they all exhibited evidence of at least moderate enjoyment of the gaming experience. Adopting a critical perspective on the value of business simulation games, Neuhauser (1976) presents anecdotal evidence of a tendency for all but the most competitive students to exhibit boredom and disenchantment with simulation games as time progresses. Whilst we have noted this phenomenon, in our study we found dissatisfaction with the learning approach only in a minority of cases. However, the linkages between team motivation, team engagement and learning were apparent, whether in a positive or negative manner.

Student groups were questioned about their perceptions regarding the game's level of realism and complexity. This provided an indication of the face validity of the exercise. It was interesting to find that all four of those groups making negative comments concerning the realism of the game were amongst those exhibiting limited evidence of learning. Conversely, those demonstrating significant learning were more likely to give balanced or favorable reports relating to the realism of the simulation. Similar results emerged from an analysis of group perceptions concerning the extent to which the gaming exercise was successfully integrated with the module lecture series. Unfavorable comments were only made by three groups, and all of these exhibited limited evidence of learning. In the case of both realism and integration of the game within the module, it is important to note that negative comments may be a reflection of teams' reluctance to acknowledge their own shortcomings in playing the game. Several authors' findings support this (Wellington and Faria, 1996; Ramnarayan and Strohschneider 1997). Their studies found, not surprisingly, that the attitudes of poorly performing students towards aspects of the design and administration of the game were unfavorable, and that such teams frequently display a tendency to blame exogenous factors for their problems. Recent research has indicated that students submitting poor module evaluations are more likely to posses an external *locus of control* (Grimes et. al, 2004). Aspects of module design and game complexity clearly have an impact upon the motivation and attitudes of playing teams; but perceptions of the adequacy of module design are in turn affected by students' locus of control.

No clear associations between the extent of learning and the amount of analysis undertaken by groups could be identified. Most groups tended to apply a similar limited range of analysis techniques in a relatively unstructured and informal manner. This tendency towards limited analysis has also been recognized by Ramnarayan and Strohschneider (1997). These authors found that the students they studied were more inclined to make decisions than to seek information to support the decision making. They also noted a tendency to rely on performance figures which distracted many students from undertaking any broader form of contextual analysis. This was also apparent in this study.

Two groups did attempt to employ more advanced analysis techniques such as forecasts based on their understanding of performance and both showed evidence of greater learning. However, overall insufficient evidence exists to identify clear associations. Whilst students' approach to planning seems to be strongly associated with learning, evidence concerning the extent of analysis upon which such planning might be based is limited. It could be that the building of a strategy based upon playing experience and intuition is as effective a platform for learning as a strategy emerging from in-depth analysis. After all, the learning derived from playing a simulation is more concerned with experiential aspects of strategy (*e.g.* making decisions under pressure, responding to external shocks, tracking decision-outcome linkages, developing confidence and even understanding psychology) than the type of analytical elements of strategy that are typically taught using a case study approach. This is supported by evidence from Knotts and Keys (1997) who identify the development of intuitive skills through the gaming experience that cannot be taught with cases or textbooks. Furthermore, Tompson and Dass (2000) who also employed the BSG for their research concluded that simulations result in significantly higher learning on the part of students than do case studies.

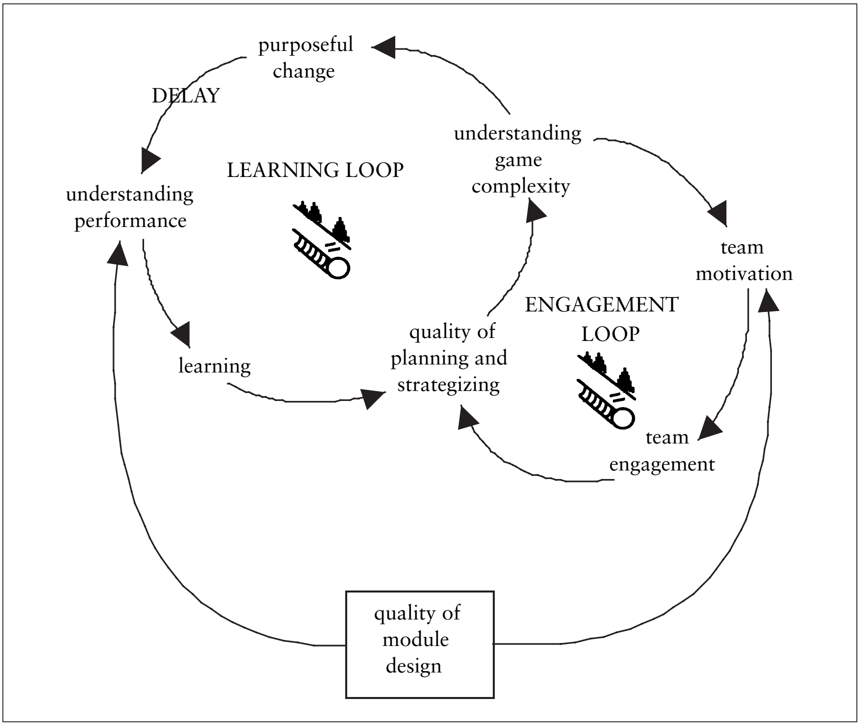
Modeling the learning process

In order to draw together and highlight the key findings of the study, a causal loop diagram (CLD) was built. CLD's are maps illustrating the cause and effect relationships between a set of interacting variables (Santos et al., 2002). They are developed following well established guiding principles (see for example, Senge, 1990).

The loop diagram shown in Figure 1 captures the dynamics of the learning that was achieved by the students in the course of playing the BSG. Rather than showing the full structural complexities of the gaming learning process, this diagram seeks to outline the key components that appear from the research results to be driving the dynamics of learning. Sterman (2000; 2001) explains that human systems have high levels of dynamic complexity, and that such complexity impedes learning. By focusing on key drivers in a system, rather than all interacting variables ones understanding of that system can be enhanced, albeit at the expense of detail. The adoption of such a high-level view of a system can enable management interventions to be more readily identified.

The CLD generates insights and understandings of how this particular student cohort learnt about developing business strategy in a controlled environment. Within Figure 1 two feedback loops exist: the 'learning loop' and the 'engagement loop'. Both are reinforcing in nature, having the effect of locking students into either a virtuous or vicious learning spiral (as represented by the snowball effect). The direction through which students trace around the loop can, in part, be governed by the design of the module of study.

Figure 1. Causal loop diagram representing gaming and learning



In adopting a business simulation game, its integration in to the wider module design is critical to successful delivery of learning outcomes. The CLD shows that good module design, all things being equal, leads to a higher level of team motivation from the onset. Examining the 'Engagement Loop', we can see that a motivated team will engage more strongly in the playing of the simulation game through for example, active group dialogue and strategic thinking. This in turn can result in better quality planning and / or strategizing by the playing teams. Through effective planning and strategizing, the students are better able to identify the critical variables (and their interdependencies) that they need to understand to play the game. They are able to manage the complexity of the game through developing a more clearly directed and focused approach to their gaming. This in turn has a reinforcing effect on the motivation of team members.

We can observe in the 'Learning Loop' that good planning and strategizing guides students through the game's complexities and provides a platform for students to instigate purposeful changes to their strategies and decisions. Making changes that have been thought through in a focused manner, and then seeing the effects of these changes on company performance enhances students' understanding of their company. Note that there may be a delay between making decision changes and achieving a full understanding of company performance resulting from the multitude of cause-effects operating simultaneously. Understanding is further influenced by the quality of the module design. Aspects of this might include how well the theories, frameworks and concepts covered in the lecture materials connect with the issues being dealt with in the gaming environment. In gaining an understanding of how their actions affect the performance of the company, students attain learning. Learning, in turn, improves the quality of students' planning and strategizing.

It is the causal structure contained within a feedback loop that generates time evolutionary behavior (see Sterman, 2000). Where multiple feedback loops are driving the dynamics of a given problem, shifts in loop dominance can occur. This results in a change in the relative impact a given feedback loop exerts over the behavior of the problem under study. The evidence from the study interviews (upon which Figure 1 is based) showed that the 'Engagement Loop' dominated the dynamics of game playing in the early stages. Although students were starting from a relatively low base of subject mastery, they were interested in the novel approach to their instruction, thereby ensuring engagement. Over successive decision cycles, as students familiarized themselves with the game through repetition of play, a shift in loop dominance towards the 'Learning Loop' was evident in many of the teams. Increasingly, learning arose from an improved understanding of their competitive performance and the outcomes of the strategies and decisions made. However, it is clear that some teams did not experience this level of learning and continued to reside largely within the 'Engagement Loop'. A failure to effectively plan and strategize meant that their understanding of the game did not increase and this in turn had a negative impact on team motivation and engagement. Given the reinforcing nature of the model structure, these teams became caught in a vicious learning cycle through progressive disengagement.

Model Benefits and Limits

Learning is complex and very difficult to trace. In a dynamic business simulation environment there are many variables that will have a governing influence over how student players learn. The causal loop diagramming technique allows us to develop a picture of the interdependencies between the key factors influencing learning over a sustained playing period. The technique has a number of benefits for an educator seeking to understand learning processes and for students reflecting on their own learning. Above all, the CLD helps to explain learning and lack of learning on the part of the students. In particular, it illustrates how students may become caught only within the 'Engagement Loop', with the 'Learning Loop' having little impact on the dynamics of game playing. Given this condition, educators need to pay attention to how they might ensure a change in behavior that allows students to reside more strongly within the 'Learning Loop'. The results of this study indicate that this might be achieved through encouraging students to put greater effort into planning and strategizing as part of their gaming activities. An additional lesson emerging from the structure of the CLD relates to the reinforcing behavior of this learning system. Educators need to be conscious of the higher risks and benefits associated with using a business simulation game to teach students. Through managed interventions on their part, it is possible to tip the scales in favor of virtuous over vicious reinforcing behavior in this system. This is where the 'lever' of module design is of critical importance, as instructors can ensure that teams are well briefed, motivated and equipped with the thinking tools to allow them to strategize and understand the outcomes of their chosen strategies.

Although the CLD provides a number of insights and understandings for the educator and the learner, there are some inherent limitations to both this learning model and the more general loop diagramming approach. As is true of many models developed using this diagramming approach, the boundary of the model has been set quite narrowly. Whilst this has provided focus and benefits of clarity, by definition, it has excluded some of the wider and slower feedbacks that exist beyond the limits of this module of study. For example, we have excluded variables associated with the wider degree program and the students' personal attributes and characteristics. Given the case nature of this study, a further limitation relates to the generalizability of the CLD model. The study was based upon a single simulation game involving students on one module in a single Higher Education Institution. Hence, there may have been specific contextual issues that affected the results of the study. As a consequence, the CLD presented here is purely conceptual and requires more rigorous validation to verify and support its structure. Further research might usefully entail either repeating the same data collection approach using different simulation games or replicating this study using the BSG across different universities.

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WOLFE, J. and ROBERTS, C.R. (1986), "The Effects of Different Grade Weights on Business Game Learning Levels", *Journal of Educational Technology Systems*, Vol. 14 (4), pp. 307-316.

Causal loops show the interrelation causes and their effects. When finished you have a diagram of the positive and negative â€¦Â Causal loops diagrams (also known as system thinking diagrams) are used to display the behavior of cause and effect from a systemâ€™s standpoint. Fishbone diagrams may elicit the categories of causes that impact a problem. Causal loops show the interrelation causes and their effects.Â The diagram consists of a set of nodes and edges. Nodes represent the variables and edges are the links that represent a connection or a relation between the two variables. A link marked positive indicates a positive relationship and a link marked negative indicates a negative relation. Causal loop diagrams (also known as CLDs) are used to show the feedback within a system. Feedback is shown as a circular causal relationship within the system. They are used to show and understand the interactions within a system.Â In Systems Thinking a connection circle is used to uncover the problem and then a causal loop is used to diagram it.Â Visual Tools for Student Projects: Communicating Critical Thinking By The Creative Learning Exchange This guide helps teachers and students create projects in all areas of the curriculum.Â Through this game, students explore the hidden interconnections and dynamics surrounding the 'Egg Mobile', a portable chicken coop designed for sustainable farming at Drumlin Farm in Lincoln, MA. Introduction to causal loop diagramming. The high-level CLD for the World3 model. How to create CLDs for non-trivial problems. Turning a CLD into a system dynamics model. The limitations of causal loop diagrams. A causal loop diagram (CLD) explains the behavior of a system by showing a collection of connected nodes and the feedback loops created by the connections. One or more of the nodes represent the symptoms of the problem. The rest of the nodes are the causal chains causing the problem. The simplest possible CLD contains two nodes. Below is an example from video 3 in The Dueling Loops Video Series.Â Your list of factors should be useful here. Each node must have a carefully chosen name that clearly describes what it represents. A causal loop diagram can also be simulated to resolve issues about how the dynamics will play out. However, causal loop diagrams are rarely simulated directly. They simply don't have enough information to resolve the uncertainties. Instead, a causal loop model is used as an intermediate step in building a system dynamics model, and the system dynamics model is simulated. Chapter 11 describes system dynamics models and simulation. View chapter Purchase book. Read full chapter.Â SODA builds cognitive maps that are designed to represent the way in which a person defines an issue (Eden & Ackermann, 2001). The cognitive map is made up of constructs (nodes) linked to form chains (shown by arrows) of action-oriented argumentation (Eden & Ackermann, 1998).