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The Effect of Information Design and Presentation on Decision-Making Strategies and Performance in a Dynamic Environment

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Abstract

Information design and presentation in a Management flight simulator is relevant to people interacting with it to grasp the complexities in the underlying model. This study examines the effects of information design and presentation on people´s decision-making strategies and performance in a complex non-repetitive decision-making environment.

A two-treatment approach where the same information but different design interfaces for treatment 1 and treatment 2 was provided to subjects in treatments 1 and 2 respectively in order to determine whether there will be significantly different performance levels in the two treatments. Results suggest that information design and presentation plays an important role in achieving better overall performance.

In order to reduce the decision-making challenges in complex dynamic environment, and adopt near-optimal strategies for maximum performance, the information organization, design, and display/presentation is very essential for logical decision strategies and increased performance. Further studies should consolidate the findings of this study by taking cognizance of the limitations outlined in this study.

Word count: 158

Introduction

Information is a very essential tool for decision-making functions within every organization. As regards, information design and presentation/display is critical for decision-makers. Though a plethora of research exists on the influence of information display on decision-making processes, there is a paucity of literature focusing on the effect of information design and presentation on decision-strategies and performance in a complex dynamic environment where subjects do not have the opportunity of repetitive trials. Research on the misperception of feedback (e.g. Moxnes, 2004) as well as biases and logical incoherencies (e.g. Kahneman, Slovic, & Tversky, 1982) has revealed significant weaknesses of human judgment in dynamic decisions environment. The outcome of these studies have acted as an impetus for many researchers to further explore and examine different tools and procedures that can enhance and improve decision-making process (Kleinmuntz & Schkade, 1993) and consequently boost individual cognitive capabilities.

The purpose of this study therefore is to determine whether or not information design/categorization and display/presentation have an effect on decision-making process, strategies, and ultimately result in better performance/outcome. The focus is on information display on the interface of a management flight simulator. This is an important issue for decision-makers and all stakeholders directly or indirectly linked to the task of providing information that influences decision-making process.

Prior studies on effect of information presentation on decision-making showed that the format and organization of information displays influences the choice of decision strategy and performance (Jarvenpaa, 1989; Payne, 1982; Kleinmuntz & Schkade, 1993; Speier, Vessey, & Valacich, 2003). These studies are however concerned mainly with non-dynamic decision task, where no outcome feedback from individual decisions is shown. The attention of this study on the contrary, is on the effect of design of information displays for dynamic decision tasks for which "performance is determined by the cognitive processes related to problem solving" (Atkins, Wood, & Rutgers, 2002) and measured by the overall effect at the end of the period. The study uses a boom and bust model for the experiment. The boom and bust dynamic exemplifies a dynamic decision making system.

Boom and bust is a common dynamic occurrence in many endeavors: from service demand to product sales. Due to reasons such as market saturation, obsolesce/technological advancement, among other market dynamics, sales of new products often grow rapidly from the time they are launched. This trend is usually driven by the word of mouth communication that attracts new customers/users. Eventually the stock of potential purchasers is depleted and sales fall to an equilibrium determined by the need for replacement. This study also explores how information design and presentation in a management flight simulator can mitigate the role of cognitive misperceptions and decision-making errors in the process of the boom and bust phenomenon.

Poor performance can arise because decision makers do not perceive outcome feedback. Failure to utilize important cues can result from dynamically deficient mental models facilitated by poor information organization. Decision-makers who do not understand feedback concepts are unlikely to perceive the feedback loops, time delays, and nonlinearities that create the system's dynamics and so may not see the relevance of a critical cue: a misperception of feedback structure. At a still deeper level, even given perfect information and complete knowledge of system structure people are not able to infer the resulting dynamics. To do so requires intuitive solution of high-order nonlinear differential equations, a task that exceed human cognitive capabilities. In studies such as (Brehmer 1990), subjects had little training and experience relevant to the task. Real life situation is similar to the first trial in such experiments (Camerer 1987). Subjects in this study made decisions in the simulation without trials; this was to get results that represent a real life experience.

This study is based on an experiment conducted to ascertain the depth of relevance of information design and presentation on decision rules and ultimate performance. An appropriate information design interface is expected to lessen the cognitive effort of decision-makers and provide cues of decision leverage points for maximum performance. The findings of this study would impact information design and presentation process in management flight simulation tools to facilitate the performance. An improved information presentation strategy is expected to reduce the level of mediocrity in performance associated with system complexity and misperceptions of feedback.

The outline of the study is as follows: Firstly, literature is reviewed on important themes of the study: Good information design and presentation practices, the Misperceptions of feedback, effect of information design and presentation on decision strategies and performance. These subsections under the literature review will provide relevant findings in earlier studies related to the study goals. Secondly, the model is described. After the literature review, the next section is the model used for the experiment. The subsections of the model, key stocks and flows as well as decision parameter are clearly outlined. Thirdly, the experimental design for the study including the task subjects were given, the benchmarks, treatments, and the hypotheses are explained. The procedures involved in subjects recruitment and their background is also presented under the section. Fourthly, the results from the experiment are presented and interpreted and the stated hypotheses tested to identify which hypotheses, developed in the previous section are supported by the results. The fifth section interprets and discusses the results. Intuition is built and the implications of the findings in relation to conclusions of previous studies are outlined. The sixth part draws conclusions on the study based on the findings interpreted and discussed from the results under the discussion section. The limitations of the study are acknowledged and the recommendations and directions for future research stated. The next part presents the sources/references used in the study. The last part of the report deals with the appendices. The instructions for the experiment, the model, the two treatment interfaces are all presented in this final section.

Background/theory

Relevant literature on the major themes of the study such as, good information design and presentation practices, misperception of feedback, and information characteristics is reviewed to provide grounds for the study. Previous studies examining the effects of information presentation on decision-making, especially in terms of decision performance and choice of decision strategy is also explored.

The number of imaginable visual representations of decision problems is virtually infinite. The paper focus on three fundamental characteristics that apply to a broad range of displays: (a) the form of individual information items, (b) the organization of display items into meaningful groups or structures, and (c) the sequence of individual items or groups of items.

Information Presentation Practices

The use of images to represent data has been in existence for quite some time. The idea of employing abstract, non-representational pictures to depict numbers is recent invention (Tufte, 2011). William Playfair (1759-1823) started works on systematizing and improving knowledge by replacing numerical representation of data with visual displays. In order to improve large information acquisition, Playfair developed a novel, which he termed *linear arithmetic* (Tufte, 2011).

Centuries afterwards, graphical display of data has increasingly gained recognition and has become an inseparable part from the analysis of data. When dealing with quantitative information however, “certain methods for displaying and analyzing data are better than others” (Tufte, 1997). There is therefore the need to institute principles that can help design better visual explanations. Tufte (2011) summarized a set of principles for graphical excellence to guide the creation, presentation and interpretation of data graphics. Tufte (2011) sees graphical excellence was “a matter of substance, of statistics, and of design” with a purpose of providing the user with “the greatest number of ideas in the shortest time. Such principles were adhered to in the experimental design of this study.

Misperception of Feedback

Social science researchers have been testing and exploring the limited capabilities of human cognition since Herbert Simon coined the term “bounded rationality” Models of Man (Simon, 1957). Research in psychology and economics over the years has reached conclusions different from the predictions of rational models of behavior due fallacies and biases produced by cognitive limitations (Kahneman, Slovic, & Tversky, 1982; and others). Sterman (1989) studied the implications of individual decision-making on a system’s behaviour using an experimental setting that employed the Beer Distribution Game in order to broaden understanding of the challenges of dynamic decision context. Results from the Beer Game generally suggest that subjects would produce output dynamics that differ “significantly and systematically from optimal behaviour” in relatively simple task. According to Sterman (1989), the mental models people use to guide their decisions are dynamically deficient. People generally adopt an event-based view of causality, ignore feedback processes, fail to appreciate time delays between action and response and in the reporting of information, do not understand stocks and flows, and are insensitive to nonlinearities which may change the strengths of different feedback loops as a system evolves.

A study by Moxnes (2004) on Misperception of Feedback, contend, “Laboratory experiments used thus far have been characterized by considerable complexity and ambiguity about model structure and parameters”. An experiment was designed to examine the implications of the Misperception of Feedback in a simpler and more straightforward setting, where subjects could fully reconstruct the underlying mental model using the instructions provided. The experiment involved two treatment groups: a one-stock model, and a two stock model of the same renewable resource problem (Moxnes, 2004). The findings supported the misperception of feedback hypothesis.

According to Moxnes (2004), people are often unable to formulate appropriate mental models for decision problem hence; unable to manage a simple one-stock with two flows effectively. Later study by Moxnes and Saysel (2009) suggest the use of analogies or metaphors. In an experiment studying the effects of such analogies, they used information treatments to condition the subjects and help them form a better understanding of a CO2 stock management problem. They concluded that the use of appropriate analogies and the delivery of outcome feedback have strong effect on the ability of subjects to formulate an appropriate mental model for the experimental context.

Information Design and Presentation effect on Decision-Making strategies and Performance

Computer-based interactive learning environments (ILE) or flight simulators are a way for professionals aiding the decision-making process to transfer the responsibility of the learning experience to the decision-maker (Lawless & Brown, 1997). As a result of the technical nature of experts who design them, ILEs tend to focus more on transferring the task representation to the computer environment, and less on ensuring its quantitative and logical aptness. Information design and presentation is an essential aspect of interactive learning environment. Unfortunately, the need for "making the decision environment more conductive to effective decision making is often given less priority and neglected (Kleinmuntz & Schkade, 1993).

Kleinmuntz and Schakade (1993) posit that information design and display influences the choice of decision strategy and consequently, decision performance. Prior research in the area was focused on comparing tabular and graphical displays of data (Dickson, Gerardine & DeSanctis, 1986). The evolution of digital displays and computerized decision support systems has however created near-infinite variations in the visual representation of decision problems (Kleinmuntz & Schkade, 1993). The presentation of data generated by simulation is necessary for analysis of the decision problem. Kleinmuntz and Schkade (1993) focus on the three fundamental characteristics of visual representation – form, organization, and sequence. They explained that, "*form"* encompasses numerical, verbal, and pictorial information presentation, where pictorial consists of charts, maps, or other visual symbols- Organization refers to the structuring of information, which could be hierarchical, matrix, groups, or other patterns, and sequence regards the order in which different pieces of information are presented to the decision maker (Kleinmuntz & Schkade, 1993). "Decision makers respond adaptively to variations in information displays, using different decision processes depending on the different arrangement of form, organization, and sequence" (Kleinmuntz & Schkade, 1993). In relation to the form of information presentation, Dickson, DeSanctis, & McBride, (1986) conducted three experiments to study the effectiveness of graphs for decision support in comparison to tabular representation of data. They found that the graphical presentation of data was superior in cases where "analysing time-dependent patterns was important", and when "large amounts of data had to be presented to prompt the recollection of specific facts".

Graphical data presentation amplifies cognition by capitalizing on peoples' acute perceptual capabilities (Card et al., 1999); hence researchers are increasingly exploring novel ways to present visual information in clinical displays. Effkena et al., (2008) compared the impact of two clinical displays on ICU nurses' event detection, treatment efficiency, cognitive workload and satisfaction in a simulated oxygenation management task and concluded that, one provided higher user satisfaction and efficiency than the other. In a study by Gurushanthaiah, et al., (1995), histogram and polygon displays were shown to be superior to a numeric display when compared in a laboratory simulation environment. The graphic displays decreased anesthesia residents' response latency and increased their accuracy in detecting changes in physiologic variables.

Findings of research in the area are contradictory and highly contextual. Again, the implications of information design and presentation in dynamic and complex decision environment is not thoroughly researched. The dynamic decision-making literature "has largely neglected the influence of feedback formats on task performance" (Atkins, Wood, & Rutgers, 2002) few researchers attempted to investigate the combined effect of information format, organization, and sequencing (Kleinmuntz & Schkade, 1993), contained in this study.

Method

A model was developed for this experiment. The model idea is from the Boom and Bust, and failure to learn in experimental markets experiment by Paich and Sterman (1994). Modifications were made to the model to suit the context and goals of this study. Whiles the original model involved decisions based on two parameters (price and capacity) with five treatments, this study is focused on one parameter; hiring rate, with two treatments in order to achieve maximum accumulated net profit at the end of the simulation period. Unlike the original model which included three sectors: the market, the firm, and the competitor, only two: the market and the firm sectors are used in the present study. The model assumed that there are no competitive dynamics for the duration of the simulation. This was intended to simplify the dynamics and moderate feedback complexity arising from the model in order to focus on task complexity aspects of the interface. The study also sought to limit the information requirement for subjects to enable them to create effective decision-making strategies. The goal of the research was not to test the misperception of feedback hypothesis. It has received in-depth support from renowned scholars. As regards, the competition sector was eliminated to simplify the basic market dynamics for the participants through alternative interfaces.

The market sector

The idea of the market model is based on the Bass diffusion (Bass, 1969), a simple mechanism for generating orders based on the sales personnel and the word-of-mouth communication by adopters. The model represents the feedback structure through which potential customers become aware of the product and make a purchase decision (Figure 2 in appendix). Adoption/purchases increases the customer base, generating word of mouth, which leads to additional sales (a positive feedback), but also depleting the pool of potential customers (a negative feedback). The customer base follows an s-shaped pattern, while sales increase exponentially, peaks, and decline to the rate of replacement purchases as the market saturates. "Potential customer" purchase rate is based on:

- The "fraction of adoption initiated by salespeople" variable that indicates a base sales rate.
- The "fraction of adoption from word of mouth" variable, influenced by the number of customers/adopters and a multiplier consisting of "potential customers" divided by "total market" that represents that higher market saturation makes further penetration more difficult; and also a contact rate and adoption fraction.

The "total market" was assumed to be constant, which is a reasonable assumption considering the 5-year time frame. It was also assumed that there are no capacity limitations and once there is a market demand, it is immediately satisfied and the potential customers become actual customers.

Word-of-mouth is generated by customers who have purchased the product. Word of mouth is determined by two constants:

- Fraction of customers who are willing to promote the product
- Number of contacts per customer who promotes the product

Probability of adoption, representing the probability that each of those contacts will be willing to purchase the product and become part of the customers via word of mouth effect;

Customers, generated by the "word of mouth" effect are then added to the "fraction initiated by the sales people" to produce the purchase rate.

The key features of the market sector include:

- Product price is fixed and does not affect the number of potential adopters.
- The greater the hiring rates of the firm, the larger the fractions of potential customers who purchase each quarter. Diminishing returns set in for high sales people hired.
- Demand is also generated by word of mouth. Word-of-mouth is driven by adopters (people who already own the product).
- A fraction of the customer base re-enters the market each quarter to replace worn or obsolete units.
- Profit is revenue less total costs. Total cost is equal to the variable costs (salaries of the sales people hired to sell the product). Revenues are determined by the quantity demanded in the current quarter and the average price received for those units.

The firm sector

The firm segment is mainly composed of the sales people. The sales force structure depends on the participants to make decisions based on the sales force they wish to have at a given time by hiring sales people. One-third of the sales force faces automatic attrition as a result of contract expiration. The parameter in relation to which decision is made by the decision-maker is "the hiring rate". The purchase rate is multiplied by the price per unit of the product and the cost is ascertained by multiplying the sales force by the salaries per sales person. The revenue and cost computation is carried out in the model to determine the net profit.

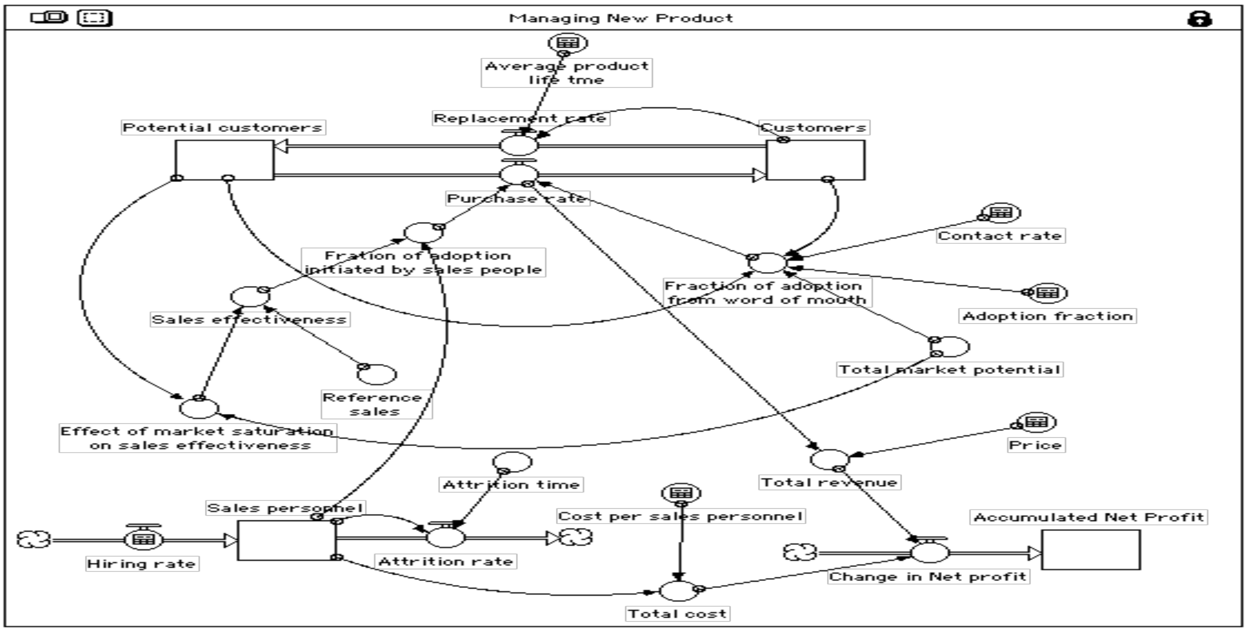

Figure 1: Experiment Model

Task

The task for this experiment basically was for participants to manage a new, durable product (with a life span of three years) that has just been launched. Their goal was to accumulate as much profit as possible by hiring the sales personnel they needed to sell the product. The product could only be sold in two ways: when sales people convince potential customers to buy, and when people who bought the product also promote it to potential customers via word of mouth during interactions with them.

The researcher developed an interactive management flight simulator based on the principles of good information data presentation (Tufte, 2011) and interface design principles (Senge and Sterman 1992, Graham et al. 1992, Sterman 1989). The flight simulator contains a model representing a firm and its market. Subjects managed a new product from launch through maturity, making decisions on how many sales people to hire each quarter of a year through a period of five years. Subjects were made aware of a constant sales force attrition rate of one-third of the sales force.

Optimal Solution

Setting benchmark is relevant in many decision fields. It involves setting performance metrics against which the outcome of a set of decision rules or strategies is measured. In this experiment, the model for the experiment itself was not revealed to subjects. They were only provided instructions regarding the model structure that is supposed to give insights about the feedback loops. The simulation outcomes as well as the decision parameter were revealed. The performance/decision outcome of subjects in one treatment (treatment 1) was compared to those in the other (treatment 2). The benchmark in this scenario is much more focused on the logic behind subjects reasoning and decision strategies based on the information made available to them. Indeed, a benchmark/optimal performance here would involve decision rules that are conscious of the feedback loops. The decision parameter, hiring rate, is expected to be high at the beginning and gradually decrease as the efficiency per sales person diminishes due to market saturation.

Experimental Design

In order to execute the planned laboratory experiment, a management flight simulator was designed based on the model described above. There were two interfaces built on the System Dynamics simulation model. The interfaces and the model were developed using the iThink modelling software. The experiment includes two treatments – an initial treatment (T1), where the interface was designed and information presented with buttons and two graphs. One graph had the simulations of the relevant stocks in the model whiles the other contains their flows.

Figure 1: Interface for Treatment 1

The alternative treatment (T2), which was an improvement of the initial treatment, contains the same buttons as the first interface but with three graphs. One graph contains two related stocks and their flows, the second graph contains another stock with an inflow and outflow, and the third graph contains the simulation of the goal, which the participants were tasked to maximize.

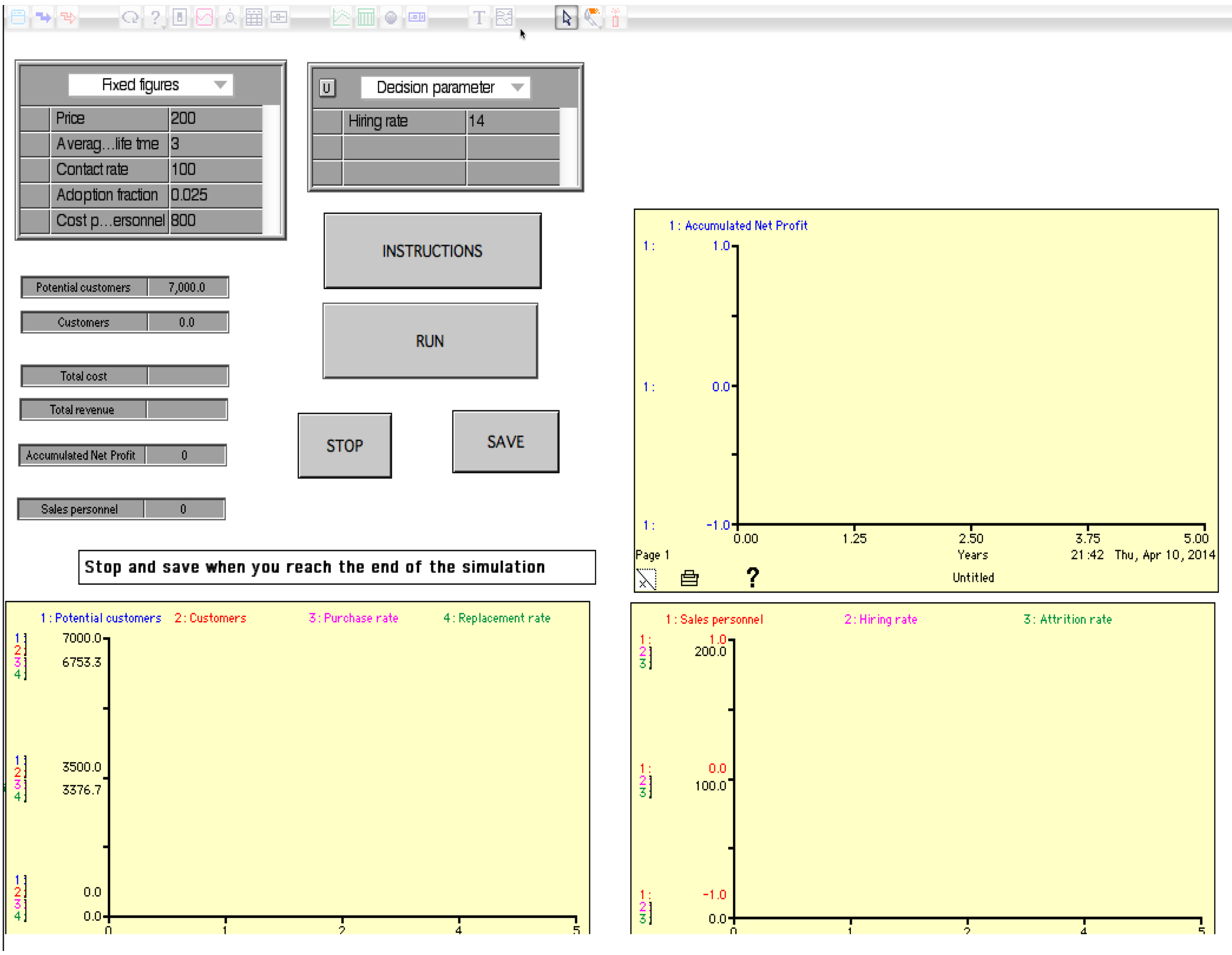

Figure 2: Interface for Treatment 2

The interface of the alternative treatment (T2) was developed using Tufte's suggestions for good data presentation. Participants were recruited for the experiments and randomly assigned to either of the treatments. Instructions (Appendix 1) were given and the subjects were allowed to ask questions about the interface or the instructions before beginning the simulation. No further information regarding the system structure was revealed besides what was given as initial instructions and available through the simulator interface.

Hypotheses

Limited information is provided in the System Dynamics literature regarding the ways of designing simulation interfaces to improve learning experiences of users (Andersen, Chung, Richardson, & Stewart, 1990). The interfaces of experiments in seminal studies are still characterized by considerable complexities. Research on the decision support needed often focus on employing metaphors and abstractions to help create valid mental model (Moxnes & Saysel, 2009). Flight simulators are often used to aid the formation of mental models (Davidsen, 2000). The information communicated through the simulation interface should help decision makers formulate an appropriate mental model. According to Moxnes and Saysel (2009), it is difficult to form a correct mental model without guidance. The design of the information presented, including the simulation interface, is a way to provide such guidance without direct intervention in this study. After gleaning from literature on how information presentation affects decision process and performance, the researcher hypothesizes:

H_0: *Distinction in information design and presentation/display does not have an effect on decision-making strategies and performance.*

Kleinmuntz and Schkade (1993) demonstrate how information affects decision makers' choice of decision strategies. Decision-makers adopt adaptive strategies as response to problem complexity and information display characteristics (Payne, 1982). Since variations in the form and organization of information presentation lead to the formation of two different pairs of anticipated effort and anticipated accuracy (one for each display), the chosen strategies within those two environments could also differ. Different studies suggest that, characteristics of information design and presentation (form, organization, and sequence) influences decision process through the adaptive mechanism of balancing the desire to maximize accuracy and minimize effort. Carefully designed information can lead the decision-maker to use a good decision process or strategies, and variation in decision strategies can produce measurable differences in performance outcomes (Kleinmuntz & Schkade, 1993), hence:

***H_1:** Distinction in information design and presentation/display affects decision-making strategies and performance.*

There is a negative relationship between task complexity and performance (Paich & Sterman, 1993). A study by Jarvenpaa (1989) examined the implication of information organization on decision-making and concluded that organization of information displays has an effect on decision accuracy (performance).

Decision strategies based on a correct understanding of a dynamic problem would result in better performance. A study by Speyer, Vessey, and Valacich (2003) concludes that, graphs are more appropriate for information design and presentation than tables in a more complex decision environment. It is reasonable therefore to assume that applying design principles to the form and organization of information design and presentation to reduce complexity would result in improvement of performance, hence the hypothesis:

***H_2:** An improvement in information design and presentation/display helps decision-makers to understand the system complexity and perform better.*

The performance herein is the accumulated profit at the end of the simulation period.

Subjects and procedure

The methodology of using two treatments and a single trial was adopted in order to avoid the error of attribution due to learning. The chance that, learning might have occurred after a single initial trial would result in better decision. This would make it difficult to distinguish the effect of learning on performance from the information display or presentation on the overall performance.

The study was conducted in April, 2014 at the University of Bergen. Participants were randomly chosen for the study. Even though the participants had different backgrounds in terms of education and nationality, they were all System Dynamic students at the University of Bergen. While most of them are Masters Students, others were PhD candidates. A total of 15 subjects participated consisting of eight subjects (8 people) in the initial treatment (T1) that received a less favorable information design and presentation interface, and seven subjects (7 people) in the alternative treatment (T2). These subjects are potential managers who also have an idea of the structure of the hypothetical organization that they manage. It is fair to say that; they have a good grasp of the complexities involved in dynamic decision environment.

Smith, (1982) proposed five precepts for conducting experiment. They are satiation, saliency, dominance, privacy, and parallelism. The desirability of Vernon Smith´s precepts depends on the objectives of an experiment. Precepts such as Monotonicity, Salience, and Dominance are important for the experiment. Precepts ensure that subjects aim maximum because of the reward/incentive at stake. In this study, it was important for subjects to be committed to the task and try to achieve as much profit as possible. In order to boost commitment, the researcher offered to participate in experiments with full commitment conducted by the subjects. There was restriction of communication between subjects.

Results

The results of the accumulated net profit of subjects in the two treatments are displayed in the chart below. The blue bars in the charts depict how subjects in the base treatment (Treatment 1) performed with regards to achieving the goal (accumulating as much profit as possible) at the end of five years. The red bars in the chart shows the performances of subjects in the second/alternative treatment (Treatment 2).

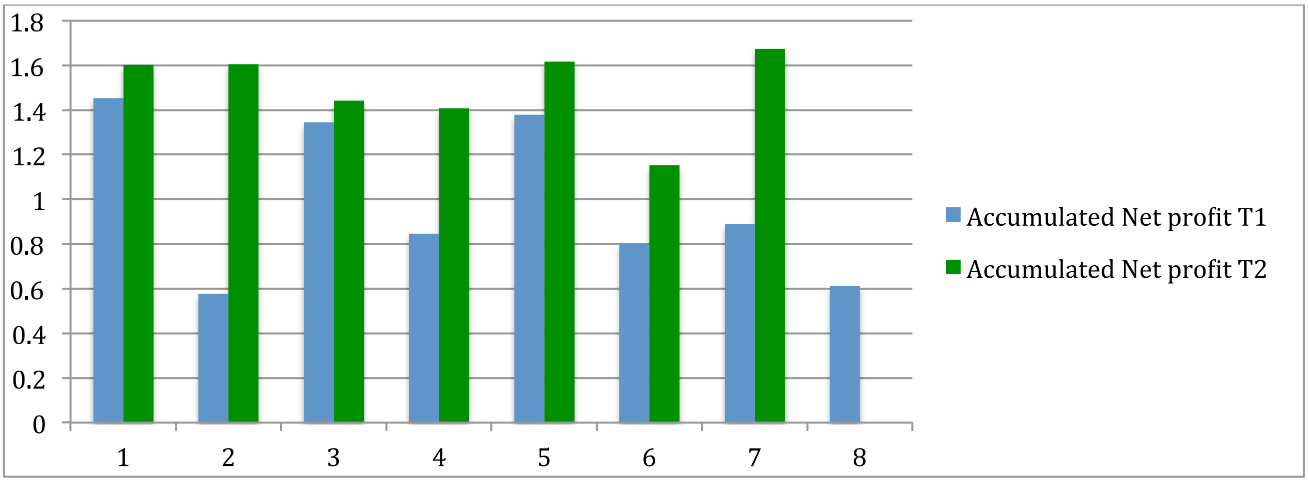

Figure 1: Accumulated net profit in millions

The y-axis shows figures of accumulated net profit in millions while the x-axis represents random individual subjects in the two treatments.

T-Test

A T-Test was carried out to determine the standard deviation and the mean values of the two treatments. These statistics are presented in table 1 below.

Table 1: Group Statistics

	The sample group or category of treatment	N	Mean	Std. Deviation	Std. Error Mean
The total profit accumulated at the end of the simulation period	Poor/Distorted information display	8	987657	352819	124740
	Good/Improved information display	7	1499669	181217	68493

The independent sample test, which revealed the significance/p-value as well as the result for the test for equality of variances are displayed in table 2. Equal variances are not assumed since the significance of the Levene´s test is below the set significance level of 0.5. The p-value or significance level is 0.004, which is less than the significance threshold of 0.5. The null hypothesis of the study is rejected.

Table 2: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
The total profit accumulated at the end of the simulation period	Equal variances assumed	6.613	.023	-3.451	13	.004
	Equal variances not assumed			-3.598	10.7	.004

Table three below is an extension of table two which represents the mean difference, and the confidence interval of difference with lower and upper confidence intervals.

Table 3: Independent Samples Test

		t-test for Equality of Means			
		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
				Lower	Upper
The total profit accumulated at the end of the simulation period	Equal variances assumed	-512011	148371	-832547	-191475
	Equal variances not assumed	-512011	142308	-826229	-197793

Results from Non-parametric test

Non-parametric tests: Mann-Whitney Test was conducted to determine the mean ranks and the sum of ranks of the two treatments. The results for these tests are displayed in table 4.

Table 4: Ranks

The sample group or category of treatment		N	Mean Rank	Sum of Ranks
The total profit accumulated at the end of the simulation period	Poor/Distorted information display	8	5.13	41.00
	Good/Improved information display	7	11.29	79.00
	Total	15		

Table 5 shows the Mann Whitney U value and the Wilcoxon W values. The asymptotic significance as well as the exact 2-tailed significance of the study is also present in the table below.

a.

Table 5: Test Statistics[a]

	The total profit accumulated at the end of the simulation period
Mann-Whitney U	5.000
Wilcoxon W	41.000
Z	-2.662
Asymp. Sig. (2-tailed)	.008
Exact Sig. [2*(1-tailed Sig.)]	.006[b]

Grouping Variable: The sample group or category of treatment

b. Not corrected for ties.

Discussion and conclusions

The experimental design for the study was such that, subjects who fully grasped the complexity of the system would increase their hiring rate (the decision parameter) at the beginning and decrease as the sales effectiveness decreases. This was the best decision strategy to adopt in order to have chances of achieving high returns in accumulated profit at the end of the simulation. Subjects whose hiring rate falls from beginning to the end would be deemed to have good decision strategies. The results from the study indicates that, there is a significant level of difference in the performance of subjects (8 people) in the initial treatment (T1) who received a less favorable information design and presentation interface, and those (7 people) in the alternative treatment (T2), with good/improved information design and presentation. Results from the independent sample test show a significance level of 0.004. This suggests that, the way information is designed in a management flight simulator has an effect on the performance of people interacting with such systems. In order to further strengthen the results, a Mann Whitney U test was also carried out to determine the performance of the two groups based on ranking. The Mann Whitney U test revealed a value of 5, which means that, 5 subjects in the alternative treatment performed better than all the participants in the initial treatment. The mean ranking of the alternative treatment is also far greater than that of the mean value in the initial hypothesis. These results mean that there is not enough evidence to support the null hypothesis. The null hypothesis: ***H_0:*** *"Distinction in information design and presentation/display does not have an effect on decision-making strategies and performance",* is therefore rejected. Since the alternative hypothesis, ***H_1,*** is a reverse of the null hypothesis, the findings support the alternative hypothesis. The hypothesis ***H_1:*** *"Distinction in information design and presentation/display affects decision-making strategies and performance"* is supported by the results.

The study also investigated whether or not subjects that receive good information design in a management flight simulator interface have a better understanding of the system´s structure and complexity. It was therefore hypothesized: ***H_2:*** *An improvement in information design and presentation/display helps decision-makers to understand the system complexity and perform better.*

Good information display should provide deep insight on the underlying structure of the system resulting in better decision rules (Jarvenpaa, 1989). Poor information display would lead to poor decision choices as the mental model of the individual makes sense of a system´s complexity based on the information available. The results from the study suggests that, the treatment group that had an improved information display had a better understanding of the underlying structure and made much more logical decisions. Their hiring rate was high at the beginning and reduced as the simulation advances. A further analysis of opinions from the participants concerning why they made those decisions regarding their hiring rate in the experiment points to this assertion:

- " I reduced the number I hired as the market become more saturated",
- "It depended on my belief of the effectiveness of the word-to-mouth effect. When I considered (based on the sales) that the word-to-mouth effect was huge and the sales persons made no difference then I started decreasing the sales staff",
- "After reading your instructions I had a feeling about the models that you used. There was too much information and I decided that I will not be able to calculate decisions from the numbers you provided so I just used my intuition and previous knowledge about the model behavior".

The views sampled after the experiment seem to allude to the conclusion drawn by Kleinmuntz & Schkade, (1993) that, procedural knowledge or previous experience influences the decision strategies as subjects have intuition of the system complexity.

The treatment group that had the low information design interface was focused on different dynamics in the system. This caused them to make rather sporadic decisions. The decision parameter results exhibit oscillatory decision pattern, which suggest that, they had a very low grasp of the system and were not entirely certain of the effects of the decision strategies. Some of the reasons of subjects in this treatment group for their decision strategies include:

- "I was looking at the number of consumers when I picked the number of employees. My target was to get more and more people with lowest number of employees possible. More people more profits",
- "The main factors influencing my decision were the cost and revenue built-up or structure".

It is clear from the results that, the improved information group, Treatment two (T2) had a better understanding of the model structure and complexity than the less favorable information group, Treatment one (T1). Consequently, subjects in T2 performed better with a higher mean value and ranking than those in T1. The hypothesis: ***H_2:*** *"An improvement in information design and presentation/display helps decision-makers to understand the system complexity and perform better"* is supported.

The findings of this study are consistent with previous scholars (Sterman, 1989; Moxnes, 2009) who studied the misperceptions of feedback and posit that; the information treatments could enhance subjects' mental formulation of a complex dynamic system. Information display features such as the form, organization and sequence of information influence decision processes through an adaptive mechanism whereby a decision maker balances the desire to maximize accuracy against the desire to minimize effort. The findings of this study implies that, people who provide information in organization should ensure that, relevant details as well as conventional principles of information design are applied so as to avoid ambiguity and promote performance.

Information design and presentation is essential for decision-makers. People sometimes perform averagely because poor information design and presentation makes it difficult for them to comprehend the dynamic structure behind the interface they interact with. This study set out to investigate the effect of information design and presentation/display on decision-making strategies and performance. A laboratory experiment approach where people interact with a Management Flight simulator was adopted. A total of 15 System Dynamics students were recruited as participants in the experiment. The group was divided into two: Treatment 1 (T1) with 8 subjects and Treatment 2 (T2) with 7 subjects. The major findings from the study are that, there is a significant difference between subjects' performances in the two treatments. Participants in T2, which had improved information design and presentation performed better than those in T1 (less favorable information design). The study also found that, besides the overall performance difference between the two groups, Participants in T2 seem to have a better mental model of the complex dynamic environment that the decisions were made. These participants made much more logical decisions based on their hiring trend.

The study concludes from the results and analysis that, the way information is designed has an effect on the decision strategies and performance. The prudent decision strategies and performances of subjects in T2 are attributable to the way the information is designed and presented. It enhances their mental model to have a better understanding and also reduces their cognitive efforts in making better decisions.

Even though there is high confidence in the study results, which demonstrates that information design, and presentation does have an effect on decision strategies and performance, the findings of this study should be used with reservation because of the limitations associated with it.

The model modification for simplicity inhibits the ability of the researcher to compare the results of this study to the original study by Paich and Sterman's Boom and Bust experiment (1993). The sample size used for the study is somehow inadequate for the findings to be generalized. The experiment was conducted with two samples; one with better information design and the other poor information design. The observed differences could be attributed to subject's personal orientation rather than the information presented. A constant price was maintained in the model. The real world scenario often involves variation in price. This study focused on the representation of stocks and flows on graphs. Future studies could delve into other design characteristics on the interface layer such as the buttons and colour of design. Subsequent studies should also consider overcoming some of the limitations in this study to see how that affects results.

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Appendix

Appendix 1: Experiment Instructions

The following interface presents information about the market development, customer adoption, and the profit accumulated from sales of a new durable home product called BLUE CHINCK, which has an average life span of three years.

There are 7000 potential customers in the market out of a total population of 10000 people with no Actual customers at the beginning. A customer buys a single unit of the product at a time and uses it until it´s life span runs out then they join the potential customers and make a purchase again. People buy the product and become customers either through the sales people or word-of-mouth communication by people who are already customers. The initial sales effectiveness was 7 products per sales person per month but this falls as the market becomes saturated.

There is a 100% contact rate of customers with the potential customers and fractions of 0.025 adopt/purchase the product after an encounter with existing customers. The purchase rate is a sum of people adopting through sales people and the word-of-mouth. The replacement rate is after three years; the time the product life span is reached. The price of the product is fixed at $200 and the cost per every sales person is $800. Accumulated net profit is the difference between the revenue (price * Units of the product sold) and the cost (cost per sales person * the number of sales people) over the period. You do not have any competition in the market.

Your task is to ***make a decision with regards to the number of sales personnel you need to hire (hiring rate)*** for the product. Sales people are hired for a period of three months after which the contract can either be terminated or renewed depending on the number of sales employees you desire, that is, you can decide how many sales people you desire after every simulation.

As a manager, you want to hire as many sales people as needed to boost your sales revenue and increase profit at the end of the five years period but there is also cost associated with every sales person hired and their effectiveness diminishes in the long run as the market become saturated.