

How to correct misperceptions of delays:
an interactive learning environment to reduce binge drinking

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Abstract

Background: People misperceive accumulation processes. Take for example the case of people becoming more drunk than intended. Such misperceptions can lead to high costs that in some cases may be fatal.

We ask: Could interactive learning environments (ILE) using water analogies help people understand accumulation processes. In particular can ILE's help juveniles understand the process of alcohol intoxication?

Method: High school students participated in a laboratory experiment. Some of them interacted with a funnel simulator in order to learn about accumulation processes. In a two by two full factorial design where some subjects could see the level of water in the funnel (Transparent); others could not (Opaque). Some got explicit information about water analogies and others did not. Afterwards, all subjects including a group that did not interact with the funnel simulator were tested in an alcohol simulator similar to one developed by Moxnes & Jensen (2009). Thus we tested the effectiveness of using water analogies for knowledge transfer. A questionnaire complemented the experiment.

Results: Subjects that did not use the funnel simulator (water analogies) produced larger overshoots in BAC than those using it (with borderline significant level for two of the treatments). The combination of transparency and information about the analogy seems to have an effect on subjects' performance. A bigger proportion of subjects that did not use the funnel simulator used strategies that did not take in account accumulation processes.

Conclusion: Our ILE might improve the performance of the subjects using the BAC simulator proposed by Moxnes & Jensen. It might also improve the understanding of accumulation processes. Further studies may enhance the ILE by taking in account the U-shape phenomenon during learning processes.

1. Introduction

Researchers have found that people generally misperceive the dynamic behind phenomena involving delayed processes (Jensen 2005, Moxnes 2004, Moxnes & Jensen 2009, Moxnes and Saysel 2009). People tend to decrease their performance while solving experimental tasks that involve delaying processes (Rouwette, Größler and Vennix 2004).

There are many examples of systems with second order delays in different fields, ranging from commodity markets to shower's pipeline delays. Here we will take another look at the problem discussed by Moxnes & Jensen (2009). They conducted an experiment that revealed how misperceptions of the underlying dynamics behind alcohol intoxication lead to overshoot of the subjects' intended level of blood alcohol concentration (BAC). Their experimental results do not differ much from reality. A study carried out in the US, which suggested that almost half of the responders were binge drinkers. "Frequent binge drinkers are more likely to experience serious health problems and other consequences of their drinking behavior than other students" (Henry Wechsler, et al. 1994). Even more, they induce others to drink more, creating a reinforcing loop in binge drinking. This implies huge costs for the society and especially for the young population itself.

Moxnes & Jensen (2009) found that one group of subjects who interact with a simple simulator that addresses the importance of delays, perform better than those who do not. This suggested that interactive learning environments (ILEs) could help to improve the understanding of underlying dynamics behind certain phenomena. They also proposed that: "Further research is also needed to develop and test teaching strategies to reduce overshoots making use of cognitive conflict, water funnel analogies, and thumb rules."

According to constructivism (Kilpatrick 1987, Piaget 1950, Ausubel, Novak and Hanesian 1983), learners develop understanding by adjusting previous knowledge after experience in relevant contexts. The subject will give a new meaning to the acquired knowledge by reorganizing, restructuring concepts and redefining their links. In other words, the way in which an individual acquires new knowledge depends on the experiences that the person has had in the past. By first using analogies to alcohol

problems, we try to improve understanding of the relationship between structure and behavior in a second order delay system (Davidsen 1992).

Virtual worlds (Schön 1983) (J. W. Forrester 1961) (J. Sterman 2000) provide the learners the possibility of testing their mental models in a controlled and “off-line” world iteratively in order to adjust mental models.

Our hypothesis is that an ILE based on water analogies will improve mental models, performances and behaviors of the subjects intervened.

The current work proposes an ILE that helps to improve the understanding of delays. It uses a water funnel analogy to illustrate, in a simple manner, the dynamics behind second order systems but in particular the phenomenon of alcohol intoxication. The ILE consists basically of a computer simulator in which the subject must fill a glass with water that first flows into a funnel.

We are interested in finding the characteristics of our ILE that can trigger better understanding of delays. Therefore, we created an experiment with five different treatments. Four treatments come from the combination of subjects being able to see the level of water inside the funnel, subjects that were not able to (transparent Vs semitransparent) and people getting information about the analogy between our funnel and BAC models. The other treatment consists of people not using our ILE and taking the post-test.

As a post-test we use a BAC simulator similar to the one used by Moxnes & Jensen (2009) accompanied with post-test questionnaires. The experiment was carried out in two High Schools in Medellin, Colombia (N=99).

The results show that our ILE can improve the subjects’ performance. We found that performance cannot be used to measure the understanding of delays. Even though, those subjects using a semitransparent funnel simulator and being informed about the analogy, overshoot their BAC levels, their strategies and their answers in the post-questionnaire evidenced certain understanding of delays. We think that longer interventions could achieve better conceptual changes in peoples’ mental models about delays. Our research raised new questions and therefore we suggested some improvements for our ILE using new theories in the field of cognitive development.

This work is divided in five sections. In the first section we introduce the problem, the hypothesis and the analysis. The second section describes the methodology that we propose. It describes the alcohol simulator and the underlying model. We also explain how our hypothesis is also our policy for the problem. We describe our funnel simulator and the model behind it.

Additionally, we explain the analogy between the BAC model and the funnel model. The treatments for the experiment are explained in this section as well. We used innovative information and communication technologies in the developing process of the software that supports our ILE and they are explained in this section too. We also explain our experimental design used.

The third section shows the results from the experiment in a descriptive manner, before we discuss the outcomes from the experiment. Here, we propose a feedback strategy as a possible explanation for the results obtained. Our findings encouraged us to propose improvements for our hypothesis and do further research. We describe them in this section.

Finally in the fifth section, we point to the most important finding in this work.

2. Methods

A funnel simulator composes our ILE. It consists of a system in which the user has to fill a glass with water that first flows into a funnel. The user can control the flow intensity of the tap. It uses advanced 3D interactive animations to illustrate accumulation processes using water analogies. We created two versions of the funnel simulator. One allows the user to see the level of water inside the funnel (transparent) and the other one does not (Opaque). The simulator runs on a computer over the Internet. In this section we describe in detail the underlying model behind this simulator and we give an overall description of the software design. This system is an analogy of the process of alcohol intoxication. The water represents the alcohol, the funnel the stomach and the glass the BAC.

In order to test the effectiveness of our ILE, we designed and implemented a similar version of the BAC simulator created by Moxnes & Jensen (2009), there are, however, some differences that we describe later on. There are two versions of this simulator. One gives the user information about the analogy between the funnel simulator and the other one does not.

We are also interested in testing if transparency and information about the analogy has an effect on the understanding on accumulation processes and knowledge transfer. Therefore we created five treatments. Four of them are the combination of transparency and information policies (information about the analogy) and one is for subjects not using our ILE and interacting directly with the BAC simulator. The treatments are described in detail later on in this section.

In this section we also explain the experimental design and we describe the characteristics of the subjects and the context where the experiment was carried out.

2.1. The Alcohol simulator

A study by Jensen & Moxnes (2009) tested what happens when high school students make drinking decisions in a laboratory experiment. Simulations and questionnaires supported the experimental design. The results showed that the students tended to overshoot their intended blood alcohol concentration (BAC) levels. The overshoot was

much larger for treatments with long stomach delays than without stomach delays. Written information about the delay did not have much effect in reducing the overshooting. However a pre-test experience with an alcohol simulator parameterized for a mouse had a positive effect on student results. This last finding inspires the current work.

This work is focused on developing and testing a new methodological approach to enhancing learning when dealing with systems with second order delays. A new BAC simulator interface was developed, based on the alcohol simulator used by Jensen & Moxnes (2009). This simulator was used as a post-test as part of the process of analyzing the effectiveness of our hypothesis.

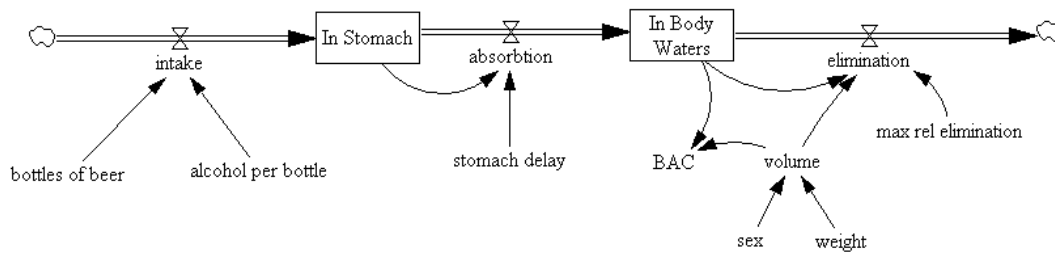


Fig. 1. Stock and flow diagram of the BAC model

The equations used in the BAC simulator used by Jensen & Moxnes are the same as the ones used in this work. Fig. 1 shows a stock and flow diagram of the BAC model. The symbols come from the field of System Dynamics (J. W. Forrester 1961). Table 1 shows the equation we used.

Variable / Constant

Equation / Value

alcohol per bottle = 12.25

intake = bottles of beer * alcohol per bottle / "15 min"

in Stomach = $\int (intake - absorbtion)dt + in\ Stomach_0$;

in Stomach₀: Initial value for “in Stomach”.

$$\text{absorbtion} = \text{In Stomach} / \text{stomach delay}$$

$$\text{Stomach delay} = 22.5$$

$$\text{In Body Waters} = \int (\text{absorbtion} - \text{elimination})dt + \text{In Body Waters}_0;$$

In Body Waters₀: Initial value for “In Body Waters”.

$$\text{max rel elimination} = 0.15/60$$

$$= 0.7 * \text{weigh}; \text{ if sex} = \text{male}$$

volume

$$= 0.6 * \text{weight}; \text{ if sex} = \text{female}$$

$$\text{BAC} = \text{In Body Waters}/\text{volume}$$

Table 1. Alcohol model equations

A stock is an entity (variable) that accumulates something. In the model we are describing two stocks (“In Stomach” and “In Body Waters”). When a model has two stocks we refer to it as a second order system. Therefore, this model represents a second order system.

There are some differences from the simulator used by Jensen & Moxnes (2009) and the simulator used in this experiment. First, our interface includes a graph, which is the main difference between the one used in Jensen and Moxnes’ study. The horizontal axe represents the time and the vertical axe represents the BAC. This feature gives subjects access to historical data. Fig. 2 and Fig. 3 show the visual interface of our simulator.



Fig. 2. Alcohol simulator parameterization screen

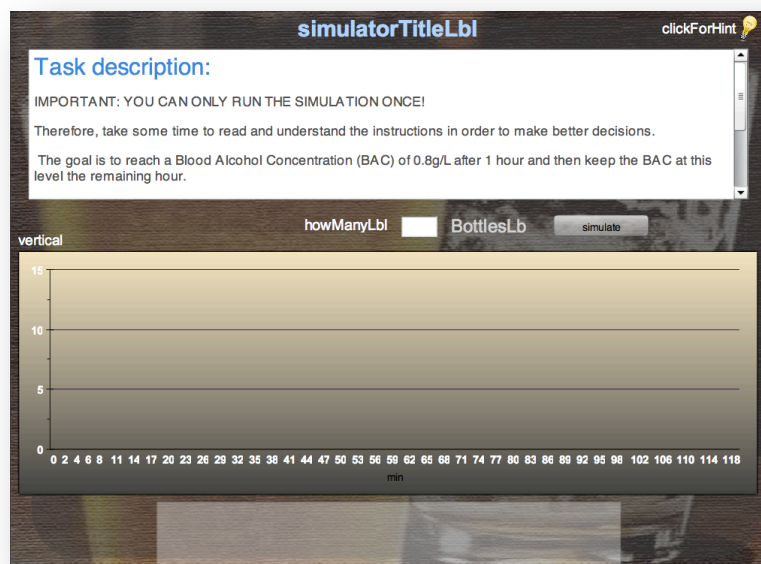


Fig. 3. Alcohol simulator main simulation screen

Similar to Jensen & Moxnes' BAC simulator, we use a stomach delay of 22.5 minutes for our BAC simulator when testing ILE effects. The simulator is included in an online interactive learning environment management system.

Our simulator allows the subject to type decimal number as the number of beers to drink.

Finally our version can be loaded directly on the Internet and the data of the subject is immediately stored in a remote database located in our server.

2.2. Hypothesis for learning policy

In the Jensen & Moxnes (2009) experiment, subjects using a simple simulator as a pre-experience for the alcohol simulator, showed a significant difference in their performances. This pre-experience consisted of a parameterized mouse (computer pointing device) simulator that produced a delay response to the users movements. They found that the group using this simulator had a better performance than those who did not. Therefore, we suspect that the interactive learning environments (ILEs) could help improve the learning process of understanding certain phenomena.

The use of new information and communication technologies (NICT's) into learning environments may improve the processes of learners. Virtual worlds (Schön 1983) provide the learners the possibility of testing their mental models in a controlled and "off-line" world, increasing the possibility of structural changes in mental models.

We want to provide the user with a transparent simulator. We understand transparency as giving access to the subject to the underlying structure of the phenomenon simulated. Transparency seems to have a positive effect in the subjects' performances (Rouwette, Größler and Vennix 2004).

Größler, Maier and Milling (2000) suggested considering different forms of providing structural information in simulation gaming. Taking this in account, we have developed a graphical interface that clearly shows the relationship between the elements involved in the simulator.

The analogy may play an important role in knowledge acquisition, according to Rouwette, Größler and Vennix (2004) mental model similarities is found to have a significant effect on the subjects' performances. We assume that analogies may enable the subjects to transfer knowledge from previous experiences to new challenges.

We believe that individuals are able to change conceptual structures. The conceptual structures remain without significant changes, while there is equilibrium between them and the phenomena that they represent. We are concerned about the "motor" of change

that can induce a conceptual structural change in individuals. This is one of the key issues that we attempt to address with our ILE. That is, it should challenge the subject to use the cognitive structure as a problem-solving device. Accordingly, we expect that there will appear a cognitive conflict that can lead to changes in the conceptual structures of individuals (Duschl, Philosophy of Science, Cognitive Psychology, and Educational Theory and Practice 1992).

Since learning is a key concept in this work, we assume it as the gain of new knowledge, skills, values, preferences or understanding. Particularly, we adopt Piaget's general conception of the nature of knowledge, which is divided in five characteristics: It is cognitive, constructivist, it involves the epistemic subject, it is interactivist and it is rooted in the operatory praxis (Duschl, Philosophy of Science, Cognitive Psychology, and Educational Theory and Practice 1992).

These statements motivate our hypothesis, which reads as follows: The learning process of the delay concept in second order systems can be improved and accelerated by providing an ILE that triggers cognitive conflicts and a methodological transfer of knowledge between similar phenomena. A partially transparent ILE can reinforce structural relationships in mental models by forcing the subject to find explanations to experienced behaviors.

2.3. The funnel analogy

In order to achieve our goal, we need a phenomenon that is similar in structure with the BAC model proposed by Jensen & Moxnes (2009). Hence, we created "the funnel model". This model achieves two important characteristics: it represents a phenomenon in which a large group of people is familiar with and it is similar in structure with the BAC model according to Jensen & Moxnes (2009) as is shown later on.

The funnel model represents a system where a glass is filled up with water that first flows through a funnel. The water runs into the funnel from a tap. Additionally a pump sucks a small amount of water from the glass at a constant rate.

All the subjects that participated in the laboratory experiment reported that they have had experience with the funnel phenomenon. Accordingly, we addressed the constructivism aspect of our hypothesis.

The model is based on a stock and flow diagram shown in Fig. 4 and it uses the symbols defined in the field of System Dynamics (J. W. Forrester 1961). Rectangles denote stocks (levels) and double lines denote flows. The rest of the diagram represents variables that deal with how flows are controlled. In equations, we used symbols that are abbreviations from the variable names. We will also illustrate systematically the analogy by comparing our model components with the BAC model proposed by Jensen & Moxnes (2009).

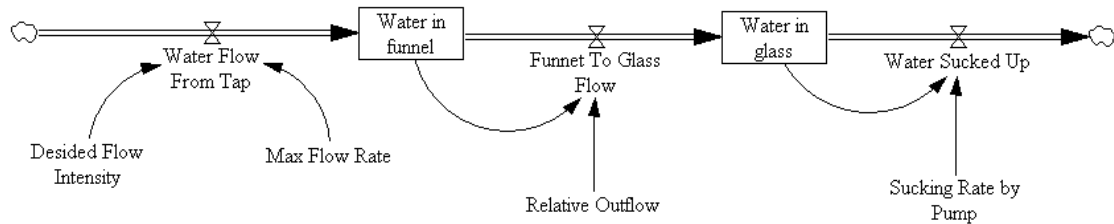


Fig. 4. Stock and flow diagram of the funnel model

The water flow from the tap (WFT) in L/sec

$$WFT = \text{MIN}(MFR, DFI) \quad (1)$$

is given by the minimum values between the maximum flow rate from the tap (MFR) and the decided flow intensity by the user (DFI). In comparison with the BAC model, WFT is similar to the Intake (I). The difference from Jensen & Moxnes's model is that they extracted the alcohol from the bottles of beers and then converted this value in an alcohol intake rate by dividing the time interval between decisions of the user. In contrast to them we added an upper limit to the model for the flow from the tap. Also, there is no need to divide by any time interval, since the decision given by the user is already given in L/sec. The amount of water in the funnel (WF) (L)

$$WF = \int (WFT - WFF)dt + WF_0 \quad (2)$$

increases with the water flow from the tap (WFT) and is reduced by the water flowing from the funnel to the glass (WFF). Initially there is no water in the Funnel, $WF_0 = 0$. Compared with Jensen & Moxnes' model, the amount of water in the funnel could be

compared with the amount of alcohol in the stomach. The water flowing from the funnel to the glass (WFF) (L/sec)

$$WFF = WF * RO \quad (3)$$

is equal to the water in the funnel (WF) times the predefined relative outflow (RO) (1/sec), which we assumed as 0.2, $RO = 0.2$. Even when the fluid dynamic behind this particular part of the model is more complex in reality, this is a good enough approach for the purposes of this work. Initially, the amount of water in the glass (WG) (L)

$$WG = \int (WFF - WS)dt + WG_0 \quad (4)$$

is zero, $WG_{0=0}$. It increases with the water flowing from the funnel (WFF) and is reduced by the water sucked up by the pump (WS) (L/sec)

$$WS = \text{MIN} (WG, SR) \quad (5)$$

As soon as the amount of WG is high enough, the water sucked up (WS) is constant and equal to sucking rate (SR) (L) equal to 0.01 ($SR = 0.01$). The Min-function introduces nonlinearities in the model and ensures that no more water than is available is sucked up from the glass.

The water in the glass can be compared to the amount of alcohol in body waters on Jensen & Moxnes' model, which is proportional to the BAC.

The water sucked out of the glass is a simplified analogy of the process of elimination of alcohol from the body water, described in Jensen & Moxnes' BAC model.

In contrast to Jensen & Moxnes' model, the funnel model runs continuously. Initially our model was designed in a manner that the subject could take decisions every two simulated seconds. However, a pilot experiment showed that this fact created a gap between the simulator and the experience that the subjects had with the phenomenon before.

The development process of the software was cyclic and divided in five stages according to the Rational Unified Process (RUP): requirements, analysis and design, implementation, test and deployment.

In order to test and improve the software artifacts developed; a pilot experiment took place at EAFIT University in Medellin, Colombia. In the pilot nine people participated. They came from different professional backgrounds including: graphic design, computer science, biomedical engineering, public accounting and administration.

The pilot helped us identify the key problems that may appear during the real experiment. We collected feedback information from the subjects about their experience with the ILE. This information was used to improve the experimental and software design.

2.4 Treatments

The experiment had five treatments based on two criteria. The first one was the transparency of the funnel simulator and the second one was according to the information provided about the analogy between the funnel and the alcohol models. We refer to this as enlightening.

The funnel simulator can be loaded in two modes: transparent and opaque. When it is open in “transparent-mode” the program allows the subject to see the amount of water in the funnel. In contrast, when the funnel simulator is loaded in “opaque-mode”, the subjects can’t see the amount of water in the funnel¹.

Fig. 5 shows the PC screen with the simulator elements. The image to the left shows the funnel simulator in opaque mode and the image to the right shows the funnel simulator in transparent mode.

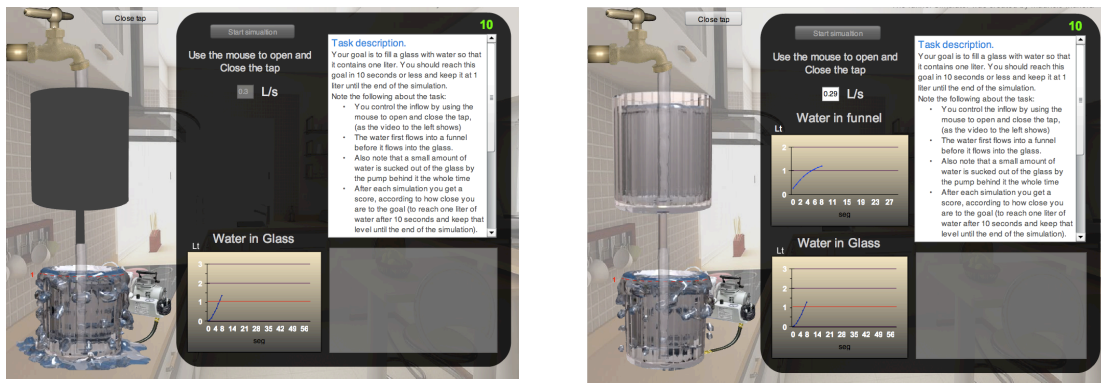


Fig. 5. Opaque (left) and transparent (right) simulator

The five treatments were:

¹ The subjects cannot change the mode of the funnel simulator. Only the administrator has the access to do that.

TI: Interaction with the transparent funnel simulator and the alcohol simulator with information about the analogy (total of subjects = 19, cases excluded = 11).

T: Interaction with the transparent funnel simulator and the alcohol simulator without information about the analogy (total of subjects = 20, cases excluded = 10).

OI: Interaction with the opaque funnel simulator and the alcohol simulator with information about the analogy (total of subjects = 20, cases excluded = 8).

O: Interaction with the opaque funnel simulator and the alcohol simulator without information about the analogy (total of subjects = 21, cases excluded = 10).

NF: Interaction only with the alcohol simulator (total of subjects = 19, cases excluded = 10).

2.5 Further design issues

2.5.1 Learning environment platform: technical aspects

The simulator has been created as a web application. Running the simulator on the Internet as an online application allows us to avoid on-site installation. In addition, having a web based learning environment system (LMS) permitted us to trace the activity of the subjects during the experiment, have a controlled authentication system and include online questionnaires, which we used for post-testing purposes.

The simulators are entirely developed in Action Script 3.0. For the 3D animations, we used Blender. For the server-side scripts we used PHP, and Moodle supported the rest of the learning management system.

The main features of the software are:

- It runs both as a standalone and web-application.
- It is multilingual.
- It can easily be embedded in a learning management system.
- The simulation engine is fully embedded into the application.
- It is parameterizable.
- It uses 3D components to increase the realism of the application.

- The supporting platform has an authentication system that only allows access to registered subjects and administrators.

2.5.2 Experimental design

For the funnel simulator, the experimental task was to fill a glass with water so that it contains one liter. The subjects have to reach this goal in 10 seconds or less and then keep this level until the end of the simulation. In order to reach the goal, the subjects had to take in account the following considerations:

- They could control the inflow by using the mouse to open and close the tap.
- The water first flows into a funnel before it flows into the glass.
- Also note that a small amount of water is sucked out from the glass by a pump during the whole simulation.

Decisions were made continuously. That is, during the simulation the subjects could manipulate the tap handle at any time during the first 20 simulated seconds.

Subjects within the treatments using the funnel simulator were able to run the simulation as many times they wanted for fifteen minutes.

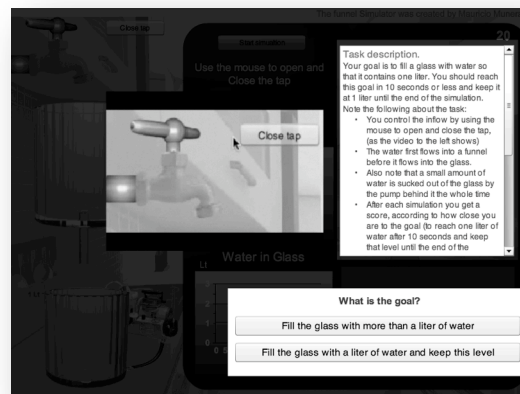


Fig. 6. Welcome screen funnel simulator

Fig. 6 shows the welcome screen for the funnel simulator. This screen includes a simple question about the experimental task. Also, it makes a visual emphasis on the description of the task and the elements to control the simulation².

Fig. 5 shows the elements incorporated in the simulator. The task description was always available for the subjects and it was displayed in the large text area on the right side of the screen. The graph(s) in the middle showed historical amount of water in the glass and funnel³. On top of the graphs, a text field indicated the current flow level. In Addition, a button in the top-center of the screen was used to start the simulation. The subjects could use the mouse to open and close the tap in order to control the inflow. A text area under the task description, showed some feedback information to the subjects and the time left to complete the simulation was displayed on the top-right side of the screen.

The funnel simulator also showed, continuously, an animation of the water flowing from the tap through the funnel and finally into the glass, according to the subjects' decisions.

After simulating for 20 seconds, the simulator closed the tap and displayed a message to the user asking him to pay attention to the water left in the funnel. The program kept simulating until the funnel was empty, the simulator gave a score to the subject ranging from 0 to 100 and invited him/her to simulate again.

The task for the alcohol experiment was similar to the one used in the experiment carried out by Jensen & Moxnes (2009). The subjects had to reach a BAC of 08 g/L in 1 hour and then keep that level the remaining hour. The subjects made decisions each simulated quarter of an hour with assumed uniform drinking over the intervening time intervals. Information was updated each 15 simulated minutes.

² The subjects were not able to start the simulation before answering the questions correctly.

³ The funnel in transparent mode shows both the graphs for the historical levels of water in the funnel and the glass. However, the funnel simulator in opaque mode only shows the graph for the level of water in the glass.

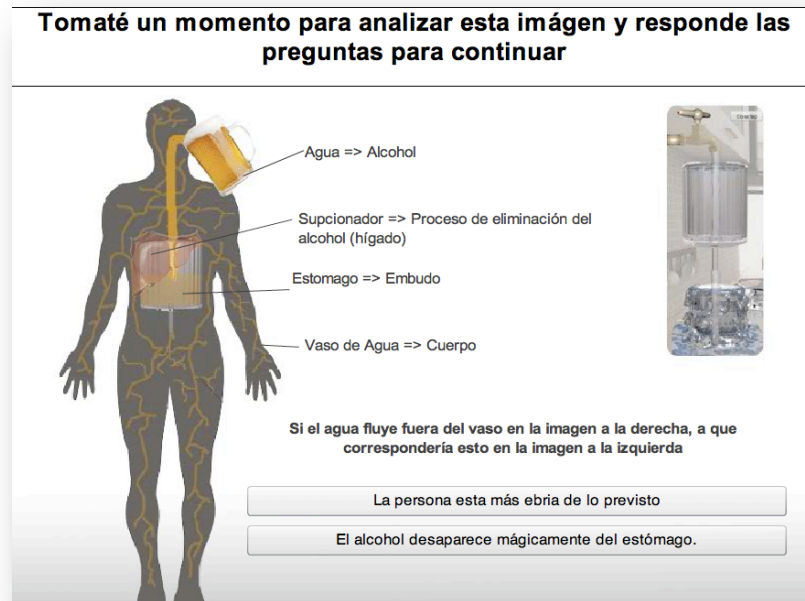


Fig. 7 Analogy hint screen in the alcohol simulator

Fig. 7 shows the PC screen illustrating the analogy between the funnel model and the model of the BAC. We refer to this screen as the hint screen. Only those subjects within the treatments TI and OI saw the hint screen when starting the alcohol simulator. The subjects within the other treatments went directly to the parameterization screen when loading the alcohol simulator. In order to close the hint screen, the subject had to answer correctly a few questions about the analogy.

Fig. 2, shows the PC screen for the parameterization of the alcohol simulator. In this screen the subjects entered their weight and gender and then continued to the screen showed in Fig. 3, this is the screen for the actual simulator.

In the alcohol simulator, the subjects were able to see; a text area with the task description, a graph showing the historical and current levels of the BAC, a text box where the subjects typed in their decisions and a feedback text area where the information to the user was showed. For those subjects with access to the hint screen, a button to display the hint was also shown in the simulator screen.

The subjects were able to run the alcohol simulation once only.

The subjects were paid according to the average deviation from the BAC target in the period from 1 to 2 hours; they were told that payments would range from 3.000 COP to 10.000 COP depending on their performance. They were told that the information, including payoff, would be confidential. We advised the subjects not to take the alcohol simulator as an exact indication of their own tolerance levels. We did not serve alcohol and therefore ethical issues have not been considered (Pratt and Davidson 2005). The subjects were informed about the effects of the target BAC value. The subjects were also asked not to speak to anybody else other than the administrator of the experiment. They were able to raise their hands and ask the administrator of the experiment about the experimental task or the simulator interface. All the given information and the software interface were given in Spanish.

The experiment was carried out in two high schools in Medellin, Colombia, in 2010; one was an all boys' school and the other one was a mixed school, but only girls were chosen for the experiment to have an equal number of boys and girls. A total of 100 students participated in the experiment. The subjects were between 16 and 17 years and were chosen randomly from different classes. 96% of the students reported having consumed alcohol, even though the minimum legal age to consume alcohol in Colombia is 18 years. Participants were recruited from different classes. We had two sessions in each school with 25 participants each. Initially, 20 participants were randomly assigned to a treatment with exception of the treatment 'NF'. After 20 minutes of each session, a group of five new participants were assigned to the treatment NF. Participants worked independently in separate computers in a classroom between ordinary classes. In order to access the ILE the participant needed a username and a password, which was given to them when they were assigned to a treatment.

After the experiment, the subjects filled out an online questionnaire (post-questionnaire). We asked them about their impressions about the ILE, their explanations on their results, their grades in mathematics, and how many times they had been more drunk than initially intended.

One student apparently didn't understand the alcohol experiment and didn't complete the simulation.

At the end of the experiment, each subject was interviewed in order to get verbal feedback and to clarify questions and concerns that subjects might have. This was particular important as a few subjects came with dangerous assumptions after participating in the alcohol experiment as is documented further down in this document.

3. Results

The results are divided according to the simulator they come from.

For the funnel simulator we collected around 1368 records, each containing more than 2500 pieces of data including information about: the user, the location of the computer and each performance. In total there were more than 3'420.000 pieces of data to analyze. We resumed that data in this section.

For the alcohol experiment we collected 100 records with information about the performance of each subject. The analysis of that information is also included in this section.

3.1 Funnel simulator results

When studying the outcomes from the funnel simulator, we found that all subjects reached at some point a score above 85%. We consider a score above 85% as a good result. Both for those with the transparent funnel and those with the opaque funnel the average number of times to reach the goal is 4 to 5 trials with not significant difference between the opaque simulator and the transparent one (average = 4.38 for both cases, t-test $p = .987$).

100 subjects ran the funnel simulator between 8 and 30 times in a period of 15 minutes.

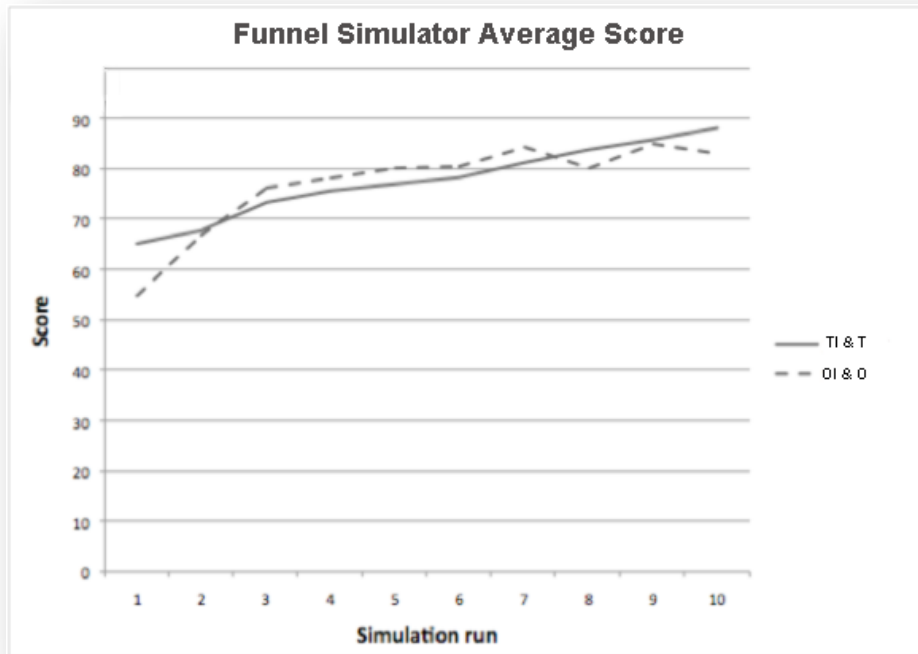


Fig. 8. Funnel simulator average scores

Fig. 8 shows the average score per trial for the treatments using a transparent funnel simulator and the treatments using an opaque funnel simulator. Even though the graph suggests a more rapid score improvement for the treatments using an opaque funnel simulator, there is not a significant difference between the slopes of the curves for the average score in each treatment during the first four periods (Mann-Whitney U test, $p = 0.136$). The graph also suggests a lower score for the initial try in treatments using the opaque funnel, however the difference is not significant (t-test, $p = 0.68$). The average maximum score reached by those using the opaque funnel simulator was a bit higher than the one reached by the subjects using the transparent funnel ($96 > 95.6$), however, the difference is not significant (t-test, $p = 0.432$).

3.2 BAC simulator results

100 (100%) subjects used the alcohol simulator, but to be consistent with Moxnes & Jensen (2009), when analyzing the maximum BAC (MBAC) reached by subjects, we excluded those cases in which the subject continued drinking for several periods after reaching the goal. We initially assumed that in those cases the subject misunderstood

the experimental task. However, these cases are treated later on. In total we excluded 49 % of the samples. Also, one subject did not complete the alcohol simulator and therefore our sample was reduced to 99 subjects in total.

The results for the alcohol post-test experiment are summarized in Fig. 9. It shows the average BAC development together with the target BAC over the eight 15 minute periods for the five treatments involved. There are considerable differences.

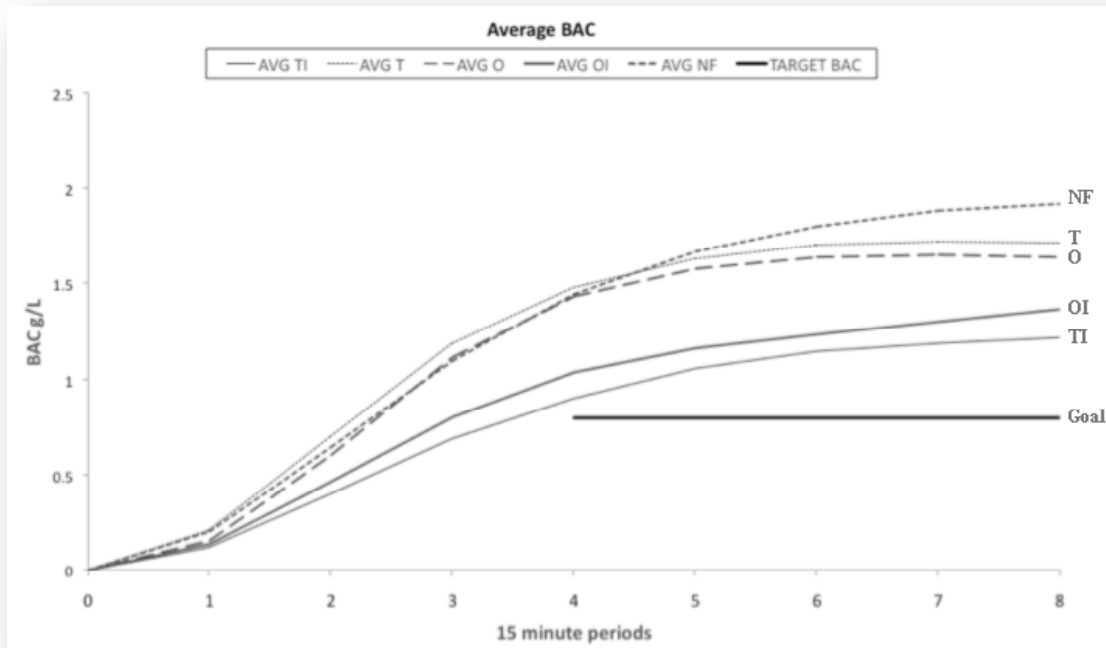


Fig. 9. Average BAC development in five treatments together with target

As in Moxnes & Jensen experiment (2009), the focus is on overshooting intoxication. Therefore, we use maximum BAC (MBAC) obtained by the subjects as a measure of interest. All the subjects reach its MBAC in period 8.

We first tested that the data is normally distributed (Shapiro-Wilk; $p > 0.05$. for all treatments) (Park 2008). For each treatment we used a simple t-test to compare the average MBAC with the target BAC. To compare average MBACs between treatments, a two sample independent t-test was used. When there are few samples, we used non-parametric statistic test under alternative assumptions about distribution and we use a confidence interval of 95% ($\alpha = 0.05$).

In the treatment “TI” the individuals’ MBACs for 8 subjects range from 61% below the target to 202% above the target. Fig. 10 shows all 8 individual BAC developments. The average MBAC is 1.22 g/L ($s = 0.758^4$). While this value is 52% above the target, t test failed to reveal that there is any statistically reliable overshoot. ($p = 0.156$). Hence, it’s still possible that people using the transparent funnel and the information about the analogy reach in average a maximum BAC of 0.8 g/L. There are few cases to consider as a t-test. What is more interesting is to note that 4 subjects end up close to the target. When reading the answers that those subjects gave in the post-questionnaire, we found that two of them based their decisions on their personal experience and the other two did not provide relevant information about their strategy.

Table 2 resumes the answers given by subject who overshoot their BAC levels.

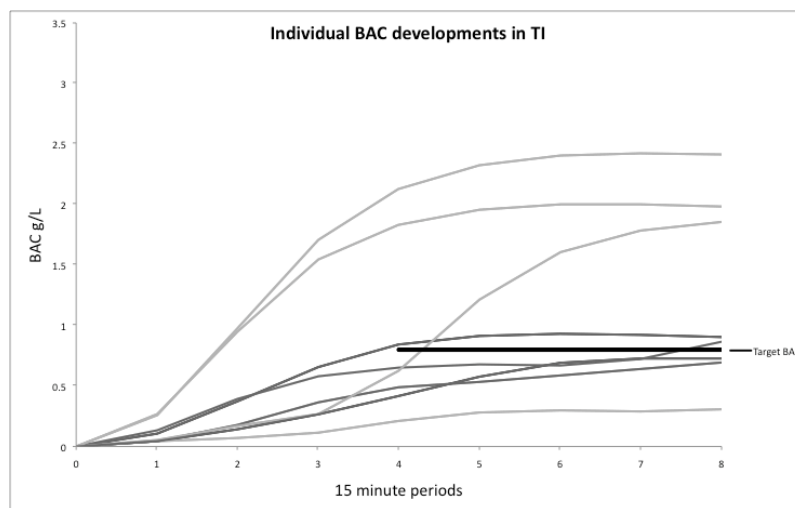


Fig. 10. Individual BAC developments in TI for 8 subjects

In treatment “OI” the individuals’ MBACs for 12 subjects range from 22.5% below the target to 233.8% above the target. The average MBAC is 1.73 g/L ($s = 0.67$), which is 116% above the target BAC ($p = 0.001$) Hence we reject the null hypothesis about no overshoot.

There were two subjects close to the target. When reading their written answers in the post-questionnaire, one of them explicitly shows a knowledge transfer from the funnel

⁴ s: Standard Deviation.

simulator to the alcohol simulator. He/she said: “My score was 94. This is because in the first simulator, I was able to practice many times until I understood that the funnel accumulates a percentage of water and then lets it flow out. Also, I understood that the pump sucks up water every certain time.”[sic]⁵. The other subject did not provide relevant information about his/her strategy.

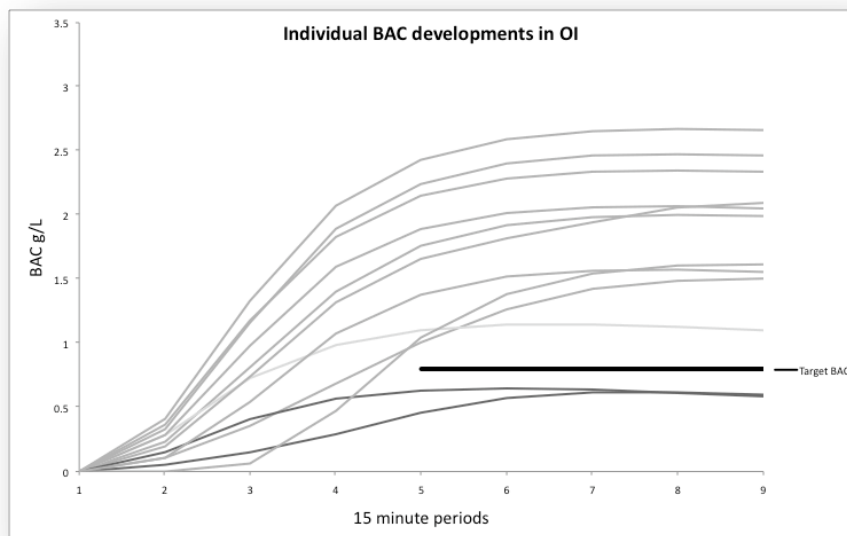


Fig. 11. Individual BAC developments in OI for 12 subjects

In treatment “T” the individuals’ MBACs for 10 subjects range from 5.9% below the target to 278.6% above the target. The average MBAC is 1.66 g/L ($s = 0.8$), The t-test a statistical significant overshoot.

There were five subjects close to the target (42% of the sample). When reading their written answers in the post-questionnaire, one of them explicitly shows a knowledge transfer from the funnel simulator to the alcohol simulator. He/she said: “The truth is, that I thought a lot about it. I did many math calculations, but in the end I realized that the first simulator was very related to the second one. I was very concentrated and I

⁵ Translated from the original text in Spanish: “*Mi resultado fue de 94 esto se debe a que en el primer simulador practiqué varias veces y comprendí que el embudo almacena cierto porcentaje de liquido y luego lo expulsa y que el subsionador cada cierto tiempo extrae un poco de liquido*”

think that it greatly facilitated the decision making in the second simulator”[sic]⁶. Two subjects wrote that they based their decisions on their personal experience and one wrote that he/she tried to be objective and that he/she tried to think well before his/her decisions were made.

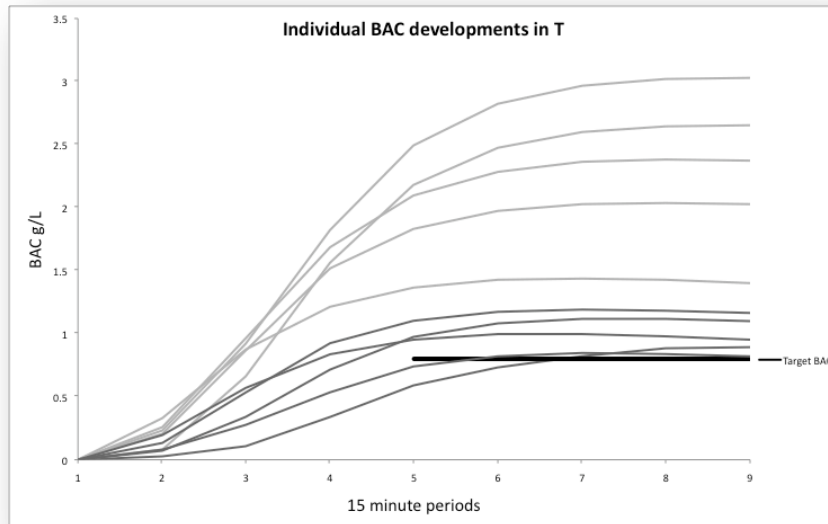


Fig. 12 Individual BAC developments in T for 10 subjects

In treatment “O” the individuals’ MBACs for 10 subjects range from 7.7% below the target to 169.4% above the target. The average MBAC is 1.37 g/L ($s = 0.51$). Even though this value is 71% above the target, a t-test revealed that the overshoot is not significant ($p = 0.007$); we accept with a small margin that it is possible that people using an opaque funnel and not getting information about the analogy will get an average MBAC that doesn’t differ significantly from the target BAC.

There were four subjects close to the target. When reading their written answers in the post-questionnaire, one of them explicitly shows a knowledge transfer from the funnel simulator to the alcohol simulator. He/she said: “Well, in the first simulator, I tried to

⁶ Translated from the original text in Spanish: “*La verdad, la pensé mucho. Hice demasiados cálculos matemáticos, pero al final me di cuenta que el primer simulador tenía muchísima relación con el segundo. Estuve muy concentrada y creo que eso facilitó mucho la toma de la decisión en el segundo simulador.*”

close the tap before reaching half of the glass, because in the first attempts, I overflowed the glass. In the second one, when I saw the level of BAC increasing a lot, I stopped drinking for a while”⁷. The other three subjects did not provide relevant information about their strategy.

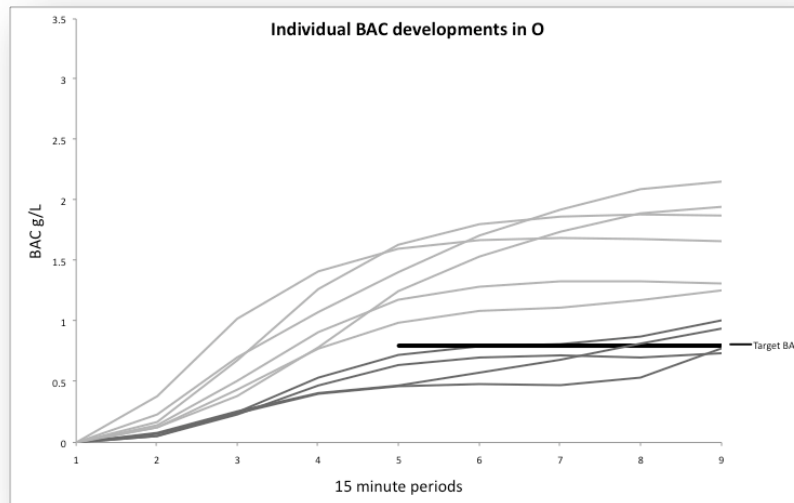


Fig. 13. Individual BAC developments in O for 10 subjects

In treatment “NF” the individuals’ MBACs for 9 subjects range from 2.7% below the target to 229.7% above the target. The average MBAC is 1.92 g/L ($s = 0.58$), which is 140% above the target BAC ($p = 0.000$). Consequently, we reject the null hypothesis about no overshoot.

There was one subject close to the target. This person wrote that he found an analytical way to solve the problem. We show and translate his answer, later on this document.

⁷ Translated from the original text in Spanish: “*pues en el primer simulador trataba de cerrar la llave antes de llegar al mitad ya que en los primeros intentos siempre se me desbordaba el agua. en el segundo cuando vaia q el nivel de alcohol amentaba mucho dejaba de tomar certvezas por un rato.*”

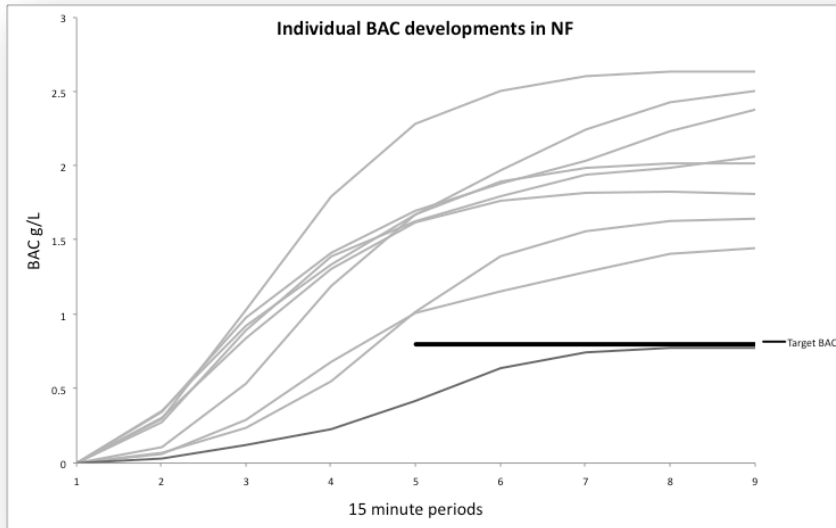


Fig. 14. Individual BAC developments in NF for 9 subjects

Explanation	Treatment	TI	OI	T	O	NF	Total
He/she wasn't careful when taking decisions.		1	4	3	1	5	14
He/she misunderstood the task.		1	2	1	0	0	4
He/she doesn't provide a clear answer		0	1	0	3	2	6
He/she has not experience with alcohol.		0	1	1	0	1	3
He/she was surprised when the BAC increased after stopped drinking.		0	1	1	2	0	4
He/she had problems controlling the simulator		0	1	0	0	0	1
He/she reported knowledge transfer but used a wrong strategy.		1	0	0	0	0	1
Total							33

Table 2. Responses by subjects who overshoot their BAC levels

The average MBAC over all treatments is 1.6 g/L, which is 100% above the target with no significant difference (ANOVA, p=0.2). Comparing the average MBAC (AMBAC)

between treatments using a 2-sample independent t-test, we found that the average MBAC in treatments TI and treatment O are significantly lower than in treatment NF ($p = 0.049$, $p = 0.043$). Table 3 shows the p-values for the hypothesis tests. We are not able to reject the null hypothesis of equal AMBAC among the other treatments.

For the post-questionnaire, we didn't exclude any of the answers from the subjects. Initially, we look at the feedback we got from the subjects about the simulators. We received 89 positive feedbacks, four negatives and six neutrals. Within the positives feedbacks, people expressed that they found the Interactive Learning Environment (ILE) very interesting, creative and entertaining. On the other hand, the negative feedbacks were related to the fact that people didn't understand the purpose of the experiment. When we couldn't classify the answer within the last two categories, we assumed them as neutral.

Independent t-test of AMBAC, $\alpha = 0.005$, Equality of variances assumed (Levene's Test for Equality of Variances with $p > \alpha$) for all treatments	
H_0	p-vau
TI = OI	0.135
T = O	0.49
T = NF	0.42
TI = T	0.261
OI = O	0.184
OI = NF	0.5
O = NF	0.043
TI = NF	0.049
OI = T	0.82
TI = O	0.49

Table 3. AMBAC comparison of between treatments

We found that the MBAC of the subjects who explained (in the post-questionnaire) not to understand the experimental task were significantly higher than those who did not mentioned having problems understanding the experimental task (Mann-Whitney U test, $p=0.000$).

We asked people about how many times they had been more drunk than initially intended. The possible answers were: never, once, few times, many times. Consequently, we created four groups of subjects according to their answers. According to Fig. 15 it appears that there are significant differences between the groups, however, due to the small sample size in some of the groups, we refrain from executing any type of inferential statistical procedure.

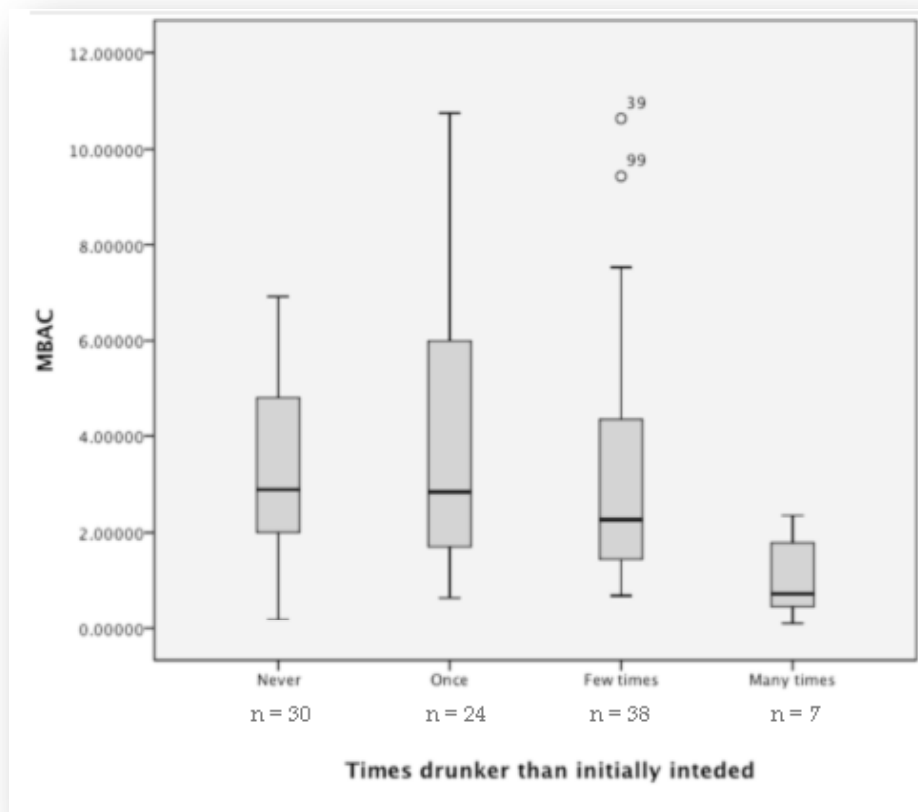


Fig. 15. Boxplot showing the MBAC within groups divided by the frequency of times more drunk than initially intended.

The grades in mathematics the subjects reported didn't seem to have an effect on the their performances (ANOVA, $p=0.272$).

Fifteen subjects achieved a MBAC of 1.1 g/L or less. Eleven people gave informative explanations of their results (open question). One person said: “I deduced a way to calculate an average with only one decision and for the rest I took decisions based on this calculation”⁸. Three people said that they read with attention the instructions and tried to be careful when taking decisions. Three based their strategy on their drinking experiences. Three affirmed that they based their decisions on what they learned from the funnel simulator and one person reported that when he/she saw his/her BAC level going above the target then he/she stopped drinking for a while. Six participants did not give relevant information about their strategy.

When analyzing the answers from the post-questionnaire for 100 subjects, we found that 80 subjects gave informative explanations of their results. Table 4 resumes the most common post-questionnaire answer of subjects.

Answer	Treatment					Total
	TI	OI	T	O	NF	
Subjects who explicitly explained that they did not understand the phenomenon	3	2	6	3	7	21
Subjects who explained that their bad performance was due to a bad initial decision	7	1	1	3	3	15
Subjects who explicitly explained that they based their decision on personal drinking experiences	2	1	1	0	0	4
Subjects who explicitly explained that they made wrong calculations	1	1	2	0	0	4
Subjects who explicitly explained that their bad results were a consequence of their lack of experience with drinking alcohol.	1	2	1	0	0	4
Subjects who explicitly explained that by taking hasty	2	4	3	2	1	12

⁸ Translated from original answer in Spanish “*Deduje una forma de calcular un promedio con una sola decisión, y las demás las hice en base a este calculo*”

decisions, they got bad results						
Subjects who evidence in their answers that they are not aware of accumulation processes involved in the phenomena. ⁹	2	2	3	2	0	9
Subjects that explicitly explained that they didn't understand why their BAC level increased even though they decided not to drink anymore	1	1	1	2	0	5
Subjects who explicitly explained that the task was difficult	1	1	0	1	2	5
Subjects who explicitly explained that they did not put enough attention to experiment and therefore they obtained bad results	1	1	0	1	2	5
Subjects who explicitly explained that they did not understand how to use the simulator properly	0	1	0	0	0	1
Subjects who explicitly explained that the simulator demanded a lot of concentration	0	0	1	3	0	4
Subjects who explicitly explained that they used a numerical approach to solve the problem	0	0	2	0	1	3
Subjects who claimed the need of a better explanation of the task	0	0	1	1	0	2
Subjects who explicitly explained that they misunderstood the fact that the alcohol simulator only could be run once and that expected to be able to run the simulation many times.	0	0	0	1	0	1
Subjects who explicitly explained that they expected an instantaneous decreasing on the BAC level when drinking less bottles of beer.	0	0	1	0	0	1

Table 4. Resumed post-questionnaire answers

⁹ Subject explained that they don't understand why after reducing their drinking, their BAC levels kept increasing. Some decreased their drinking to zero bottles, others decreased to less or equal number of bottles than their previous drinking decisions.

We found 4 explicit answers in the post questionnaire, which indicate certain level of understanding of accumulation processes. We find important to document these answers since they support the purpose of this work pretty well. One subject from treatment TI wrote: "The simulator was very clear. It compares how the body consumes the beers (alcohol) using the tap, the funnel and the glass model. It is possible to see that when drinking one beer like in the funnel, the stomach, accumulates the liquid and eliminates it relatively slowly according to the inflow. The body requires some time to consume what is inside."[sic]¹⁰. Another subject, also from treatment TI, wrote: "I did not take proper account of the funnel system and thus I took more bottles than needed after the first decision, which added to funnel effect, and therefore, I ended up with values above the goal"[sic]¹¹. A subject from treatment OI wrote: "My score was 94 due that in the first simulator I was able to practice many times until I understood that the funnel accumulates certain percentage of liquid and then it lets it flow out and that the pump sucks water every certain period."[sic]¹². One subject from Treatment O wrote: "Well, in the first simulator I tried to close the tap before reaching half (of the glass) because of, in the first trials, I always overflowed the water. In the second one, when I saw the BAC level rising a lot, I stopped drinking for a while." [sic]¹³

¹⁰ Translated from the original text in Spanish: "*el simulador estuvo bastante claro , el cual compara como el cuerpo consume las cervezas (alcohol) con el esquema de la canilla el embudo y el vaso. se puede ver que la tomarse una cerveza al igual que en el embudo , el estomago va acumulando el liquido y lo que expulsa es relativamente poca cantidad con respecto a la que se ingiere y se necesita de bastantico tiempo para que se consuma todo el liquido que hay dentro del cuerpo*".

¹¹ Translated from the original text in Spanish: "*No tome bien en cuenta el sistema del embudo y por esto tome mas botellas de las necesarias despues de la primera decicion lo que se sumo con el efecto del embudo y termine obteniendo datos mucho mayores a los optimos.*"

¹² Translated from the original text in Spanish: "*mi resultado fue de 94 esto se debe a que en el primer simulador que pude paracticar varias veces pude comprender que el embudo almacena cierto porcentaje de liquido y luego lo expulsa y que el subsionador cada sierto tiempo extrae un poco de liquido*".

¹³ Translated from the original text in Spanish: "*pues en el primer simulador trataba de cerrar la llave antes de llegar al mitad ya que enlos primeros intentos siempre se me desvordaba el agua. en el segundo cuando vaia q el nivel de alcohol amentaba mucho dejaba de tomar certvezas por un rato*".

4. Discussion

Once we got the results, we are interested in analyzing deeper and try to understand where the results come from.

We are interested in understanding how it is possible to improve mental models of subjects in order to improve their understanding of accumulation processes. We looked at how the subjects responded to the feedback obtained in the BAC simulator (BAC levels). Their decision patterns can give us clues in order to model a hypothesized behavior. In this section we discuss and propose a hypothesized simple feedback strategy to simulate subjects' performances. This can help us to detect misperceptions about accumulation processes. This can lead us to further future improvements of our ILE.

We also discuss why it is important to look only at the user performance to test competence based on the U-shaped phenomenon that occurs in learning environments.

Finally, This work has come out with important conclusions, besides that it has raised new questions and new horizons for further research. We describe later on in this section what the next steps are to follow this research.

4.1 Simple feedback strategy

We noted in the data that a common mistake among the subjects with high levels of BAC was to choose a large amount of beers in their first decision. We conducted an interview with each participant when we proceeded with payment. We perceive that almost all the subjects that choose a large number of beers, except for one person, didn't link the task in the BAC simulator with the reality at the very beginning. Most of them verbally expressed that drinking 4 or 5 beers in 15 minutes is something that they would not normally do. Choosing too many bottles of beer at the beginning of the simulation will lead to high levels of BAC no matter what the future decisions are during the rest

of the simulation. Since we are aware of this misperception, it is more interesting to analyze the subjects' decisions after reaching the target BAC than only focus on their BAC levels.

We notice from some of the results, that some people slowly decrease the number of beers to drink instead of avoiding drinking. This suggests that some subjects believe that there is an instantaneous effect of the number of beers drank and the BAC level and therefore they expect that by decreasing the number of beers it will decrease the BAC level. This is a misperception of the accumulation processes. By looking at all the subjects' decisions and their BAC levels we were able to categorize the subjects into four different groups defined as follows:

- Category 1: Subjects that stopped drinking after reaching the target BAC. People in this category evidenced understanding of the accumulation of alcohol in the stomach stock.
- Category 2: Subjects that slowly decreased their drinking after reaching the target BAC for at least the next two periods. People in this category misperceived accumulation processes as explained earlier. Either they believe in a static model or a high outflow rate (metabolism).
- Category 3: Subjects that increased their drinking after reaching the goal. We assumed that the people in this category either did not understand the task or didn't follow the instructions properly.
- Category 4: Subjects that stop drinking after reaching the target BAC, but that after noticing that the BAC levels kept increasing ended up in frustration and then increased their drinking.

We believe that from a constructivist point of view, it is not appropriate to define competence in terms of performance (Camp 2010) (Duschl and Hamilton 1993). In the particular case of the alcohol experiment, subjects not only had to deal with finding a good strategy to solve the task, but also with uncertainty. Many subjects confirmed in the interview after the interaction with the simulator, that the reason why they got high levels of BAC was because they introduced a large number of beers at the very beginning of the simulation, which led to a sudden overshoot no matter what the next decisions were. If that is true, the performance (BAC level) would not give us relevant

information about their strategies. Therefore by creating the categories defined before we are able to get richer information about their strategies. In particular by using this method we obtain some clues about their awareness of the delay caused by the stomach in the BAC model. Since the purpose of this work is to improve the learning processes of delays, we are most interested in studying what could have triggered strategies that took in account water analogies.

By looking at Fig. 16 and Table 5, a bigger proportion of subjects in treatment OI used strategies that evidenced a certain level of understanding of delayed processes. The data evidence shows that a semitransparent ILE with information about the analogy could help improving the understanding of accumulation and delayed processes as our initial hypothesis indicates.

We are aware that if a subject stopped drinking after reaching the goal, it doesn't necessarily mean that they were aware of the delay in the system before reaching the goal, however it evidences that at least they considered that even though the BAC levels could keep increasing, the best option was to stop drinking. In other words, they decided to wait and see the BAC behavior over time, instead of expecting an instantaneous effect of the bottles of beer drunk and the BAC level. That is not particularly the case of the strategies falling into Category 2. In that case the subjects evidenced a clear misperception of the delay and instead established an instantaneous relationship between the intake of alcohol and the BAC levels. Even more, based on the observations of their strategies, they seem to expect that by decreasing the intake rate of alcohol the BAC level will decrease in the same way.

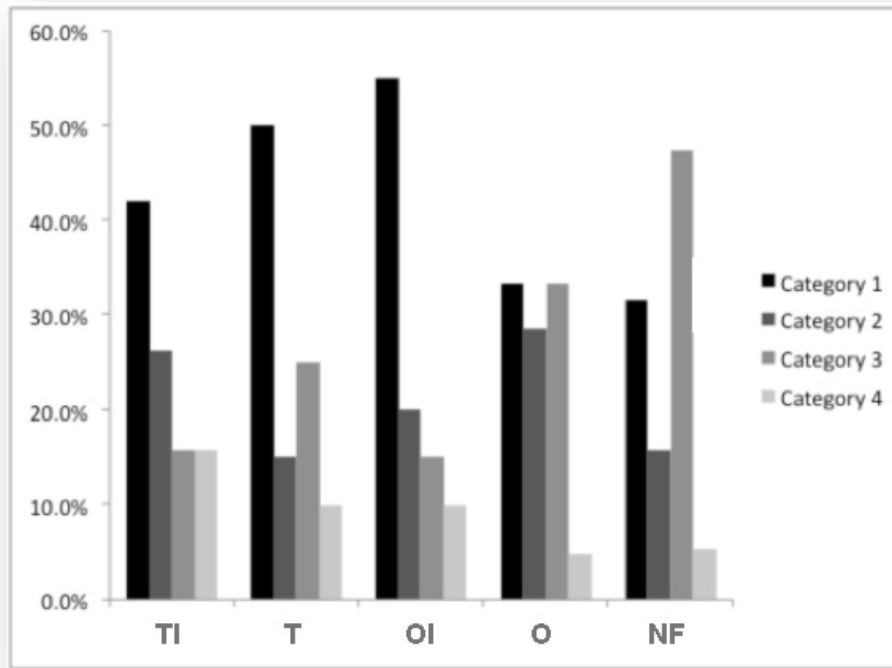


Fig. 16. Categorized subject's strategies

Treatment	Category 1	Category 2	Category 3	Category 4
TI	42 %	26 %	16 %	16 %
T	50 %	15 %	25 %	10 %
OI	55 %	20 %	15 %	10 %
O	33 %	29 %	33 %	5 %
NF	32 %	16 %	47 %	5 %
Total percentage overall treatments	42 %	21 %	27 %	9 %

Table 5. Percentage of subjects within categories

For the case of the strategies falling into Category 3, we believe that either the subjects didn't understand the task or they didn't understand the dynamic behind the phenomenon. Subjects behave as if they expect that the more they drink, the less intoxicated they get.

In Category 4, subjects seem to have a mental model in which to stop drinking after reaching the goal is the best option; so far, so good and the water analogies seems to help. However, a cognitive conflict appears when they stop drinking more and the BAC level keeps increasing. It seems that they questioned their mental models and then tried other strategies based on wild trial-and-error instead of strategies relying on their mental models.

Previous studies evidenced the misperception of delays and the use of strategies based on static mental models to solve dynamic tasks (Moxnes 2004, Moxnes and Jensen 2009, Moxnes and Saysel 2009, Jensen 2005). Jensen & Moxnes (2009) believed that the subjects overshoot their BAC due to a misperception of the delay caused by the stomach. Their hypothesis is that the subjects used a simple feedback strategy based on a static mental model to describe the phenomenon. Our results showed a similar pattern. Here we propose two different hypotheses for the feedback strategies according to the categories defined previously. It is important to notice that it is beyond the scope of this work to propose an absolute general strategy for each case. However our hypothesized behavior tries to explain the most representative strategies within Categories 1 and 2.

When we observed the subjects' decisions in this category, we found very interesting patterns. Most of the subject slowly decreased their drinking to a specific value, however after at least one period, they suddenly increase their drinking forming the picks that can be appreciated in Fig. 17. According to our theory, subjects in this category misperceive the accumulation produce by the stomach, and instead it seems that they are seeking a drinking value that lead their BAC levels to the target as shown in Fig. 18. That could explain why they are decreasing their drinking slowly, but, why did they increase their drinking again? We believe that it is product of frustration.

This behavior is not rare. Moxnes (2004) found a similar pattern in his reindeer experiment. Once the subject reaches the target, the subject realized that his/her strategy, based on his mental model, is not working since their BAC kept increasing. It seems that they question their strategy and frustration affects his decision-making process. Once a subject reached the goal, he/she only has two options, stop drinking or increase their drinking. In this case it seems that they chose to increase their drinking in order to decrease their BAC levels.

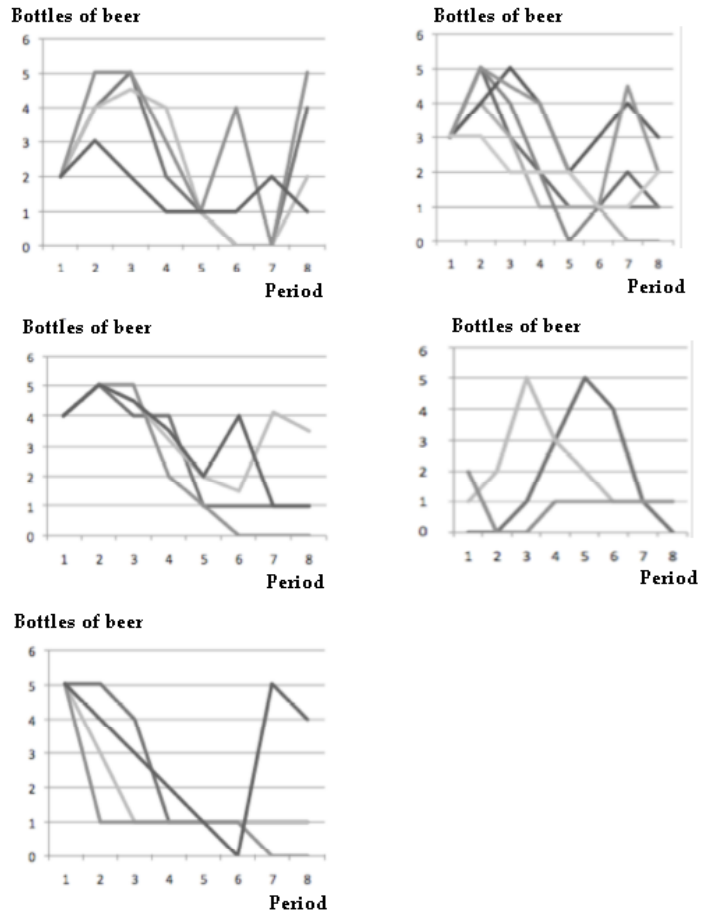


Fig. 17. Decision pattern in category 2

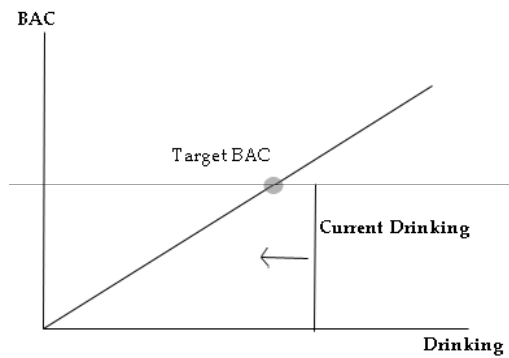


Fig. 18. Graphical approach to the hypothesized behavior

We believe that subjects in Category 2 used a simple feedback strategy to solve the task in our alcohol experiment. In fact, we found some similarities between the hypotheses

that we are about to define Category 2 and the one proposed by Moxnes (2004) in his reindeer experiment. We believe that the subjects adjusted their decision based on their last decision (D_{t-1}) and the gap between the target BAC (DBAC) and their current BAC level. The aggressiveness of the strategy (α) and the initial decision (D_0) varies among the subjects' performances. The subjects in this category gradually decreased their drinking after reaching the target BAC level. We proposed the following feedback strategy according to that behavior.

$$D = D_{t-1} + \alpha ((DBAC - BAC) / DBAC) \geq 0 \quad (6)$$

D denotes the decided number of beers to drink in the next 15 minute period.

Fig. 19 shows a stock and flow diagram for the hypothesized simple feedback strategy in Category 2. Previous studies have shown that subjects use similar strategies to solve dynamic systems with second order delays (Moxnes 2004).

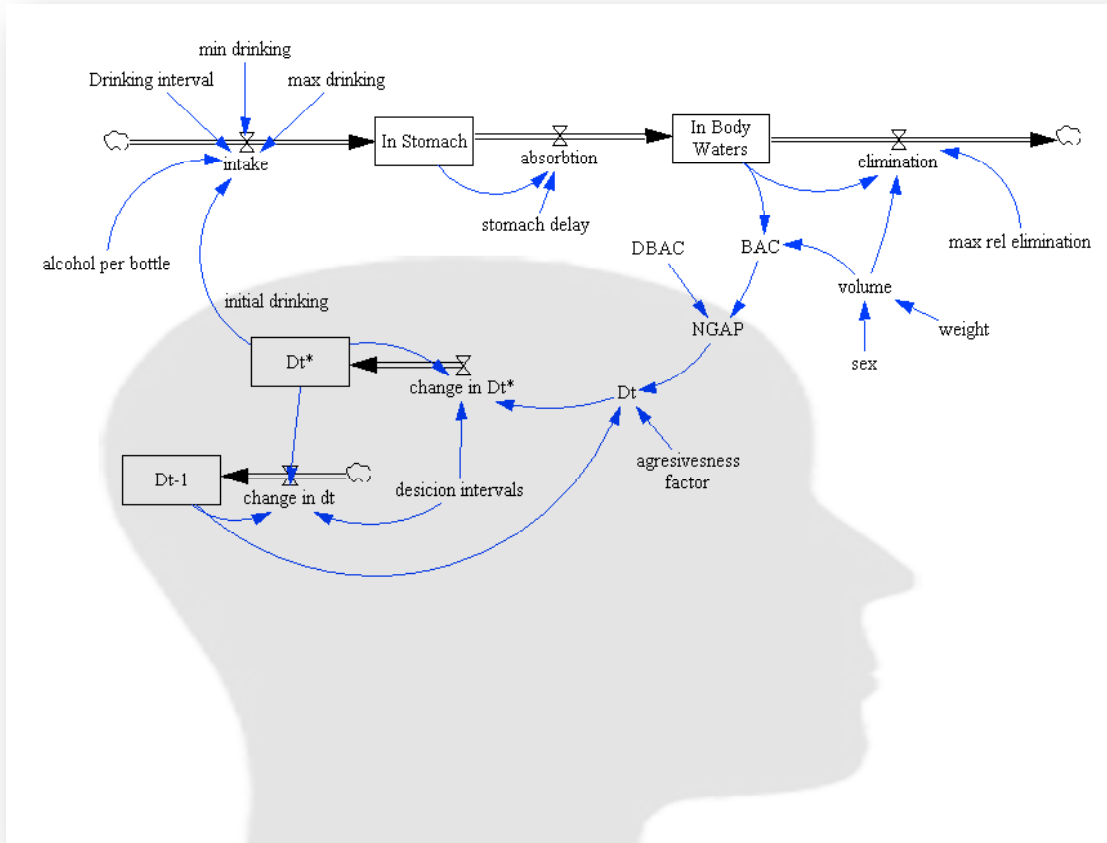


Fig. 19. Stock and flow diagram for the feedback strategy in Category 2

Fig. 20 shows the average BAC development for subjects in Category 2 together with the simulated average behavior. In the background we drew all the BAC development for subjects in this category. We were able to achieve a great fit between the observed behavior and the simulated behavior.

We use the average BAC development as an anchor graph. Fig. 21, Fig. 22 and Fig. 23 show the effect of the initial decision, the aggressiveness of the strategy and the subject's weight, on the curve. Using these parameters makes it possible to approach most of the observed subjects' behavior in Category 2.

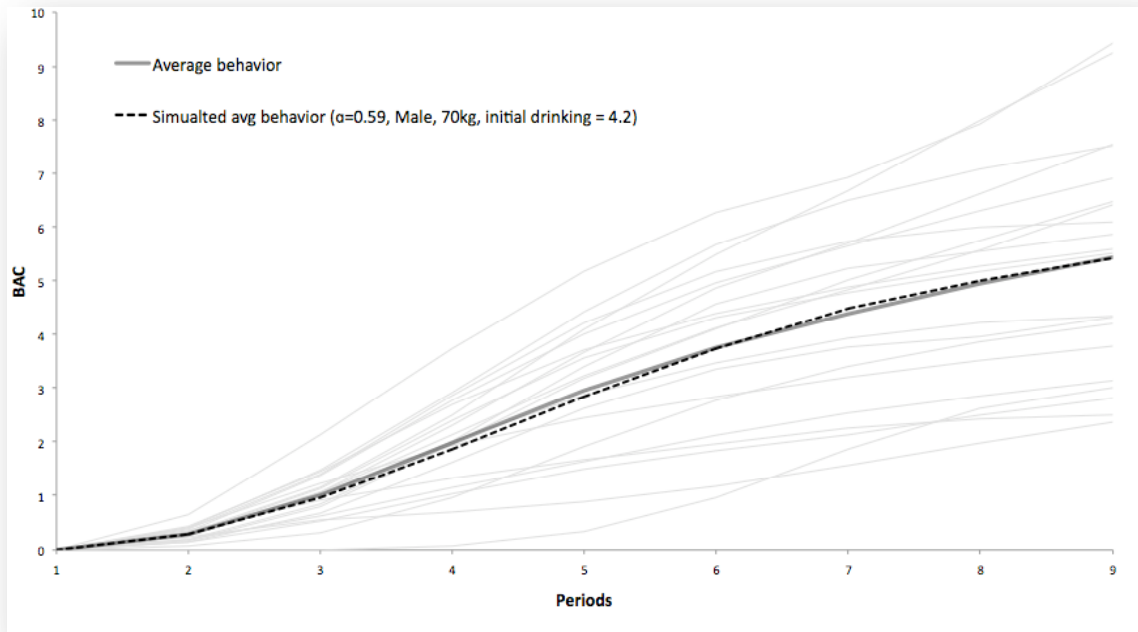


Fig. 20. Average simulated behavior for category 2 ($\alpha=0.59$, Male, 70kg, initial drinking = 4.2)

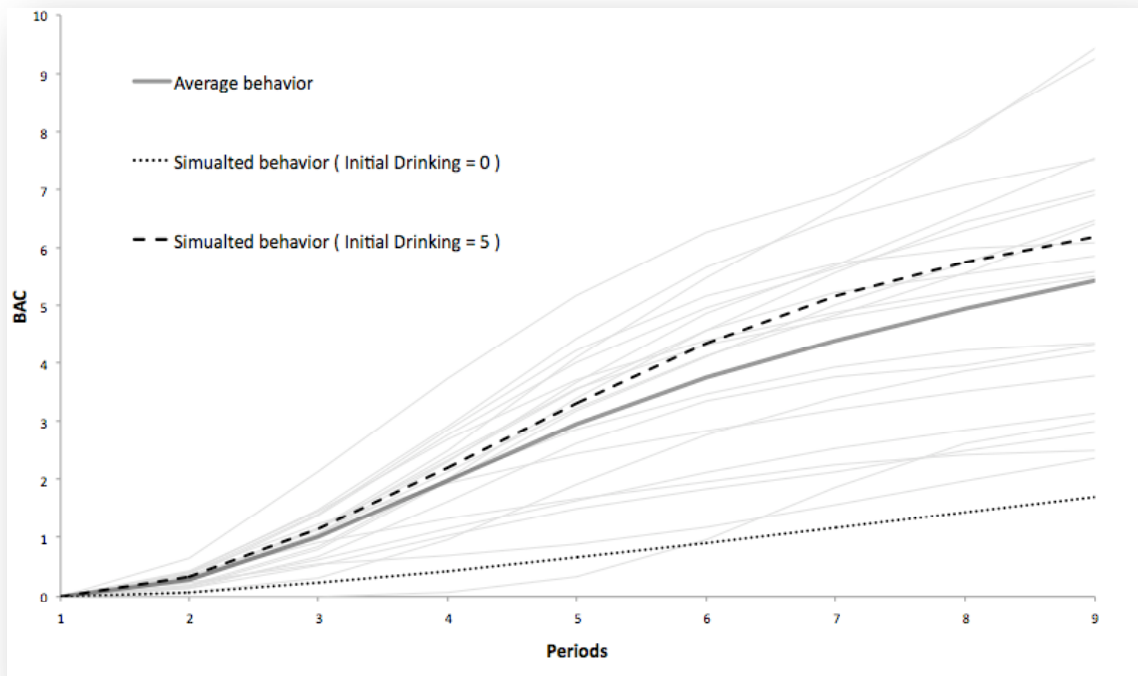


Fig. 21. Simulated behavior for two different values of initial drinking ($\alpha=0.59$, Male, 70kg)

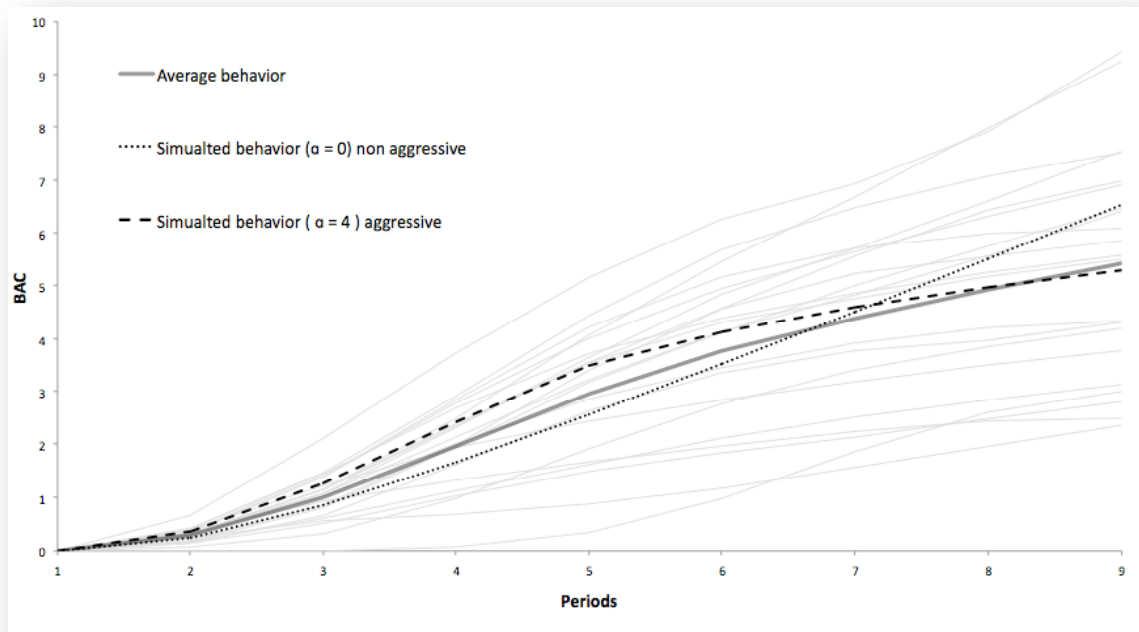


Fig. 22. Simulated behavior for two different aggressiveness (Male, 70kg, initial drinking = 4.2)

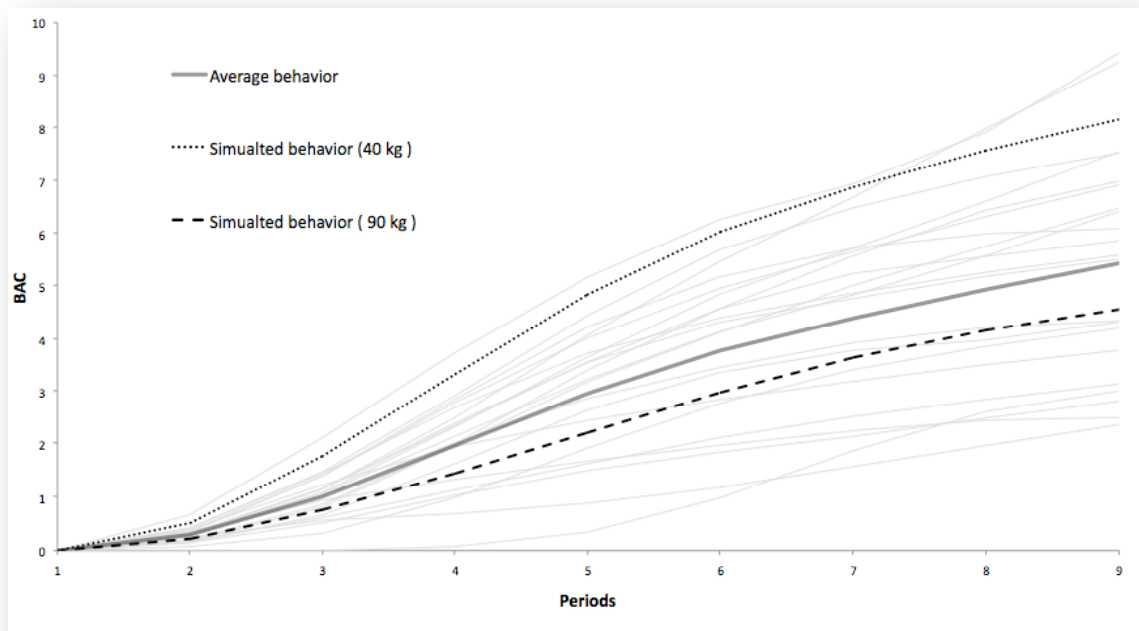


Fig. 23. Simulated behavior for two different weights (Male, $\alpha=0.59$, initial drinking = 4.2)

The subjects in Category 1 also seemed to misperceive the delayed effect produced by the stomach, however, after reaching the goal they stopped drinking. In contrast with

the subjects in Category 2 they don't assume an instantaneous relationship between alcohol intake and the BAC level. We believe that they based their decisions on the gap between their current BAC and the target BAC. The following equation describes our theory:

$$D = (\alpha (DBAC - BAC)/DBAC) + \gamma \geq 0 \quad (7)$$

γ represents the level of alcohol necessary to keep the current BAC steady after reaching the goal.

Fig. 24 shows the average BAC development for subject in Category 1 and the simulated average behavior. In the background we drew all the BAC development for subjects in this category. We were able to achieve a great fit between the observed behavior and the simulated behavior.

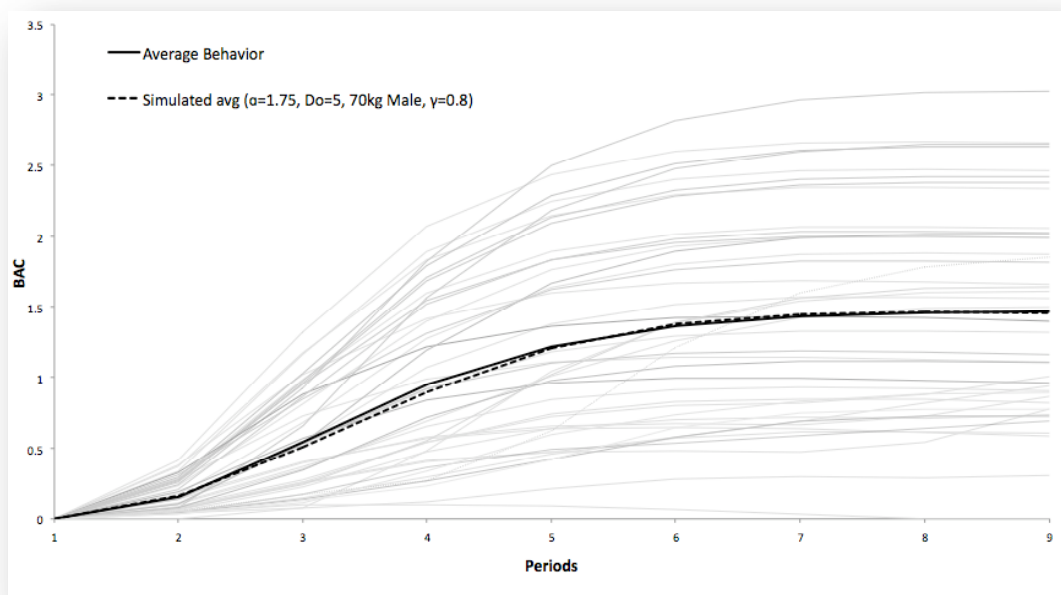


Fig. 24. Simulated average behavior for category 1 ($\alpha=1.75$, $D_0=5$, 70kg Male, $\gamma=0.8$)

We use the average BAC development as an anchor graph. Fig. 25, Fig. 26 and Fig. 27 show the effect of α , γ and the initial decision (D_0) on the curve. Using these parameters it is possible to approach most of the observed subjects' behavior in Category 1.

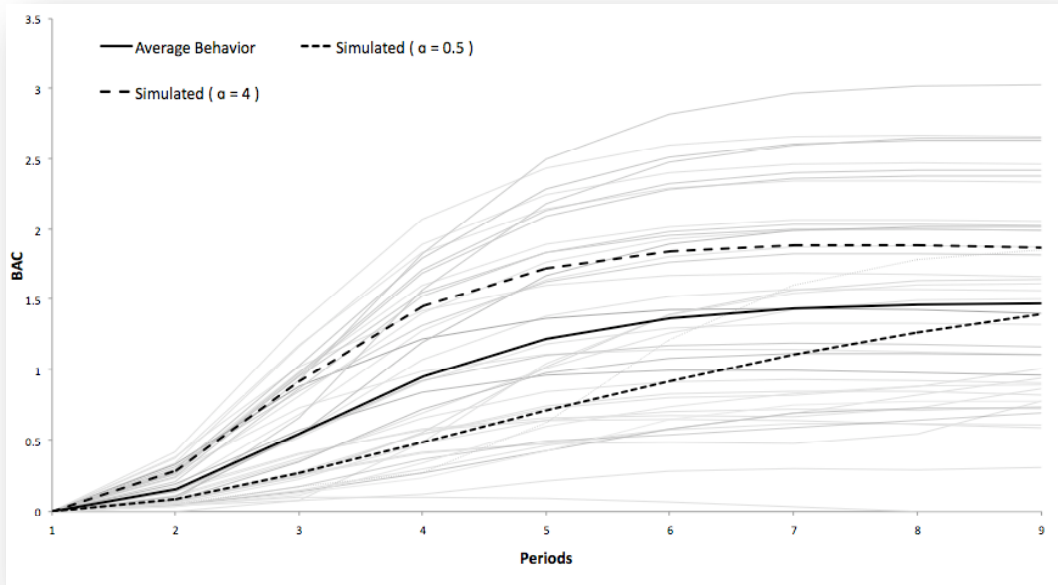


Fig. 25. Simulated behavior with different aggressiveness for category 1 ($D_0=5$, 70kg Male, $\gamma=0.8$)

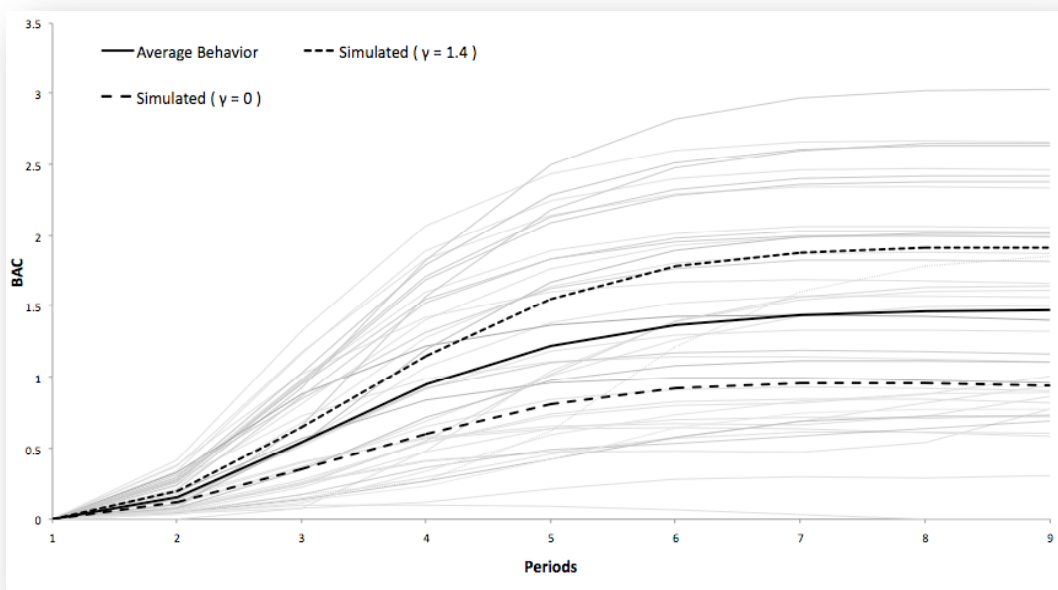


Fig. 26. Simulated behavior with different γ for category 1 ($D_0=5$, 70kg Male)

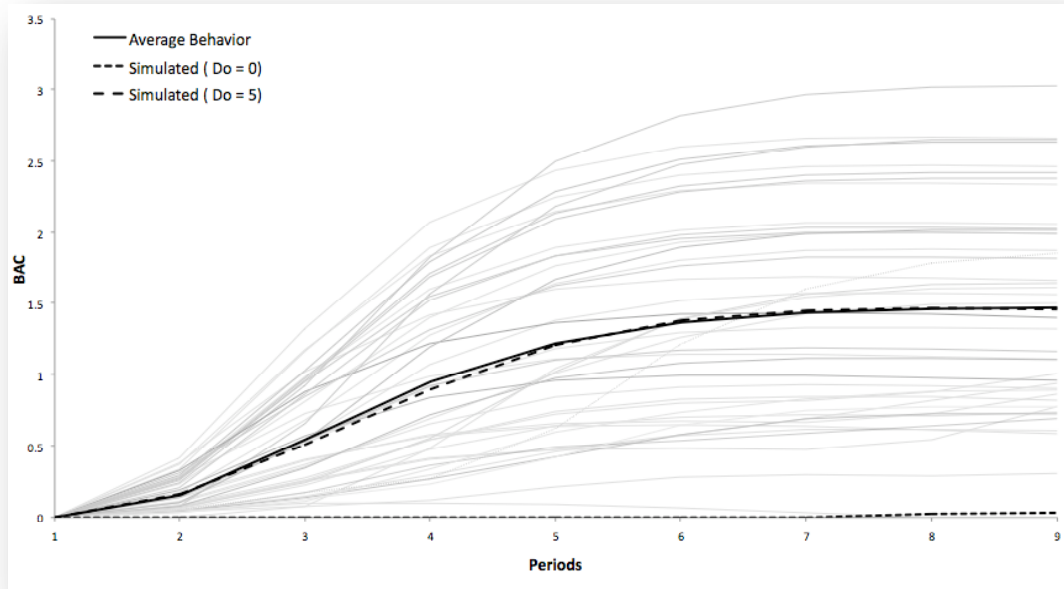


Fig. 27 Simulated behavior with different initial drinking for category 1

This experience was valuable in order to collect relevant information about key issues that may improve the learning processes of delays. Yet, our intervention with the subjects is based on 35 to 40 minutes of interaction. We believe that learning is a slow, iterative, interactive and non-monotonic complex process and therefore there is space for improvements in teaching strategies to develop the understanding of delays.

Since we assumed that the only factor that segregated the subjects is the characteristics of each treatment, we believe some of these characteristics were able to trigger behaviors in the subjects when choosing a strategy to solve the task in the BAC simulator. We suspect that a transparent funnel simulator accompanied by information about the analogy helped the subjects to choose more convenient strategies to solve the task in the BAC simulator. On the other hand, by not providing transparency and information about the analogy together to the subjects, it could reinforce misperceptions and confusion among the subjects.

Previous studies evidenced the misperception of delays and the use of strategies based on static mental models to solve dynamic tasks (Moxnes 2004, Moxnes and Jensen 2009, Moxnes and Saysel 2009, Jensen 2005).

Jensen & Moxnes (2009) believed that the subjects overshoot their BAC due to a misperception of the delay caused by the stomach. Their hypothesis is that the subjects used a simple feedback strategy based on a static mental model to describe the phenomenon. Our results showed a similar pattern.

4.2 A proposal to improve the learning strategy

After this experience we raised new questions that can lead to improvements of our ILE. Is it possible that by extending the interaction between subjects and the ILE, the subjects will be able to achieve better results?

Is the performance really telling us something about their understanding of the phenomenon? Even more, Can we expect a progressive improvement in performance each time the subject interacts with the ILEs? Recent studies in the field of cognitive development lead us in new directions in order to find interesting approaches to answer questions.

Some studies in different fields revealed the existence of non-monotonic development in performance during learning (Camp 2010). There appears to exist a phenomenon known as a U-shaped learning curve where people experience a decrease in performance while they build and restructure new mental models. It means that a decrease in performance does not necessarily mean decrease in understanding of a phenomenon.

Camp (2010) mentioned 3 different categories of explanations for U-shaped development Patterns.

1. “Newly acquired reasoning processes may be over-generalized, and applied in situations for which the new approach is inherently flawed.”
2. “A newly acquired processing approach places greater demands on the processing system than does one that is long experience. Therefore, the greater cognitive load may result in temporary decreases in efficiency.”
3. “The skill in question is actually composed of multiple sub-skills which develop (monotonically) at different rates.”

This new approach inspires us for future enhancements of our ILE. Even though our funnel simulator allowed the subject to iteratively interact with the phenomenon simulated, we believe that intermediate interventions could improve the understanding of delays. This would also help us to mitigate a possible video game syndrome (J. D. Sterman 2006).

Those interventions would consist of an individual, and a group activity. The subject will interact with the simulator for a certain period of time that can vary from 10 to 15 minutes. Then, a short explanation to the subjects about how to create a concept map will take place. Afterwards each subject will create a concept map to describe the phenomenon represented in the funnel simulator. Once the subjects have finished their own concept maps, the subjects will create a collaborative concept map. The administrator of the ILE will control this last activity. When the concept map created by all the subjects is ready, the subject will have to explain in questionnaire a strategy to solve the task in the funnel simulator. The subject could afterwards interact with other simulators that describe different phenomena where delay processes exist. As an example the alcohol simulator could be used, but it seems to be a better option to use more than one simulator. A simulator representing getting hot water in a shower as a delayed process is also a good candidate, since phenomena share a similar structure compared to the alcohol and funnel model. The reason why it is a better option to use more than one simulator for the transfer of knowledge is inspired in the study work carried out by Paul J. Camp (2010). He said in the third category of explanations for U-shaped development patterns, which was mentioned earlier, that: "...when performance is variable, the relevant memories are poorly and/or sparsely indexed and therefore mostly inaccessible except in very specific situations. The correct pedagogical approach, predicted by this model, would therefore be to shift the same content to a series of different contexts, which requires drawing on the same memories in order to be successful, and thereby deliberately triggering a series of representation failures. This, in turn, would require re-indexing those memories at a more abstract level, so that they are accessible in a broader range of context and linked to more and more remote areas of direct experience." In other words if we are able to expose the subjects to use their mental models to solve different tasks with similar dynamics, according with this theory, they will after a while be able to restructure and consolidate a conceptual

structure that explains the meta-dynamic involved in the different phenomena. Despite that their results could worsen in the intermediate stages of the learning process. Actually decreases in performance could be a consequence of mental model changes (Camp 2010).

4.3 Further research

There is always room for improvements to our proposed ILE and the good feedback we got from our subjects (89% positive feedbacks considering the ILE useful and/or interesting) motivates them. We encourage testing the improvements to the teaching strategy that we proposed. We believe that the study of learning processes is a multidisciplinary field, where the applications of emerging theories from different areas of knowledge could lead to interesting results.

In this work we proposed an ILE to improve the learning process of delays, which is widely topics studied in the field of system dynamics. However similar work could be developed to improve the learning process of other topics within the field, such as: nonlinearities and feedback effects.

This work was under the scope of a master thesis. We tried to efficiently use the resources we had to develop the current work. It would be interesting to bring this experience to a higher level. In the case of understanding the alcohol intoxication as a delay, it would be interesting to test the effect of our ILE in the drinking behavior of the subjects in a longer period of time. If positive results come out of an experience like that, the implications could be huge, since we would be able to propose effective alternatives to mitigate negative effects of binge drinking in the young population.

But we do not limit this work only to the problem of alcohol intoxication. Our ILE could be used to understand phenomena in other fields where delays also are involved.

4.3.1 ILEs in a e-learning context

We effectively used new information and communication technologies to assemble our ILE. We have explored the potential of 3D modeling, content management systems, learning management systems, system dynamic modeling and simulation tools and customized web development; together with best practices for content development for

e-learning environments. By developing this framework we were able to run a rich interactive learning environment with minimum requirements and an effective management of experimental data collected in real time.

We designed a scalable architecture, which allowed us to expand the range of ILEs in a repository of learning objects (Munera 2007). It is possible to use the system that we developed for our experiment as a learning management system, that people around the globe could access. Additionally other developers could add new learning objects to the system, creating a virtual community around learning resources in the field of system dynamics.

After implementing the required software to analyze the outcomes of the experiment, we find very useful to use the libraries for subject strategies categorization in order to implement an expert tutorial. Since now we have the algorithms that identify in which category a subject is, it is possible to display particular and personalized content to the user after they finish using the alcohol experiment. The content displayed to the user would be according to their strategy and will be extra learning material to improve their mental models of the problem.

5. Conclusion

Our experiment tested the effectiveness of a proposed interactive learning environment for improving the understanding of delays. To do that, we used the BAC simulator (also known as the alcohol simulator) developed by Moxnes & Jensen (2009) as a post-test, together with a post-test questionnaire. The results suggested that our ILE might improve the performance of the subjects using the BAC simulator. Different combinations of transparency and information about analogies between experimental tasks may impact the performance of the subjects in different manners.

Some of the subjects explicitly explained that their good results on the alcohol simulator were a consequence of applying the knowledge acquired in the funnel simulator. Those cases evidence the effectiveness of using water analogies to understand accumulation processes.

The collected data in this experiment suggested that for some subjects, the performance did not reflect the acquisition of important concepts of delays. Therefore, we attempted to deduce strategy patterns used by the subjects to solve the task based on the observations of the subjects' decisions. The data shows that close to 55% of the subjects evidenced usage of strategies that at some points took in account accumulation processes in the system.

The observation of the subjects' performances suggested that almost all the subjects used a simple feedback strategy to solve the experimental task. We developed a hypothetical model for a general simple feedback strategy. This model used two parameters, the aggressiveness of the strategy and traditional drinking. We were able to simulate subjects' performances for two different feedback strategies.

Finally we proposed some improvements to our ILE and encourage the community to participate in further research.

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Appendix 1 Software implementations

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Alcohol Simulator.

Class AlcoholModel: Alcohol Simulation engine

```
package classes{  
  
    import classes.Variable;  
  
    public class AlcoholModel {  
  
        // class helpers  
  
        private var startTime:Number = 0;  
  
        private var timeStep:Number = 1;  
  
        private var time:Number = 0;  
  
        //constants  
  
        private var sd:Number = 22.5; // stomch delay  
  
        private var apb:Number = 12.25; //alcohol per bottle  
  
        private var mre:Number = 0.15/60; // max rel elimination  
  
        private var desired_Level:Number = 0.8;  
  
        //policy
```

```
private var bob:Variable; // bottles of beer

//flows

private var I:Variable; // intake

private var A:Variable; // absorbtion

private var El:Variable; // elimination

//auxiliars

private var BAC:Variable;

private var vol:Number; //volumne

private var sex:String; //sex

private var w:Number; //weight

//stocks

private var IS:Variable; // Alcohol in stomach

private var IBW:Variable; //Alcohol in body waters

public function AlcoholModel(sex:String,w:Number) {

    //Parameters

    this.sex = sex;

    this.w = w;

    if (this.sex == "M"){

        this.vol = 0.7*w;

    }else{

        this.vol = 0.6*w;

    }

    //policies

    this.bob = new Variable("");

    //flows

    this.I = new Variable("");

    this.A = new Variable("");

    this.El = new Variable("");
```

```

//Stocks

this.IS = new Variable("grams");

this.IBW = new Variable("grams");

//Auxiliares

this.BAC = new Variable("gr/l")

// initial Values for stocks

this.IS.setValue(0);

this.IBW.setValue(0);

}

public function simulate(interval:Number, bob:Number):void {

    var counter:Number = 0;

    for (var i = time - startTime; i < (time - startTime + interval); i=i+timeStep) {

        this.bob.setValue(bob);

        this.I.setValue(this.bob.getValue(i)*apb/15);

        this.A.setValue(IS.getValue(i)/sd);

        this.IS.setValue(this.IS.getValue(i) + this.I.getValue(i) - this.A.getValue(i) + this.IS.getValue(0));

        this.El.setValue(Math.min(IBW.getValue(i)/15, mre*vol));

        this.IBW.setValue(this.IBW.getValue(i) + this.A.getValue(i) - this.El.getValue(i) +
this.IBW.getValue(0));

        this.BAC.setValue((IBW.getValue(i)/vol));

    }

    this.time = this.time + interval;

}

public function IS_Values():Array{

    return this.IS.getArrayOfValues(time-startTime);

}

public function I_Values():Array{

    return this.I.getArrayOfValues(time-startTime);

```

```

}

public function A_Values():Array{
    return this.A.getArrayOfValues(time-startTime);
}

public function IBW_Values():Array{
    return this.IBW.getArrayOfValues(time-startTime);
}

public function getPolicyValues():Array{
    return this.bob.getArrayOfValues(time-startTime);
}

public function BACValues():Array{
    return this.BAC.getArrayOfValues(time-startTime);
}

public function getDesiredLevelArray():Array{
    var array:Array = new Array(time-startTime);
    for(var countTemp=0;countTemp<array.length;countTemp++){
        array[countTemp] = this.desired_Level;
    }
    return array;
}

public function getXAxisNames():Array{
    var array:Array = new Array(120);
    for(var countTemp=0;countTemp<array.length;countTemp++){
        array[countTemp] = this.startTime+countTemp;
    }
    return array;
}

public function getCurrentTime():uint{
    return time;
}

```

```

    /*public function getAssumedCost():Number{

        var result:Number = 0;

        var values:Array = this.BACValues();

        for (var j=0;j<time-startTime;j++){

            result = result + (Math.abs(this.desired_Level - values[j]));

        }

        return result;

    }*/

    public function getScore():Number

    {

        var assumedCost:Number = 0;

        var goalArea:Number = (119-59)*this.desired_Level;

        var values:Array = this.BACValues();

        var initialTime:Number = 60 / this.timeStep;

        var finalTime:Number = 120 / this.timeStep;

        for (var j=initialTime;j<finalTime;j++){

            assumedCost += (Math.abs((this.desired_Level - values[j])*this.timeStep));

        }

        var score:Number = (goalArea - assumedCost) * 100 / goalArea;

        return ((score)<0)?0:score;

    }

}

```

Class Variable: Class to store the historic values of variables

```

package classes{

    public class Variable {

        private var values:Array;

        private var units:String;

        private var numPush:Number=0;

        function Variable(units:String) {

            this.values = new Array();

            this.units = units;

        }

    }

}

```

```

public function setValue(val:Number) {
    this.values.push(val);
    numPush++;
}

public function setUnits(units:String) {
    this.units=units;
}

public function getValue(index:Number):Number {
    return this.values[index];
}

public function getValues():Array {
    return this.values;
}

public function getUnits():String {
    return this.units;
}

public function printValues():void {
    var temp:String = "";
    for (var i=0; i<this.values.length; i++) {
        temp = this.values[i]+" ";
        temp = temp.replace(' ',',');
        trace(temp);
    }
}

public function getIndex():uint {
    return this.values.length-1;
}

public function getArrayOfValues(limit:Number):Array {
    var array:Array = new Array(this.values.length);
    for (var i=0; i<limit; i++) {
        array[i]=this.getValue(i);
    }
    return array;
}
}
}

```

```

package classes{

    import flash.events.Event;

    import flash.events.IOErrorEvent;

    import flash.net.URLLoader;

    import flash.net.URLRequest;

    import flash.events.EventDispatcher;

    public class DictionaryLoader extends EventDispatcher {

        public static var LOAD_COMPLETE:String = "loadComplete";

        public static var LOAD_ERROR:String = "loadError";

        private var lang:String;

        private var xmlLoader:URLLoader = new URLLoader();

        private var xmlData:XML;

        private var xmlLoaded:Boolean;

        private var errorLoading:Boolean;

        public function DictionaryLoader(lang:String){

            this.lang = lang;

            this.xmlLoaded = false;

            this.errorLoading = false;

        }

        public function load():void{

            this.xmlLoader = new URLLoader();

            this.xmlData = new XML();

            xmlLoader.addEventListener(Event.COMPLETE, loadXMLComplete);

            xmlLoader.addEventListener(IOErrorEvent.IO_ERROR,loadingErrorHandler);

            xmlLoader.load(new URLRequest("./lang/"+lang+".xml"));

        }

        protected function loadingErrorHandler(evt:IOErrorEvent){

            this.xmlLoaded = false;

            this.errorLoading = true;

            dispatchEvent(new Event(DictionaryLoader.LOAD_ERROR));

        }

    }

```


FLA alcohol Simulator Scene 1 loader code

```
import flash.events.ProgressEvent;

function updatePL(e:ProgressEvent):void
{
    var percent:Number = Math.floor( (e.bytesLoaded*100)/e.bytesTotal );
    if(preloaderMC is MovieClip){
        preloaderMC.gotoAndStop(percent);
        loadingPercentageLbl.text = String(percent).concat(" %");
    }
    if(percent == 100){
        play();
    }
}

this.loaderInfo.addEventListener(ProgressEvent.PROGRESS, updatePL);

// Extra test for IE
var percent:Number = Math.floor( (this.loaderInfo.bytesLoaded*100)/this.loaderInfo.bytesTotal );
if(percent == 100){
    nextFrame();
}

stop();
```

FLA Alcohol Simulator Scene 1: Initial configuration

```
stop();

/*****+
|   ALCOHOL SIMULATOR   |
| Created by: mauricio.munera@gmail.com |
| Copyrigh - All rigths reserved   |
+*****/

import classes.AlcoholModel;
import flash.filters.DropShadowFilter;
```

```
import com.yahoo.astra.fl.charts.*;
import com.yahoo.astra.fl.charts.series.*;
import fl.controls.Slider;
import fl.events.SliderEvent;
import fl.controls.Label;
import flash.net.navigateToURL;
import flash.net.URLRequest;
import flash.net.URLRequestMethod;
import flash.net.URLVariables;
import classes.DictionaryLoader;

this.loadingMask.visible = true;

//Parameters
var player:String = String(getParams(this).player);
var lang:String = getParams(this).lang?String(getParams(this).lang).toUpperCase();"ES";
this.lang = this.lang.substr(0,2).toUpperCase();
var mode:String = getParams(this).mode?String(getParams(this).mode).toUpperCase();"FTE";

// Variables
var sex:String = "";
var weight:Number = 0;

var dictionary = new DictionaryLoader(this.lang);

// Loading dictionary
this.dictionary.addEventListener(DictionaryLoader.LOAD_COMPLETE, handleDictionaryLoadComplete);
this.dictionary.addEventListener(DictionaryLoader.LOAD_ERROR, handleDictionaryLoadError);
this.dictionary.load();

function handleDictionaryLoadError(evt:Event):void{
    this.initialize();
    this.loadingMask.msg.text = "Error loading text";
}

function handleDictionaryLoadComplete(evt:Event):void{
    this.initialize();
}
```

```

        this.loadingMask.visible = false;
    }

    function initialize():void {
        // ADDING EVENTS LISTENERS AND TEXT
        this.hintMC.visible = ((this.mode == "FTE") || (this.mode == "FNTE"))?true:false;
        wLbl.text = wSlider.value+"";
        wSlider.addEventListener(SliderEvent.CHANGE, changeHandler);
        cBtn.addEventListener(MouseEvent.CLICK, checkAndContinue);
        this.loadInterfaceTexts();
    }

    function loadInterfaceTexts():void {
        this.formTitleLbl.text = this.dictionary.get("formTitleLbl", "interface");
        this.formGenderLbl.text = this.dictionary.get("formGenderLbl", "interface");
        this.formWeighLbl.text = this.dictionary.get("formWeighLbl", "interface");
        this.FormMFLbl.text = this.dictionary.get("FormMFLbl", "interface");
        this.formKiloLbl.text = this.dictionary.get("formKiloLbl", "interface");
        this.cBtn.label = this.dictionary.get("continue", "interface");
        this.hintMC.loadText();
    }

    function changeHandler(event:SliderEvent):void {
        wLbl.text = event.value+"";
    }

    function checkAndContinue(event:MouseEvent):void {
        if(wLbl.text != "" && sexLbl.text != ""){
            sex = sexLbl.text;
            weight = Number(wLbl.text);
            nextScene();
        }
    }

    function getParams(documentRoot):Object

```

```

{
  try {

    var params:Object = LoaderInfo(documentRoot.loaderInfo).parameters;
    var pairs:Object = {};
    var key:String;

    for(key in params) {
      pairs.key = String(params.key);
    }

  } catch(e:Error) {
    return {};
  }
  return params;
}

```

FLA alcohol Simualtor : Scene 2. Main simulation controller

```

stop();
this.hintMCSimple.visible = false;
this.loadingMask.visible = false;

/*****+
|   ALCOHOL SIMULATOR   |
| Created by: mauricio.munera@gmail.com |
| Copyrigh - All rigths reserved   |
+*****/

// MODEL CLASS
var model:AlcoholModel = new AlcoholModel(sex,weight);

// FLAGS
var valuesSent:Boolean = false;
var simulationTimeLimit:Number = 120; //Subjects make desision for 20 seconds, starting from time cero.
var maxSimulationTime:Number = 120; //Program simultate for 10 sec more 20 + 10 = 30 to empty the water in the funnel
var timeBetweenDecisions:Number = 15;
var maxBottles:Number = 5;
var taskFolderName:String = "task_description_files";

```

```

var descriptionFileName:String = "./"+ taskFolderName +"/taskDescription_" + this.lang + ".html";

// INITIAL SETTING UPS
setUpBACChart();
setUpOutput();
setUpMode();

// ADDING EVENTS LISTENERS AND TEXT
this.policyDecisionLbl.text = "";
this.policyDecisionLbl.restrict = "0-9\.";
this.simulateBtn.addEventListener(MouseEvent.CLICK, simulate);
this.hintBtn.addEventListener(MouseEvent.CLICK, hintBtnClickHandler);

loadDescription();
loadInterfaceTextsSimulator();

function loadInterfaceTextsSimulator():void {
    this.simulatorTitleLbl.text = dictionary.get("simulatorTitleLbl", "interface");
    this.howManyLbl.text = dictionary.get("howManyLbl", "interface");
    this.BottlesLbl.text = dictionary.get("BottlesLbl", "interface");
    this.simulateBtn.label = dictionary.get("simulate", "interface");
    this.verticalAxeLbl.text = dictionary.get("verticalAxeLabel", "interface");
    this.hintBtn.text.text = dictionary.get("clickForHint", "interface");
    //this.hintMCSimple.loadLbl();
    this.hintMCSimple.waterAlcoholLbl.text = dictionary.get("waterAlcohol", "interface");
    this.hintMCSimple.stomachFunnelLbl.text = dictionary.get("stomachFunnel", "interface");
    this.hintMCSimple.pumpEliminationLbl.text = dictionary.get("pumpElimination", "interface");
    this.hintMCSimple.glassBodyLbl.text = dictionary.get("glassBody", "interface");
}

function simulate(event_obj:MouseEvent):void {
    var policyValue = this.policyDecisionLbl.text;
    this.policyDecisionLbl.text = "";
    if(policyValue != "")

```

```

{
    if (model.getCurrentTime() < simulationTimeLimit) { // Is the simulation finish?

        if (Number(policyValue) >= 0 && Number(policyValue) <= (maxBottles) ) { // Is the policy in the policy range?

            output.text = dictionary.get("youHave", "messages") + " " + (((simulationTimeLimit -
model.getCurrentTime()) / timeBetweenDecisions)) + " " + dictionary.get("desicionsLeft", "messages");

            for (var i=0; i < timeBetweenDecisions; i++){

                model.simulate(1, Number(policyValue));

                refreshGraphsAndLevelObjects();

            }

        } else { // The policy is out of the policy range values

            //Report error to the user

            this.showMsg(dictionary.get("numberBeersMustBe0To5", "messages"), true, false);

        }

    } else { // The simulation is finished

        policyDecisionLbl.enabled = false;

        output.text = dictionary.get("endOfSimulation", "messages") + "\n";

        output.text += dictionary.get("score", "messages") + " " + Math.floor(model.getScore() * 100) / 100;

        reportValuesToServer();

    }

} else

{

    this.showMsg(dictionary.get("numberBeersMustBe0To5", "messages"), true, false);

}

}

function refreshGraphsAndLevelObjects() {

    BACChart.dataProvider = [model.BACValues(), model.getDesiredLevelArray()];

}

function setUpBACChart(): void {

    this.BACChart.categoryNames = model.getXAxisNames();

```

```
this.BACChart.verticalField = "gr/Lt";

this.BACChart.horizontalField = "Min";

var chartShadow:DropShadowFilter = new DropShadowFilter(0);
chartShadow.strength = 2;
this.BACChart.filters = [chartShadow];

this.BACChart.setStyle("animationEnabled",true);
this.BACChart.setStyle("textFormat", new TextFormat("Arial", 12, 0xffffffff, true));
this.BACChart.setStyle("seriesColors", [0x000099, 0xFF0000]);
this.BACChart.setStyle("seriesMarkerSizes", [2]);

this.BACChart.setStyle("backgroundSkin", CustomBackgroundSkin);

this.BACChart.setStyle("seriesLineWeights",[1]);
this.BACChart.setStyle("verticalAxisColor", 0x000000);
this.BACChart.setStyle("horizontalAxisColor", 0x000000);
this.BACChart.setStyle("verticalAxisGridLineColor", 0x440044);
this.BACChart.setStyle("verticalAxisTickColor", 0x000000);
this.BACChart.setStyle("verticalAxisMinorTickColor", 0x000000);

this.BACChart.setStyle("dataTipBackgroundSkin", CustomDataTipBackgroundSkin);
this.BACChart.setStyle("dataTipTextFormat", new TextFormat("Arial", 11, 0xffffffff));
}
```

```
function reportValuesToServer() {
    if(!valuesSent){
        var url:String = "save.php";
        var request:URLRequest = new URLRequest(url);

        var variables:URLVariables = new URLVariables();
        var loader:URLLoader = new URLLoader();
        loader.dataFormat = URLLoaderDataFormat.TEXT;

        variables.player = this.player;
    }
}
```

```

        var temp = model.getPolicyValues().toString();

        variables.decisions = temp;

        temp = model.BACValues().toString();

        variables.BAC = temp;

        variables.score = model.getScore();

        variables.sex = sex;

        variables.weigth = weight;

        request.data = variables;

        request.method = URLRequestMethod.POST;

        //navigateToURL(request);

        valuesSent = true;

        loader.addEventListener(Event.COMPLETE, handleSendValuesComplete);

        loader.addEventListener(IOErrorEvent.IO_ERROR, onIOError);

        loader.load(request);

    }
}

function handleSendValuesComplete(evt:Event):void{

    var phpAnswer = evt.target.data.toString();

    output.text += '\n';

    trace(phpAnswer);

    output.text += "(phpAnswer == '1')?dictionary.get("dataSavedMsg", "messages"):dictionary.get("problemsSavingData", "messages");

    this.showMsg(dictionary.get("closeWindow", "messages") + "\n" + dictionary.get("score", "messages") + " "+
(Math.floor(this.model.getScore() * 100) / 100), false, false);

}

function onIOError(evt:IOErrorEvent){

    output.text += '\n';

    output.text += dictionary.get("problemsOpeningPHPFile", "messages");

}

function setUpOutput():void{

    var tf:TextFormat = new TextFormat();

    tf.color = 0x00FF00;

```



```
tf.font = "Arial";

tf.size = 15;

output.setStyle("disabledTextFormat", tf);

output.enabled = false;
}

function loadDescription():void
{

    var loadit:URLLoader = new URLLoader();

    loadit.addEventListener(Event.COMPLETE, descriptionCompleteHandler);
    loadit.addEventListener(IOErrorEvent.IO_ERROR, descriptionErrorHandler);
    loadit.load(new URLRequest(descriptionFileName));
}

function descriptionCompleteHandler(event:Event):void
{

    this.descriptionTA.htmlText = event.target.data as String;
}

function descriptionErrorHandler(event:Event):void
{

    var urlTemp:String = "/task_description_files/taskDescription_EN.html";
    var loadit:URLLoader = new URLLoader();

    loadit.addEventListener(Event.COMPLETE, descriptionCompleteHandler);
    loadit.addEventListener(IOErrorEvent.IO_ERROR, descriptionTwiceErrorHandler);
    loadit.load(new URLRequest(urlTemp));
}

function descriptionTwiceErrorHandler(event:Event):void
{

    this.descriptionTA.htmlText = "It wasn't possible to open the task description file, please contact the administrator";
}

function hintBtnClickHandler(evt:MouseEvent){

    if(this.hintMCSimple.visible){
```

```

        this.hintMCSimple.visible = false;

    }else{

        this.hintMCSimple.visible = true;

    }
}

function setUpMode():void{

    if ((this.mode as String) == "FTE" || (this.mode as String) == "FNTE") //E 'Enlightening'
    {

        this.hintBtn.visible = true;

    }

    else //NE 'Not Enlightening'

    {

        this.hintBtn.visible = false;

    }

}

function showMsg(msg:String, closeBtn:Boolean = true, loadingAnimation:Boolean = true):void
{

    this.loadingMask.msg.text = msg;

    this.loadingMask.closeBtnLoading.visible = closeBtn;

    this.loadingMask.loadingAnimation.visible = loadingAnimation;

    this.loadingMask.visible = true;

}

```

Funnel Simulator

Class FunnelModel: Funnel simulation engine

```

package classes{

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```

```
import classes.Variable;

import classes.NewDataEvent;

import flash.events.EventDispatcher;

public class FunnelModel extends EventDispatcher{

    // class setup variables

    private var INITIAL_TIME:Number = 0;

    private var FINAL_TIME:Number = 0;

    private var TIME_STEP:Number = 0.25;

    private var index:uint = 0;

    // auxiliar variables

    private var intervalSimulationToReportValues:uint;

    // clock (time)

    private var MODEL_TIME:Number;

    // mode constants constants

    private var max_flow_rate:Number = 0.3;

    private var relative_outflow:Number = 0.2;

    private var relative_leaking:Number = 0.01;

    private var desired_Level:Number = 1;

    //policy

    private var decided_flow_intensity:Variable;

    //flows

    private var water_flow_tap:Variable;

    private var water_flow_funnel:Variable;

    private var leaking:Variable;

    //stocks

    private var water_in_funnel:Variable;

    private var water_in_glass:Variable;
```

```

public function FunnelModel(initialTime:Number, finalTime:Number, timeStep:Number, policyDesition:Number,
reportingValuesTimeInterval:Number = 0.5) {

    // setting up auxiliar variables

    this.intervalSimulationToReportValues = Math.round(reportingValuesTimeInterval / timeStep);

    this.INITIAL_TIME = initialTime;
    this.FINAL_TIME = finalTime;
    this.TIME_STEP = timeStep;

    //setting up time;
    this.MODEL_TIME = this.INITIAL_TIME;

    //policies
    this.decided_flow_intensity = new Variable("lt/seg");

    //flows
    this.water_flow_tap = new Variable("lt/seg");
    this.water_flow_funnel = new Variable("lt/seg");
    this.leaking = new Variable("lt/seg");

    //Stocks
    this.water_in_funnel = new Variable("lt");
    this.water_in_glass = new Variable("lt");

    // initial Values for stocks, flow and variables
    this.water_in_funnel.setValue(0);
    this.water_in_glass.setValue(0);
    this.decided_flow_intensity.setValue(policyDesition);

    this.water_flow_tap.setValue(Math.min(this.max_flow_rate,this.decided_flow_intensity.getValue(this.index)));
    this.water_flow_funnel.setValue(this.water_in_funnel.getValue(this.index)*this.relative_outflow);
    this.leaking.setValue(this.water_in_glass.getValue(this.index) * this.relative_leaking);
}

public function getIndex():uint{
    return this.index;
}

```

```

// Step forward in the simulation

public function simulateOnce(decided_flow_intensity:Number){

    // move the time forwards

    this.MODEL_TIME += TIME_STEP;

    this.index ++;

    // calculate variables levels

    this.decided_flow_intensity.setValue(decided_flow_intensity);

    this.water_flow_tap.setValue(Math.min(this.max_flow_rate,this.decided_flow_intensity.getValue(this.index)));

    //trace("WFT " + this.water_flow_tap.getValue(this.index));

    this.water_flow_funnel.setValue(this.water_in_funnel.getValue((this.index-1))*this.relative_outflow);

    //trace("WFF " + this.water_flow_funnel.getValue(this.index));

    this.water_in_funnel.setValue(this.water_in_funnel.getValue((this.index-1)) +
this.TIME_STEP*(this.water_flow_tap.getValue(this.index) - this.water_flow_funnel.getValue(this.index)));

    //trace("WF " + this.water_in_funnel.getValue(this.index));

    this.leaking.setValue(Math.min(this.water_in_glass.getValue(this.index-1), this.relative_leaking));

    //trace("L " + this.leaking.getValue(this.index));

    this.water_in_glass.setValue(this.water_in_glass.getValue(this.index-1) +
this.TIME_STEP*(this.water_flow_funnel.getValue(this.index) - this.leaking.getValue(this.index)));

    //trace("WG " + this.water_in_glass.getValue(this.index));

    //trace ("Simulating time: " + this.MODEL_TIME);

    //Is it time to report Value?

    if(this.getIndex() % this.intervalSimulationToReportValues == 0){

        var glassValueTemp:Number = new Number(this.water_in_glassValues()[this.getIndex()]);

        var funnelValueTemp:Number = new Number(this.water_in_funnelValues()[this.getIndex()]);

        dispatchEvent(new NewDataEvent(funnelValueTemp,glassValueTemp));

    }

}

public function hasReachedEndTime():Boolean{

    var temp = this.MODEL_TIME.toString().split(".");

    var temp2:Number = Number(temp[0]);

    //trace(temp2 + " >= " + this.FINAL_TIME);

    if (temp2 >= this.FINAL_TIME){

        //trace("true");

```

```
        return true;
    }else{
        //trace("false");
        return false;
    }
}

public function water_in_glassValues():Array{
    return this.water_in_glass.getValues();
}

public function water_flow_tapValues():Array{
    return this.water_flow_tap.getValues();
}

public function water_flow_funnelValues():Array{
    return this.water_flow_funnel.getValues();
}

public function water_in_funnelValues():Array{
    return this.water_in_funnel.getValues();
}

public function getPolicyValues():Array{
    return this.decided_flow_intensity.getValues();
}

public function getDesiredLevelArray():Array{
    var array:Array = new Array(this.index);
    for(var countTemp=0;countTemp<array.length;countTemp++){
        array[countTemp] = this.desired_Level;
    }
    return array;
}

/*
```

```

public function getXAxisNames():Array{
    var array:Array = new Array(this.index);
    for(var countTemp=0;countTemp<array.length;countTemp++){
        array[countTemp] = this.INITIAL_TIME+countTemp;
    }
    return array;
}*/

public function getCurrentTime():Number{
    return this.MODEL_TIME;
}

/* DEPRECATED
public function getAssumedCost():Number{
    var result:Number = 0;
    var values:Array = this.water_in_glassValues();
    //var elementsToCount:uint = Math.floor(this.FINAL_TIME / this.TIME_STEP);
    for (var j=0;j<this.index;j++){
        result += (Math.abs((this.desired_Level - values[j])*this.TIME_STEP));
    }
    return result;
}
*/

public function getScore():Number
{
    var assumedCost:Number = 0;
    var goalArea:Number = (20-10)*this.desired_Level;
    var values:Array = this.water_in_glassValues();
    var initialTime:Number = 10 / this.TIME_STEP;
    var finalTime:Number = 20 / this.TIME_STEP;
    for (var j=initialTime;j<finalTime;j++){
        assumedCost += (Math.abs((this.desired_Level - values[j])*this.TIME_STEP));
    }
    //var score:Number = goalArea - assumedCost;
    var score:Number = (goalArea - assumedCost) * 100 / goalArea;
    return ((score)<0)?0:score;
}

```

```

    }

    public function getMaxFlowRate():Number{

        return this.max_flow_rate;

    }

}
}

```

Class NewDataEvent: Reporting values event

```

package classes{

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import flash.events.Event;

public class NewDataEvent extends flash.events.Event {

    public static const NEW_DATA:String = "newData";

    public var funnelValue:Number;

    public var glassValue:Number;

    public function NewDataEvent(funnelValue:Number, glassValue:Number) {

        super(NEW_DATA);

        this.funnelValue = funnelValue;

        this.glassValue = glassValue;

    }

}

}
}

```

FLA Scene 1 Loader code

```

import flash.events.ProgressEvent;

```



```

function updatePL(e:ProgressEvent):void
{
    var percent:Number = Math.floor( (e.bytesLoaded*100)/e.bytesTotal );
    if(preloaderMC is MovieClip){
        preloaderMC.gotoAndStop(percent);
        loadingPercentageLbl.text = String(percent).concat(" %");
    }
    if(percent == 100){
        play();
    }
}

this.loaderInfo.addEventListener(ProgressEvent.PROGRESS, updatePL);

// Extra test for IE
var percent:Number = Math.floor( (this.loaderInfo.bytesLoaded*100)/this.loaderInfo.bytesTotal );
if(percent == 100){
    nextFrame();
}

stop();

```

FLA: Main Simulation Controller

```

stop();

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// IMPORTING LIBRARIES
import classes.FunnelModel;
import flash.filters.DropShadowFilter;
import com.yahoo.astra.fl.charts.*;
import com.yahoo.astra.fl.charts.series.*;
import fl.controls.Label;

```

```

import flash.net.navigateToURL;

import flash.net.URLRequest;

import flash.net.URLRequestMethod;

import flash.net.URLVariables;

import flash.utils.Timer;

import flash.events.TimerEvent;

import flash.events.IOErrorEvent;

import classes.NewDataEvent;

import classes.DictionaryLoader;

//import classes.t; // FOR PRINTING VARIABLES IN DEBUGGING CASES

this.loadingMask.visible = true;

//SIMULATOR SETUP
//-----
var reportValuesUrl:String = "save.php";
var initialFlowWidth = tapFlowMC.width;
var assumedCeroWater = 0.01;
//-----

// MODEL SET UP PARAMETERS
//-----
var timeStep = 0.025;
var initialTime = 0;
var finalTime = 20; //secs
var totalSimulationTime = finalTime - initialTime;
var policyDecision = 0.3;
var totalNumberOfValues = totalSimulationTime/timeStep;
var reportToGraphIntervalTime = 1000; // Milliseconds
var totalGraphValues = totalSimulationTime/(reportToGraphIntervalTime/1000);
var glassOverflowValue = 1.1;
//-----

// MODEL CLASS
var model:FunnelModel;

```

```

// GETTING PARAMETERS FROM REQUEST

var player:String = String(getParams(this).player);

var lang:String = getParams(this).lang?String(getParams(this).lang).toUpperCase();"ES";

this.lang = this.lang.substr(0,2).toUpperCase();

var mode:String = getParams(this).mode?String(getParams(this).mode).toUpperCase();"FTE";

//var videoDescriptionUrl = "videodescription_" + this.lang + ".flv";

//TIMERS

var modelSimulationTimer:Timer;

var timeupTimer:Timer;

timeupTimer= new Timer(16*60*1000); //16 min

timeupTimer.addEventListener(TimerEvent.TIMER, showCloseWindow);

timeupTimer.start();

//SUPPORT VARIABLES

var valuesToWaterGlassChart:Array = new Array();

var valuesToWaterFunnelChart:Array = new Array();

var valuesDesiredGlassWaterLevel:Array = new Array();

var dictionary:DictionaryLoader = new DictionaryLoader(this.lang);

var taskFolderName = "task_description_files";

var descriptionFileName:String = "./"+ taskFolderName +"/taskDescription_" + this.lang + ".html";

setUpVariablesValues();

//trace("Loading chart objects...!"); //LOGS

this.addEventListener(Event.ENTER_FRAME, checkChartReady);

function checkChartReady(e:Event):void {

    if(this.waterGlassChart.contentBounds.height != 0 && this.waterFunnelChart.contentBounds.height != 0 ){

        //trace("Charts ready..!"); //LOGS

        this.removeEventListener(Event.ENTER_FRAME, checkChartReady);

        this.dictionary.addEventListener(DictionaryLoader.LOAD_COMPLETE, handleDictionaryLoadComplete);

        this.dictionary.addEventListener(DictionaryLoader.LOAD_ERROR, handleDictionaryLoadError);

        this.dictionary.load();
    }
}

```

```

    }
}

function handleDictionaryLoadError(evt:Event):void{
    this.loadingMask.msg.text = "Error opening text";
    this.loadInterfaceTexts();
    this.initialize();
}

function handleDictionaryLoadComplete(evt:Event):void{
    this.loadInterfaceTexts();
    this.loadingMask.visible = false;
    this.initialize();
}

function loadInterfaceTexts():void{
    this.infoText_useTap.text = dictionary.get("useTheTap", "interface");
    this.infoText_waterFunnel.text = dictionary.get("waterInFunnel", "interface");
    this.infoText_waterGlass.text = dictionary.get("waterInGlass", "interface");
    this.btnStart.label = dictionary.get("startSimualtion", "interface");
    this.btnCloseTap.label = dictionary.get("closeTap", "interface");

    this.cover.questionLbl.text = dictionary.get("passquestion", "passQuestion");
    this.cover.answer1.label = dictionary.get("answer1", "passQuestion");
    this.cover.answer2.label = dictionary.get("answer2", "passQuestion");
    this.cover.tryAgainTxt = dictionary.get("tryAgain", "passQuestion");
}

function initialize():void
{
    setUpVariablesValues();
    // ADDING EVENTS LISTENERS AND TEXT
    policyDecisionLbl.text = this.tapSlider.value+"";
    this.tapSlider.addEventListener(Event.ENTER_FRAME, changeHandler);
    btnStart.addEventListener(MouseEvent.CLICK, startSimulation);
    btnCloseTap.addEventListener(MouseEvent.CLICK, closeTapBtnHandler);
}

```

```

        modelSimulationTimer.addListener(TimerEvent.TIMER, simulate);
        this.tapSlider.setValueTo(0.3);
    }

function closeTapBtnHandler(evt:MouseEvent):void{
    this.tapSlider.setValueTo(0);
}

function resetSimulator():void{

    //SUPPORT VARIABLES
    valuesToWaterGlassChart = new Array();
    valuesToWaterFunnelChart = new Array();
    watchLbl.visible = true;

    model.removeListener(NewDataEvent.NEW_DATA, updateCharts);

    setUpVariablesValues();

    // ADDING EVENTS LISTENERS AND TEXT
    policyDecisionLbl.text = this.tapSlider.value+"";

    modelSimulationTimer.addListener(TimerEvent.TIMER, simulate);
    this.tapSlider.setValueTo(0.3);
}

function setUpVariablesValues():void{

    // BUILDING MODEL OBJECT
    model = new FunnelModel(initialTime, finalTime, timeStep, policyDecision, 1);
    model.addListener(NewDataEvent.NEW_DATA, updateCharts);

    // FLAGS

```

```
var valuesSent = false;

// INITIAL SETTING UPS
tapFlowMC.visible = false;
funnelFlowMC.visible = false;

setUpWaterFunnelChart();
setUpWaterGlassChart();
setUpOutput();

if (this.mode == "FTNE"){
    this.funnelCover.visible = false;
    //this.hintBtn.visible = false;
} else if(this.mode == "FNTNE"){
    this.funnelCover.visible = true;
    waterFunnelChart.visible = false;
    funnelLtLbl.visible = false;
    infoText_waterFunnel.visible = false;
    //this.hintBtn.visible = true;
} else if(this.mode == "FNTNE"){
    waterFunnelChart.visible = false;
    infoText_waterFunnel.visible = false;
    funnelLtLbl.visible = false;
    this.funnelCover.visible = true;
    //this.hintBtn.visible = false;
} else { //FTE
    this.funnelCover.visible = false;
    //this.hintBtn.visible = true;
}

//this.descriptionTA.enabled = false;
loadDescription();

//TIMERS
modelSimulationTimer = new Timer(timeStep*1000);
```

```

}

function startSimulation(event_obj:MouseEvent):void
{
    this.btnStart.enabled = false;

    this.modelSimulationTimer.start();

    output.text = "";
}

function updateWatch():void
{
    var secsLeft = 20 - model.getCurrentTime();

    if(secsLeft >= 0){
        this.watchLbl.text = Math.floor(secsLeft).toString();
    }else{
        this.watchLbl.visible = false;
    }
}

function changeHandler(event:Event):void
{
    policyDecisionLbl.text = event.target.value+"";
}

function simulate(eventObject:TimerEvent):void
{
    if(model.hasReachedEndTime() && (model.water_in_funnelValues()[model.getIndex()] <= assumedCeroWater))
    {
        modelSimulationTimer.removeEventListener(TimerEvent.TIMER, simulate);

        policyDecisionLbl.enabled = false;

        output.text += "\n" + dictionary.get("Score", "messages") + ": " + int(model.getScore()*100)/100;

        //t.obj(this.valuesToWaterGlassChart, "this is ", 1, " object");
    }
}

```

```
        reportValuesToServer();

        this.resetSimulator();

        this.btnStart.enabled = true;
    }
    else if(model.hasReachedEndTime())
    {

        output.text = dictionary.get("endSimulationCheckFunnel", "messages");

        model.simulateOnce(0);
        if(this.tapSlider._enable){
            this.tapSlider.setValueTo(0);
            this.tapSlider.disable();
            policyDecisionLbl.text = "0";
            policyDecisionLbl.enabled = false;
        }
    }
    else
    {
        model.simulateOnce(Number(policyDecisionLbl.text));
        updateWatch();
    }
    refreshLevelObjects();
}
```

```
function refreshLevelObjects():void
```

```
{
    updateWaterlevels();
    updateFlows();
}
```

```
function updateWaterlevels():void
```

```
{
```



```

// funnel

var waterFunnelValue = model.water_in_funnelValues()[model.getIndex()];

if(waterFunnelValue < assumedCeroWater){

    this.waterFunnelMC.gotoAndStop(1);

}else{

    this.waterFunnelMC.gotoAndStop(Math.floor(waterFunnelValue * this.waterFunnelMC.totalFrames / 1.5));

}

// glass

var waterGlassValue = model.water_in_glassValues()[model.getIndex()];

if(waterGlassValue < assumedCeroWater){

    this.waterGlassMC.gotoAndStop(1);

}else if(waterGlassValue > this.glassOverFlowValue){

    if(this.waterGlassMC.currentFrame < (Math.floor(waterGlassValue * 128 ))){

        this.waterGlassMC.gotoAndStop(Math.floor(waterGlassValue * 128 ));

    }else{

        //do nothing to avoid water flowing backwards

    }

}else{

    this.waterGlassMC.gotoAndStop(Math.floor(waterGlassValue * 128 ));

}

}

function updateFlows():void
{

    if(Number(policyDecisionLbl.text) > 0){

        tapFlowMC.visible = true

        tapFlowMC.width = initialFlowWidth * Number(policyDecisionLbl.text)/model.getMaxFlowRate();

    }else{

        tapFlowMC.visible = false;

    }

    var funnelFlow = model.water_flow_funnelValues()[model.getIndex()];

    if(Number(funnelFlow) > 0){

        funnelFlowMC.visible = true

        funnelFlowMC.width = (initialFlowWidth+3) * Number(funnelFlow)/model.getMaxFlowRate();

    }else{

```

```

        funnelFlowMC.visible = false;

    }

    /*if(model.water_in_glassValues()[model.getIndex()] > 0){
        leaking.visible = true;
    }*/
}

function updateCharts(e:NewDataEvent):void
{
    this.valuesToWaterGlassChart.push(e.glassValue);
    this.valuesToWaterFunnelChart.push(e.funnelValue);

    //this.waterGlassChart.dataProvider = [this.valuesToWaterGlassChart, this.valuesDesiredGlassWaterLevel]; // This generates a
    performance problem.

    this.waterGlassChart.dataProvider = [this.valuesToWaterGlassChart];
    this.waterFunnelChart.dataProvider = [this.valuesToWaterFunnelChart];
}

function setUpWaterFunnelChart():void
{
    var yAxis:NumericAxis = this.waterFunnelChart.verticalAxis as NumericAxis;
    yAxis.minimum = 0;
    yAxis.maximum = 2;

    // create X axis names
    var xAxisNames:Array = new Array();

    for (var i = this.initialTime; i < this.totalSimulationTime + 10; i = i + (this.reportToGraphIntervalTime/1000)){
        xAxisNames.push(i + "");
    }

    this.waterFunnelChart.categoryNames = xAxisNames;

    this.waterFunnelChart.verticalField = "Lt";
    this.waterFunnelChart.horizontalField = "Seg";

    var chartShadow:DropShadowFilter = new DropShadowFilter(0);

```

```

chartShadow.strength = 2;

this.waterFunnelChart.filters = [chartShadow];

this.waterFunnelChart.setStyle("animationEnabled",true);
this.waterFunnelChart.setStyle("textFormat", new TextFormat("Arial", 12, 0xfffff, true));
this.waterFunnelChart.setStyle("seriesColors", [0x0000FF]);
this.waterFunnelChart.setStyle("seriesMarkerSizes", [2]);
this.waterFunnelChart.setStyle("backgroundSkin", CustomBackgroundSkin);

this.waterFunnelChart.setStyle("seriesLineWeights",[1]); ;
this.waterFunnelChart.setStyle("verticalAxisColor", 0x000000);
this.waterFunnelChart.setStyle("horizontalAxisColor", 0x000000);
this.waterFunnelChart.setStyle("verticalAxisGridLineColor", 0x440044);
this.waterFunnelChart.setStyle("verticalAxisTickColor", 0x000000);
this.waterFunnelChart.setStyle("verticalAxisMinorTickColor", 0x000000);

this.waterFunnelChart.setStyle("dataTipBackgroundSkin", CustomDataTipBackgroundSkin);
this.waterFunnelChart.setStyle("dataTipTextFormat", new TextFormat("Arial", 11, 0xfffff));
}

```

```
function setUpWaterGlassChart():void
```

```

{

var yAxis:NumericAxis = waterGlassChart.verticalAxis as NumericAxis;
yAxis.minimum = 0;
yAxis.maximum = 3;

// create X axis names
var xAxisNames:Array = new Array();
for (var i = this.initialTime; i < this.totalSimulationTime + 40; i = i + (this.reportToGraphIntervalTime/1000)){
    xAxisNames.push(i + "");
}

this.waterGlassChart.categoryNames = xAxisNames;

this.waterGlassChart.verticalField = "Lt";
this.waterGlassChart.horizontalField = "Seg";

```

```
var chartShadow:DropShadowFilter = new DropShadowFilter(0);

chartShadow.strength = 2;

this.waterGlassChart.filters = [chartShadow];

this.waterGlassChart.setStyle("animationEnabled",true);

this.waterGlassChart.setStyle("textFormat", new TextFormat("Arial", 12, 0xfffff, true));

this.waterGlassChart.setStyle("seriesColors", [0x000099, 0xFF0000]);

this.waterGlassChart.setStyle("seriesMarkerSizes", [2]);

this.waterGlassChart.setStyle("backgroundSkin", CustomBackgroundSkin);

this.waterGlassChart.setStyle("seriesLineWeights",[1]); ;

this.waterGlassChart.setStyle("verticalAxisColor", 0x000000);

this.waterGlassChart.setStyle("horizontalAxisColor", 0x000000);

this.waterGlassChart.setStyle("verticalAxisGridLineColor", 0x440044);

this.waterGlassChart.setStyle("verticalAxisTickColor", 0x000000);

this.waterGlassChart.setStyle("verticalAxisMinorTickColor", 0x000000);

this.waterGlassChart.setStyle("dataTipBackgroundSkin", CustomDataTipBackgroundSkin);

this.waterGlassChart.setStyle("dataTipTextFormat", new TextFormat("Arial", 11, 0xfffff));

}
```

```
function reportValuesToServer()
```

```
{

    var request:URLRequest = new URLRequest(reportValuesUrl);

    var loader:URLLoader = new URLLoader();

    loader.dataFormat = URLLoaderDataFormat.TEXT;

    var variables:URLVariables = new URLVariables();

    variables.player = this.player;

    var temp = model.getPolicyValues().toString();

    variables.decisions = temp;

    temp = model.water_in_glassValues().toString();

    variables.waterGlassLevels = temp;
```

```

temp = model.water_in_funnelValues().toString();

variables.funnelLevels = temp;

variables.score = model.getScore();

variables.treatment = this.mode;

request.data = variables;

request.method = URLRequestMethod.POST;

loader.addListener(Event.COMPLETE, handleSendValuesComplete);

loader.addListener(IOErrorEvent.IO_ERROR, onIOError);

loader.load(request);
}

function handleSendValuesComplete(evt:Event):void{

    var phpAnswer = evt.target.data.toString();

    output.text += "\n";

    trace(phpAnswer);

    output.text += "(phpAnswer == '1')?dictionary.get("dataSavedMsg", "messages"):dictionary.get("problemsSavingData", "messages");
}

function onIOError(evt:IOErrorEvent){

    output.text += "\n";

    output.text += dictionary.get("problemsOpeningPHPFile", "messages");
}

function setUpOutput():void

{

    var tf:TextFormat = new TextFormat();

    tf.color = 0x00FF00;

    tf.font = "Courier New";

    tf.size = 15;

    output.setStyle("disabledTextFormat", tf);

    output.enabled = false;
}

function getParams(documentRoot):Object

```

```

{
  try {

    var params:Object = LoaderInfo(documentRoot.loaderInfo).parameters;
    var pairs:Object = {};
    var key:String;

    for(key in params) {
      pairs[key] = String(params[key]);
    }

  } catch(e:Error) {
    return {};
  }
  return params;
}

function loadDescription():void
{
  var loadit:URLLoader = new URLLoader();

  loadit.addEventListener(Event.COMPLETE, descriptionCompleteHandler);
  loadit.addEventListener(IOErrorEvent.IO_ERROR, descriptionErrorHandler);
  loadit.load(new URLRequest(descriptionFileName));
}

function descriptionCompleteHandler(event:Event):void
{
  this.descriptionTA.htmlText = event.target.data as String;
}

function descriptionErrorHandler(event:Event):void
{
  var urlTemp:String = "/task_description_files/taskDescription_EN.html";
  var loadit:URLLoader = new URLLoader();
}

```

```

loadit.addEventListener(Event.COMPLETE, descriptionCompleteHandler);

loadit.addEventListener(IOErrorEvent.IO_ERROR, descriptionTwiceErrorHandler);

loadit.load(new URLRequest(urlTemp));
}

function descriptionTwiceErrorHandler(event:Event):void
{
    this.descriptionTA.htmlText = "It wasn't possible to open the task description file, please contact the administrator";
}

function showCloseWindow(evt:TimerEvent)
{
    this.timeupTimer.stop();

    this.LoadingMask.msg.text = this.dicinary.get("closeWindow","messages");

    this.LoadingMask.msg.visible = true;
}

```

Result Manager (PHP)

Package DB: Class DBConnector

```

<?php

/**
 * @author Mauricio Munera
 * @copyright 2009
 */

/*
 * TO DO
 * Take away the echos when there is an error, implement a error system with flags that point
 * to errors after an operation and store the error message in a internal attribute
 */

require_once dirname(__FILE__).'../Configuration.php';

require_once 'MDB2.php';

class DBConnector{

```

```

var $config;

var $db; // object to store the dbconnection

var $dbOptions;

function DBConnector(){

    $this->config = new Configuration();

    $this->dbOptions = array(

        'debug' => 2,

        'portability' => DB_PORTABILITY_ALL,

    );

}

function connect(){

    // gets an existing instance with the same DSN

    // otherwise create a new instance using MDB2::factory()

    $this->db =& MDB2::factory($this->config->getDsn(),$this->dbOptions);

    /*('mysql://root:@localhost/vat');

    if (PEAR::isError($db) {

        echo ('Seems that we are having problems with the connection to the DB '$db->getMessage());

    }

}

function query($sql){

    $this->connect();

    // Proceed with a query...

    $res =& $this->db->query($sql);

    // Always check that result is not an error

    if (PEAR::isError($res) {

        echo ('Something wrong happened with the query: <br /> '$sql.' '$res->getMessage());

    }else{

        return $res;

    }

    $this->disconnect();

}

function insertValues($sth, $data){

```



```

return $this->changeRowsDB($sth, $data);

//echo $sth;
}

function updateValues($sth, $data){
return $this->changeRowsDB($sth, $data);

//echo $sth;
}

function deleteValues($sth, $data){
return $this->changeRowsDB($sth, $data);

//echo $sth;
}

private function changeRowsDB($sth, $data){
    $this->connect();

    $sth = $this->db->prepare($sth);
    $this->db->loadModule('Extended');
    $res = $this->db->executeMultiple($sth, $data);

    if (MDB2::isError($res)) { // Check the result object in case there
        echo("Seems that we are having problems inserting data -> ". $res->getMessage()); // was an error, and handle it here.
    }

    $this->disconnect();

    return $res;
}

function getLastInsertedId($table, $field){
return $this->db->lastInsertID($table, $field);
}

function disconnect(){
    $this->db->disconnect();
}
}

```

?>

Package Drivers: Class DAlcoholPlayerAttempt

This class is a driver that servers as intermediary between value object and database operations

```
<?php
/**
 * PHP Template.
 */

require_once dirname(__FILE__) . '/../vo/AlcoholPlayerAttempt.php';
require_once dirname(__FILE__) . '/../db/DBConnector.php';

class DAlcoholPlayerAttempt
{
    protected $conf, $db;

    public $excludedPlayers = array('fte10','fte05', 'fte02','fte14','fte09','fte18','fte20','fte13','fte11','fte01','fte15',
        'fte20','fnte08','fnte09','fnte18','fnte01','fnte03','fnte07','fnte05',
        'fne12','fne02','fne15','fne10','fne05','fne19','fne14','fne09','fne17','fne11',
        'fntne04','fntne08','fntne09','fntne14','fntne13','fntne05','fntne19','fntne15','fntne12','fntne16','fntne06',
        'nfntne09','nfntne10','nfntne12','nfntne17','nfntne02','nfntne20','nfntne04','nfntne03','nfntne19','nfntne18');

    function DAlcoholPlayerAttempt()
    {
        $this->db = new DBConnector();
        $this->conf = new Configuration();
    }

    function getPlayersAttemptsFromDB($treatment="")
    {
        if($treatment == "")
        {
            $treatmentFilter = "";
        }
        else
        {
            $treatmentFilter = "WHERE `player` like '$treatment%' ";
        }
    }
}
```

```
$sql = 'SELECT `player`,`desicions`,`BAC`,`score`,`sex`,`weight`,`date`,`ip` FROM `'.$this->conf->getDbPrefix().`playerAlcohol`  
'.TreatmentFilter.' ORDER BY `player`';
```

```
$res = $this->db->query($sql);
```

```
$playerAttempts = array();
```

```
$index = 0;
```

```
while ($obj = $res->fetchRow(MDB2_FETCHMODE_ASSOC)){
```

```
    $playerAttemptTemp = new AlcoholPlayerAttempt($obj);
```

```
    $playerAttempts[$index] = $playerAttemptTemp;
```

```
    $index++;
```

```
}
```

```
return $playerAttempts;
```

```
}
```

```
function getPlayerData($player="")
```

```
{
```

```
    $sql = 'SELECT `player`,`desicions`,`BAC`,`score`,`sex`,`weight`,`date`,`ip` FROM `'.$this->conf->getDbPrefix().`playerAlcohol` WHERE  
`player`.`" LIKE '$player'";
```

```
$res = $this->db->query($sql);
```

```
$playerAttempts = array();
```

```
$index = 0;
```

```
while ($obj = $res->fetchRow(MDB2_FETCHMODE_ASSOC)){
```

```
    $playerAttemptTemp = new AlcoholPlayerAttempt($obj);
```

```
    $playerAttempts[$index] = $playerAttemptTemp;
```

```
    $index++;
```

```
}
```

```
return $playerAttempts[0];
```

```

}

function filterByGender(*M or F*/$gender, $playerAttempts)
{
    for ($i=0; $i<sizeof($playersAttempts);$i++)
    {
        if($playersAttempts[$i]->sex == $gender)
        {
            $result[] = $playersAttempts[$i];
        }
    }
    return $result;
}

function getInvalidPlayersAttemptsFromDB()
{
    $sqlExcluded = "WHERE ";

    //creating SQL for excluded players
    for ($i = 0; $i < sizeof($this->excludedPlayers);$i++)
    {
        if($i != 0) $sqlExcluded = $sqlExcluded . " OR ";

        $sqlExcluded = $sqlExcluded . "`player` LIKE '{$this->excludedPlayers[$i]}'";
    }

    $sql = 'SELECT `player`,`desicions`,`BAC`,`score`,`sex`,`weight`,`date`,`ip` FROM `'.$this->conf->getDbPrefix().`playerAlcohol` '.$sqlExcluded.` ORDER BY `player` `';

    $res = $this->db->query($sql);

    $playerAttempts = array();

    $index = 0;

    while ($obj = $res->fetchRow(MDB2_FETCHMODE_ASSOC)){
        $playerAttemptTemp = new AlcoholPlayerAttempt($obj);
        $playerAttempts[$index] = $playerAttemptTemp;
    }
}

```

```
    $index++;
}

return $playerAttempts;

}

function getBestPerformances($alcoholExperimentAttempts, $limitBAC)
{
    foreach ($alcoholExperimentAttempts as $attempt)
    {
        if($attempt->getMBAC() <= $limitBAC){
            $result[] = $attempt;
        }
    }
    return $result;
}

function getPerformancesByCategory($category)
{
    $result = array();
    $resultTemp = $this->getPlayersAttemptsFromDB();

    foreach ($resultTemp as $attempt)
    {
        if ($attempt->category == $category)
        {
            $result[] = $attempt;
        }
    }
    return $result;
}
}
?>
```

Package VO: Class AlcoholPlayerAttempt

This class maps in the memory a player attempt and calculate some useful values.

```
<?php
/**
 * PHP Template.
 */

class AlcoholPlayerAttempt{

    var $player;

    var $desicions;

    var $simplifiedBAC;

    var $simplifiedDesicions;

    var $BAC;

    var $score;

    var $sex;

    var $weight;

    var $date;

    var $ip;

    var $treatment;

    var $MBAC;

    var $category;

    function AlcoholPlayerAttempt($obj){

        $this->player = $obj['player'];

        $this->desicions = explode(',',$obj['desicions']);

        $this->BAC = explode(',',$obj['BAC']);

        $this->score = $obj['score'];

        $this->sex = $obj['sex'];

        $this->weight=$obj['weight'];

        $this->date = $obj['date'];

        $this->ip = $obj['ip'];
```

```

// Extracts treatment from player's name
$this->treatment = substr($this->player, 0, -2);

//MAX BAC

$this->MBAC = $this->getMBAC();

// building simplified decisions and BAC values.

for ($i=0;$i<sizeof($this->BAC);$i= $i + 15){
    $this->simplifiedBAC[] = $this->BAC[$i];
    $this->simplifiedDecisions[] = $this->decisions[$i];
}

// and the last value
$this->simplifiedBAC[] = $this->BAC[sizeof($this->BAC) - 1];

$this->determineCategory();
}

function isAccordingToTask(){

    $targetBAC = 0.8;

    for ($i=0;$i < sizeof($this->simplifiedBAC);$i++)
    {
        if (floatval($this->simplifiedBAC[$i]) > $targetBAC)
        {
            for ($j = $i+1 ; $j < sizeof($this->simplifiedBAC); $j++)
            {
                if($this->simplifiedBAC[$j] > 0)
                {
                    return false;
                }
            }
        }
    }
}

```

```

    }
}
return true;
}

function getMBAC(){ //max BAC
    return max ($this->BAC);
}

function determineCategory()
{
    for ($indexReachedBAC = 0; $indexReachedBAC < sizeof($this->simplifiedBAC) && $this->simplifiedBAC[$indexReachedBAC] < 0.8; $indexReachedBAC++);

    $decision1 = $this->simplifiedDesicions[$indexReachedBAC];
    $decision2 = $this->simplifiedDesicions[$indexReachedBAC+1];
    if ($indexReachedBAC <= (7-3))
        $decision3 = $this->simplifiedDesicions[$indexReachedBAC+2];

    if($decision1 < 1 && $decision2 < 1)
    {
        $allZero = true;
        for ($i = $indexReachedBAC; $i < count($this->simplifiedDesicions); $i++)
        {
            if ($this->simplifiedDesicions[$i] >= 1)
                $allZero = false;
        }

        if($allZero)
            $this->category = 1;
        else
            $this->category = 4;
    }
    else if($decision2 <= $decision1 )
    {
        if($decision2 == 0 && isset($decision3) && $decision3 == 0)
            $this->category = 1;
    }
}

```



```

else if ( isset($decision3) && ($decision3 < $decision2 || ($decision3 > 0
    && $decision3 <= 1
    && $decision3 == $decision2
    && $this->simplifiedBAC[$indexReachedBAC+2] > 0.9)))
{
    $this->category = 2;
}
else if (!isset($decision3))
{
    $BACinDecision2 = $this->simplifiedBAC[$indexReachedBAC+1];
    if($this->simplifiedBAC[$indexReachedBAC+1] <= 0.9)
    {
        if($decision2 <= 1)
            $this->category = 1;
    }
    else
        $this->category = 2;
}
else
    $this->category = 3;
}
else
{
    $this->category = 3;
}
}
}
?>

```

Display scripts to obtain results

For each of the following script it is possible to filter the data by:

- Users categories
- Valid cases (those that weren't exclude for possible misunderstanding of the experimental task in the first stage of the experiment)
- Specific player
- All previous filters can be at the same time filtered by gender.

There is also possible to obtain all the attempts from the database.

These are the scripts created in order to get usefull information for analisis.

- displayAvgDesicions.php
- displayBAC.php
- displayBestPlayers.php
- displayCategories.php
- displayDesicions.php
- displayDesicions.php
- displayMBAC.php
- displayValidDesicions.php
- getAlcholRecords.php
- getBACandDecisions.php
- getPlayerData.php