LEARNING EVALUATION IN A PERSUASIVE SERIOUS GAME

K. Sammadi, T. Daouas

Institute of High Commercial Studies of Carthage, Laboratory EcStra (TUNISIA)

Abstract

In a context of serious games learning, we propose a modelling of the players-learners based on Bayesian Network technology coupled with the Diagram of Influence. This modelling has for objective evaluating the effectiveness of the serious game in learning through the evaluation of the behavioural change of the players-learners. This approach was applied to a persuasive serious game of anticorruption.

Keywords: Serious Game, Bayesian Network, Inference diagram, Behaviour evaluation.

1 INTRODUCTION

The technological progress, the digital practices of the teenagers and the expanding institutional context tend to renew the interest for the games in education and training. For the researcher, it is the question of the relations between game and learning, which is again on the agenda. The works lead in this domain concern the uses of the Serious Games (SG) in the education and training [1].

In the literature, different types of SG are presented [2]. By taking into account their main intentions, SG can be distributed in three big categories: SG of message, deliver a message in an educational, informative and persuasive aim. SG of training, improve the cognitive or driving performances of the users. SG of simulation or serious play, does not present objective to estimate the users, it offers an open panel of practices.

In [3], authors says that a big part of the SG are said "persuasive". This type of SG is defined as media of persuasive communication, often intended for a wide public. They incite the players to solve “playful problems” with the aim of provoking with them behavioural changes. The persuasive SG remains less studied. Whatever is the field of application, its fundamental objective is to provoke on players cognitive, affective and behavioural effects.

In the Persuasive SG, the Player-Learner (PL) is put right into the action; he is not a passive observer. That is why several researches focus on how to follow the learning progress of the PL. In main works, they need to design a model of the PL.

1.1 Modelling Player-Learner

We propose an approach following three steps:

- Identifying the PL behavioural characteristics using a psychological test before beginning using the game. This test reflects the behaviour of the PL in an initial state.
- Treating information coming from both PL behavioural characteristics and its SG results, by mean of a model based on Bayesian Network (BN) technology and its associated mechanism of inference.
- Evaluating the PL behaviour after each game session using the Influence Diagram (ID).

1.2 Model application

We applied the proposed modelling using one persuasive serious game. It is a game having for objective the raising awareness on the dangers of the corruption. This anti-corruption SG presents several sessions where each session illustrates a scene reflecting a situation in the real life, i.e. in school, in hospital, etc. The aim of this SG is to change the PL behaviour with regard to corruption. We, then, applied our model in order to evaluate PL behaviour change and at the same time to evaluate the persuasive SG effectiveness.

2 RELATED WORK AND CONCEPTS

Different works treated the evaluation of the PL progress in his learning, such as the research focusing on the modelling of the PL and the adaptation of the pedagogical session [4] [5]. These works use the BN to model information. They reflect the knowledge of PL, present and estimate learning progression during a playing session. Besides, other works focus on downstream phases such as activity analysis, diagnosis [6] and evaluation. Several works used the Evidence-Centered Design (ECD) model, applied to measure the PL progress following different steps [7]. The first step is identifying what the creators of the game want to evaluate such as skills and knowledge act. The second step is identifying behaviours and results we can measure and observe. The third step is identifying the types of situations in which these behaviours can be observed.

According to these works, we propose an approach that models and evaluates the PL behaviour. We keep the BN for the modelling, but we use the Influence Diagram (ID) instead of the ECD. The ID presents a theoretical framework for the formalization of the decision problem, which is related to the presentation of the final PL behaviour, given its usefulness and regarding the effectiveness of a persuasive game.

Our approach produces a fine assessment of the state of PL behaviour. It shows if there is a positive change in their behaviour or not. The purpose too, is to provide the game creators an indicator, which assesses the final PL behaviour.

2.1 Bayesian Networks

Bayesian Networks (BN), also called "belief networks" or "probabilistic networks", are graphical models intended to formalize knowledge. They are directed and acyclic graphs, where the variables of the graph present the knowledge. Each node of the graph represents a variable and the arcs represent the probabilistic dependencies between these variables. If an arc goes from a node X to a node Z, we say that X is a parent of Z. Each node Z_i having at least one parent, has a conditional probability distribution P (Z_i I Parents (Z_i)) that quantifies the effect of parents on the node [8]. The arcs of the network represent relationships between variables, they can also define deterministic rules; for example, if X = a1 then Z = b1. These rules can then be used to model logic gates, constraint satisfaction problems or probabilistic ones. The set of probabilities defines the distribution of joined probabilities for the network as shown in the formula:

$$P(X, \ldots, Xn) = \prod_{i=1}^{n} P(Xi \mid pa(Xi))$$

The propagation of information in the network is through Bayesian Inference (BI). Based on the probability tables and the knowledge acquired over time, we can calculate or revise the probabilities of the network hypotheses. According to [9], BI mechanisms use a combination of probabilities derived from the theorem of Bayes [10].

2.2 Influence Diagram

The Influence Diagram (ID) is an extension of the BN to a decision problem; this generalization of BN offers possibilities for modelling and solve not only probabilistic problems but also problems of decision support. In [11] compared to BN, two types of additional nodes are available. Therefore, there are three kinds of nodes in an ID. The chance nodes, which are the same as in BN and represent the different variables of the problem. The decision nodes, which allow modeling the different alternatives available to the decision maker. Finally, the utility nodes, which allows evaluating these different alternatives by identifying a criterion to optimize.

In an ID, the meaning of an arc differs according to the nodes that it connects:

- When an arc connects two chance nodes: it represents the causal link between the two variables (the same meaning as in a BN).
- When an arc points to a decision node: The decision-making requires knowing the value of the original node of the arc.
- When an arc points to a chance node from a decision node, each alternative of the decision node influences the different values of the variable represented by the chance node.

- When an arc points to a utility node, it represents one of the components of the utility table associated with this node.

3 PROPOSED MODEL

The proposed model is composed of three parts as shown in Figure 1. When ready to play, the PL is exposed to the behavioural characteristic identification, then begins the modelling and finally the evaluation part.

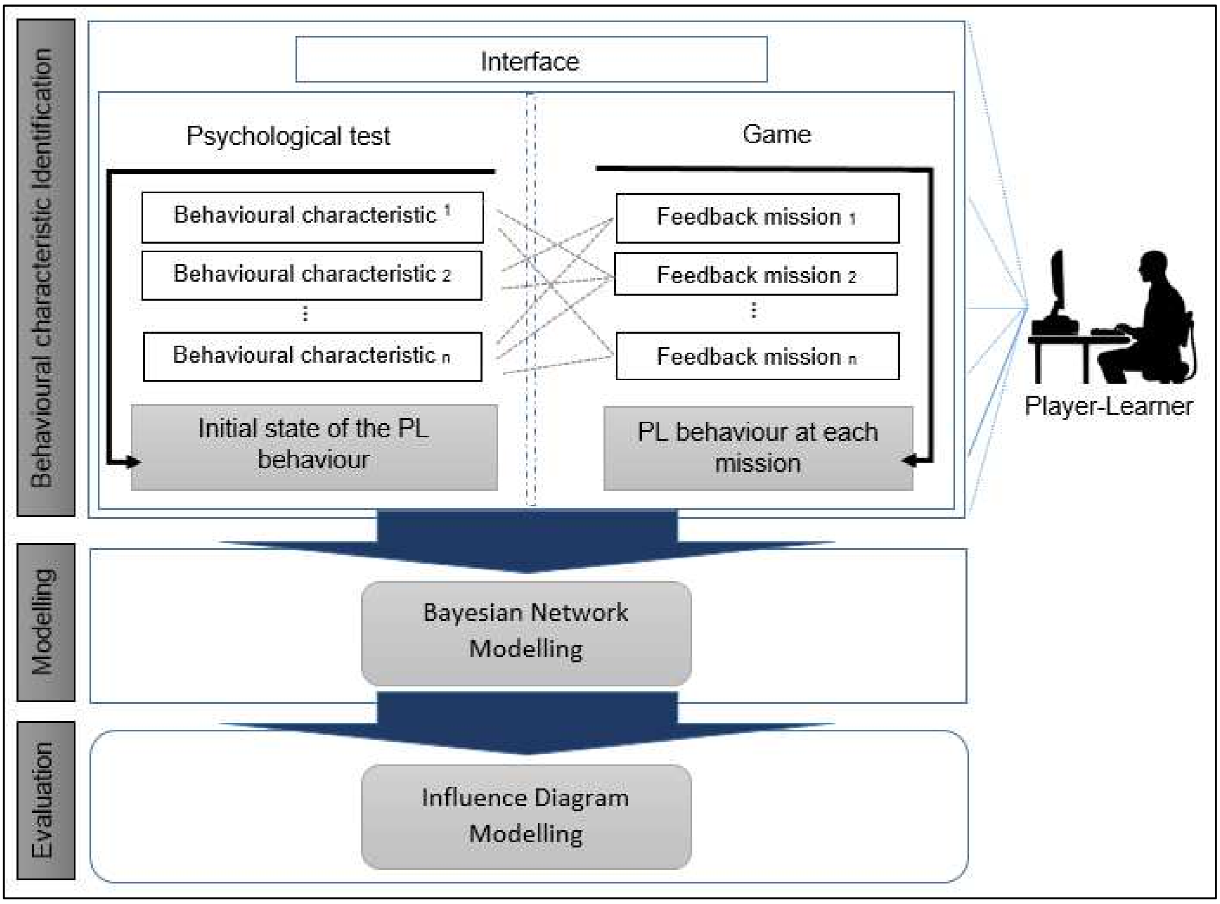

Figure 1. Architecture of the proposed model.

3.1 Identifying the PL behavioural characteristics

In order to identify its behavioural characteristics, we present to the PL a psychological test. It aims to know its initial state behaviour before playing the game. Generally, a SG has several missions or sessions. Therefore, after each playing session we collect a feedback reflecting the behavioural characteristics of the PL.

3.1.1 Psychological test

We choose to present to the PL a psychological test based on images. Not to influence the PL answers, we only expose a couple of images asking him to click on the one representing him best. Both images correspond to a characteristic, one of them is positive and the other is negative. For example, if we are treating the materialist characteristic, it should be represented in a positive way in one image and in a negative way in the other. The choice of the PL indicates if he could have the materialist characteristic or not.

For each characteristic, two image databases are available, one containing positive images and the other negative ones. The images are displayed randomly.

3.1.2 Game

The persuasive SG is composed of different missions. The PL should play the different missions and each one has two possible outcomes, positive if the PL had a positive behaviour or negative outcome otherwise. All outcomes at the end of playing represents the intermediate state of the PL behaviour.

3.2 Modelling

The modelling part with BN consists in using the initial characteristics given by the psychological test and the characteristics' outcomes given by the game, as elements of the model. These elements are transformed into variables having relationships between each other. Arcs design these cause and consequence relationships, which represent the probabilistic dependencies between variables.

3.3 Evaluation

In order to build the evaluation modelling we used two floors: probabilistic floor and decision floor. We have chosen to use discrete variables, which are a number of known and finite possible values. This choice is due to the fact that the variables, mainly represent the PL behaviour, which, therefore, does not require continuous variables that complicate the propagation of knowledge in the network.

As shown in Figure 2, the proposed model uses the principles of ID to provide a behavioural evaluation of the PL in each session of the game. First, we calculate the probability of occurrence of the behavioural characteristic as well as the chance of occurrence of results found in the different missions of the game. Then, we use the probabilities just calculated and the concepts of utility and decision of ID to assess behaviour.

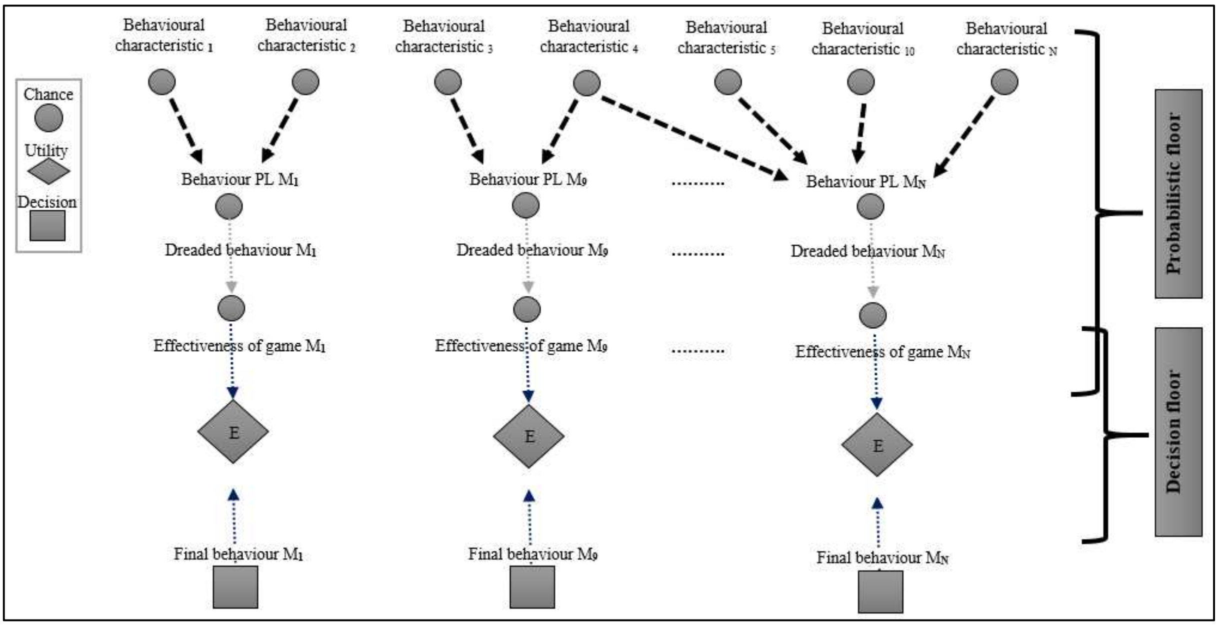

Figure 2. PL Evaluation: Probabilistic and decision floor.

3.3.1 Probabilistic floor

We use a structure with three levels to represent the PL behaviour and calculate its probabilities of occurrences. The knowledge introduced here characterizes the PL behavioural state. This phase of data processing based only on BN and their associated mechanisms of inference, aims to propagate information on the following three levels:

- Behavioural characteristics: the characteristics that reflect the PL behaviour. Each characteristic belongs to one or more missions in the game and the consequences of a characteristic may influence the occurrence of another characteristic.
- PL Behaviour: these are the results found after each game session. Since each mission has behavioural characteristics, there is a close relationship between the results found in each mission and their associated behavioural characteristics.

- Consequence: the dreaded behaviour induced by the results found in the second level.

Probabilities of occurrence are associated with the PL behavioral characteristics, to their behaviour in the game and to their consequences (dreaded behaviour). The inference mechanisms can evolve these probabilities according to the observations made. The behavioural characteristics are characterized by their probabilities of occurrence (priori probability). The knowledge about PL behaviours and the dreaded behaviour are defined by conditional probability tables, it gathers information about the impact of the different behavioural characteristics and the probability of the PL outcome in the game.

The compilation of the model propagates the information in the graph and allows to know the probability of the consequence, according to the probability of PL beheviour and the probability of behavioural characteristics.

3.3.2 Decision floor

In the Decision floor, we use the utility nodes to store the knowledge necessary for the decision. It quantifies the effectiveness of the game, so there are many utility nodes as consequences. Each consequence is then coupled with a utility node, itself linked to a decision node which then makes it possible to evaluate the final PL behaviour. The utility node uses a possible state value of the consequence. This value represents the effectiveness of the game on a scale of 0 to 1 depending on the state of the consequence. Then, the calculation makes it possible to evaluate the final PL behaviour. Therefore, the calculation used to evaluate the final PL behaviour is the same calculation used to evaluate the alternatives of a decision.

4 APPLICATION TO ANTICORRUPTION SG

4.1 Anticorruption SG

Within the framework of a promotional activity against the corruption, a project was led by a non-profit organization[1], which had for purpose the realization of a SG of raising awareness against the corruption. In this SG, the player can play with flows of money, which go towards a corrupt monster. Its aim is to demonstrate him the utility to divert these flows towards a better use in the interest of all. Therefore, it proves that a system without corruption would benefit both the victim of corruption and the beneficiary one.

This anticorruption SG presents different sessions where each session illustrates a scene reflecting real situation, where the PL is confronted with a form of corruption. Based on storytelling principle, each session is accompanied by a story explaining its situation that the PL should understand before beginning to play. The degree of difficulty of the game is progressive, from one level to another.

4.2 Identifying behavioural characteristics

4.2.1 Storytelling

For this stage, it is necessary to emphasize on the storytelling, because in the persuasive SG, we can look for the different behavioural characteristics that the PL must have to win. Let us take as an example the storytelling of the first situation, which deals with a scene in a bank.

After benefitting from a credit from the bank, the bank client wants to take a second one to renew his car and the banker disagrees because the client financial situation did not correspond to the credit criterion. The PL is supposed to be the client, what he would do? He has two alternatives; (1) He would wait until regulating his financial situation in order to satisfy the bank criterion. (2) He would find an illegal agreement with the banker to facilitate him the processing by promising him a percentage of the assigned credit.

The same system is used for all the different situations representing different missions for the PL. Each mission has its proper story.

[1] Association named « Tunisia For All », https://tunisiaforal.org.

4.2.2 Game mission and PL characteristics

The PL should understand the mission story and decide which alternative he would choose before playing. In the case of the alternative (1), when entering in the mission scene, he will be asked to put coins of money in different urns according to their colours. Otherwise, in the case of the alternative (2), when entering in the mission scene, he could help the corrupt monster eating all coins in order to finish the mission as quickly as possible.

According to this mission, the negative PL characteristics deducted are: “Materialist”, “Impatient” and “Unsatisfied”.

Playing the SG should change these PL negative characteristics to positive ones. We have identified 9 characteristics for three missions of the SG. Knowing that one characteristic could belong to one or more missions.

4.2.3 Psychological test

The psychological test contains a question for each characteristic. Continuing with the same example of the Bank situation, we will find in the test three questions related to the three characteristics. For the “Materialist” Characteristic, the PL should click on one of two images, one is reflecting a materialist person and the other a non-materialist one. Therefore, the same question system is used for all the different characteristics for all the missions. In addition and in order to not influence PL response, the same question title is used for all, which is: “Choose the image representing you the best.”

4.3 Evaluation of PL behaviour

4.3.1 Probabilistic floor model

In order to present the modelling of the anticorruption SG, we used NETICA[2], a Bayesian network development software. As shown if Figure 3, there are three levels, the first one presents the 9 behaviourals characteristics. The second level presents the results (positive or negative) obtained by the PL in the 3 missions. Consequently, the third level presents PL behaviour “Corrupted”, “Corrupted Trend” or “Not Corrupted”.

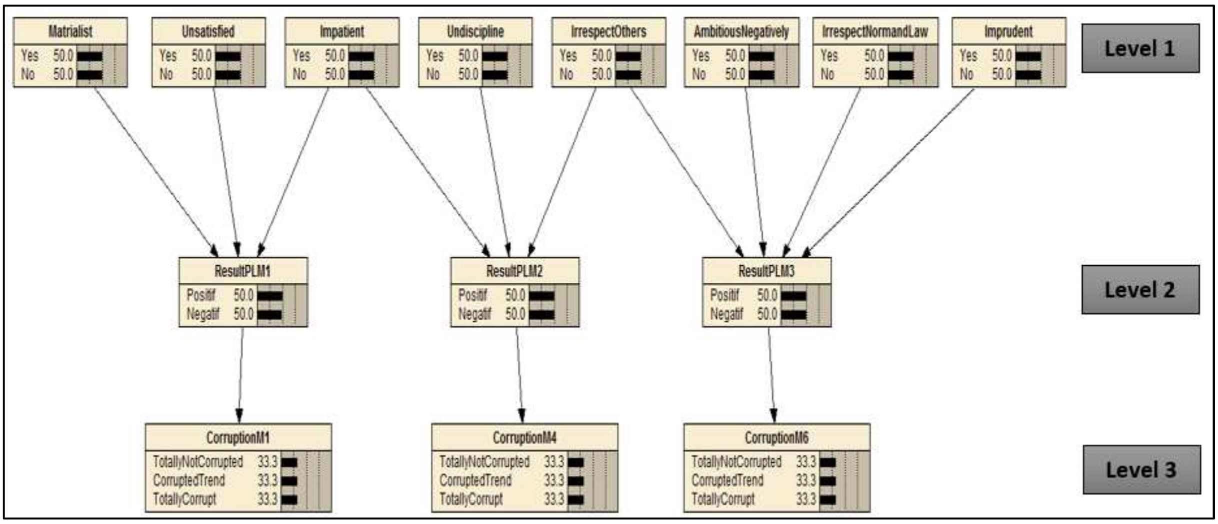

Figure 3. Modelling of the anticorruption game.

4.3.2 Decision floor model

Having the Netica Model, we added the decision and utility nodes. In Figure 4, we only present the final PL behavior for the consequence “Corruption” of the first mission. The utility table contains the corruption table data, as well as that of the decision. Therefore, we found six combinations. We have assigned a utility value for each couple of these data. The utility value is based on our private scale of relative satisfaction. They are assigned as follows:

[2] http://www.netica.org/

- We are completely satisfied when PL was totally corrupt and had a positive change, then we assign this a measure of 1 considering the game 100% effective.
- We are not satisfied at all when PL was totally corrupt and did not have any change, then we assign this measure of 0 considering the game not effective at all.
- We are more or less satisfied for the other possibilities, and then we assign this measure of 0.8, 0.6, 0.4 and 0.2 considering that the game is effective at 80%, 60%, 40% or 20% of the time.

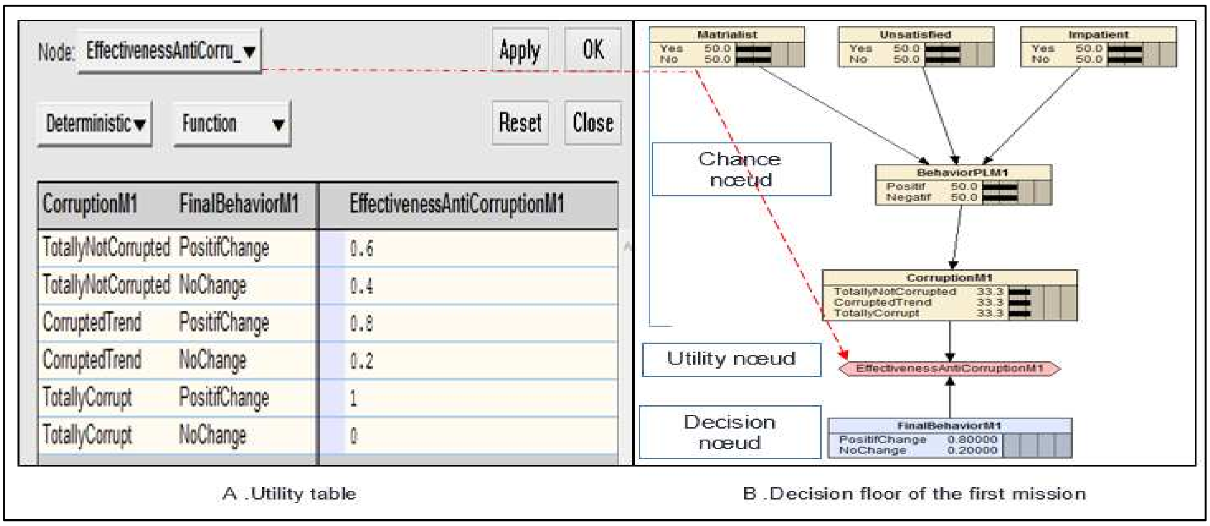

Figure 4. Presentation of decision floor of the first mission

The evaluation of the final PL behavior is calculated as follows:

E (FinalBehaviorM1=**PositifChange**) =

P (CorruptionM1=TotallyNotCorrupted) *

EffectivenessAntiCorruptionM1(CorruptionM1=TotallyNotCorrupted |FinalBehaviorM1=**PositifChange**)

+

P (CorruptionM1=CorruptedTrend) *

EffectivenessAntiCorruptionM1 (CorruptionM1=CorruptedTrend |FinalBehaviorM1=**PositifChange**)

+

P(CorruptionM1=TotallyCorrupted) * EffectivenessAntiCorruptionM1(CorruptionM1=TotallyCorrupted |FinalBehaviorM1=**PositifChange**)

We illustrate the calculations by the values of Figure 4:

33.3 * 0.6 + 33.3 * 0.8 + 33.3 * 1 = 20 + 26.7 + 33.3 = 80%.

According to the designed Netica graph, even if we do not have any information about the PL initial characteristics, the result is positive equal to 0.8 presented in decision node. It indicated that the effectiveness of the game is significant and high.

5 CONCLUSION

The proposed model has the objective to evaluate the PL progress using a persuasive SG and at the same time, to give an indicator about the effectiveness of the SG in itself. Our purpose was to avoid wasting time and even to avoid a battery of expensive tests in order to gather certain information about the final PL behaviour and the game effectiveness.

The model presents predictive results about the probabilities of occurrence of the different consequences. These results are linked to the notion of effectiveness of the game to evaluate the final PL behavior.

Applying this model to an existing persuasive SG, shows us promising results.

The next step is preparing an experimentation with real PL samples in order to gather real information about initial characteristics of the PLs and information about them during the game. Therefore, we could calculate the real probabilities and decisions.

ACKNOWLEDGEMENTS

Many thanks to the non-profit organization, Association “Tunisia For All”, to give us the full availability of use of their persuasive serious game of Anticorruption (https://tunisiaforall.org/?page_id=287).

REFERENCES

[1] J. Alvarez, D. Djaouti, “Une taxinomie des Serious Games dédiés au secteur de la santé, “ *REE*, no.11, pp.91-102, 2008.

[2] L. Michaud, Serious games Advergaming, edugaming, training and more, Understanding the digital world, *IDATE Consulting & Research*, June 2008. Retrieved from http://ja.games.free.fr/ludoscience/PDF/EtudeIDATE08_UK.pdf.

[3] M.P. Fourquet-Courbet, D. Courbet, “Les serious games, dispositifs de communication Persuasive, “ *La Découverte « Réseaux»*, no.194, pp.199-228. 2015.

[4] N. Sola, Estimation des connaissances d'un joueur-apprenant et génération de scénarios adaptés dans un jeu sérieux de simulation immobilière, Mémoire, Université du Québec à Montréal, Maîtrise en informatique, 2015. Retrieved from http://archipel.uqam.ca/id/eprint/7663.

[5] S. Callies, Architecture De Génération Automatique De Scénario Pédagogique De Jeux Sérieux éducatifs, Thèse à Université Du Québec à Montréal, 2016. Retrieved from https://archipel.uqam.ca/9183/1/D3164.pdf.

[6] N. El-Kechaï, Suivi et assistance des apprenants dans les environnements virtuels de formation, 2007. Retrieved from http://www.theses.fr/128713658.

[7] S. Messick, “The Interplay of Evidence and Consequences in the Validation of Performance Assessments”, *Educational Researcher*, vol. 23, no. 2, pp. 13-23, 1994.

[8] S.J. Russell, P. Norvig, Artificial Intelligence : A Modern Approach. Prentice Hall, 2010.

[9] P. Naim, P.H. Wuillemin, PH. Leray, O. Pourret, A. Becker, Réseaux bayésiens, Eyrolles, 2004.

[10] Investopedia, Bayes Theorem, 2018. Retrieved from https://www.investopedia.com/terms/b/bayes-theorem.asp.

[11] F.V. Jensen and T.D. Nielsen, Bayesian Networks and Decision Graphs, Springer, 2007.