TOWARDS GAMIFICATION OF THE DATA MODELING LEARNING

Research full-length paper

Track N°2

Abstract

Data Modeling (DM) is an important area in the Information System (IS) learning. In particular, in the IS analysis phase business analysts need to provide a comprehensive notation to avoid misunderstanding between software engineers and customer. Teaching DM is a challenging task, mainly because it lays great emphasis on theory. It remains often abstract, not consensual and complex to implement in real setting. In order to better motivate learners, this paper aims to assess the integration of Serious Games (SGs) in the DM learning. Previous researches on learning with SGs has mainly been focused on other areas of the IS domain, such as Business Process Management (BPM). In an attempt to fill this gap, this paper presents an exploratory experiment on the usage of the SG innov8, carried out within a business school's master students. This SG initially designed for learning BPM, has been the subject of a gamification experiment in order to design a data model. The feedback from the students and teachers were quite positive.

Keywords: gamfication, data modeling, serious games

1   Introduction

In a context marked by youth's shift to digital culture instead of academic culture, the use of Digital Based Game Learning (DBGL) [1] [2] is receiving widespread attention from Business schools. DGBL is a student-centered educational approach which adopts Serious Games (SGs) or form of simulation, situating students in a learning environment [3]. Thus, students could acquire skills and knowledge from the process of playing the games. Several studies [4] [5] indicate that DGBL can provide an enhanced experience compared to more common teaching methods.

In the Information System (IS) field, several SGs[6]have been developed such as *INNOV8*[1] and *Iseamethod*[2] for Business Process Management (BPM), *SharkWorld*[3] for Project Management and *Keep an Eye out*[4] on cyber security awareness. But few of them are used in academic programs in France, because the valuation models are still not mature.

To the best of our knowledge, only a few studies have been conducted to assess the SG's degree of efficiency in achieving the implied added value in the IS learning [7]. SGs usage or the IS learning requires a theoretical framework to evaluate its strengths and weaknesses.

This paper tries to fill this research gap by providing a feedback on the use of INNOV8, a SG developed by IBM for Business Process Management learning (BPM).

We propose to turn away the initial scenario of BPM (dynamic IS view) in order to address the data modeling issue (static IS view). We have Two key research questions:
-    RQ1: Is it appropriate to use SGs to teach data modeling?
-    RQ2: How to integrate SG in the IS conceptual modeling learning?

This experiment was conducted in the context of the course "IS modeling" taught during the second year of a business school. INNOV8 was used to train students to process modeling as well as to an initiation to Class Diagram modeling language.

Our aim was to enhance the courses traditional learning methodologies, namely: core modeling concepts presentation, readings and case studies in order to study the potential contributions of this SG. The purpose of our experiment was to discover the underlying data model to INNOV8 and to represent as a class diagram (UML).

In order to assess the quality of the data models proposed by the students, we built upon researches on data models quality [8] [9][10].

The remainder of the paper is organized as follows. In section 2, we provide background on SGs and DM assessment. We then present the research methodology, the research findings and the student's feedbacks. The conclusion discusses contributions, limitations and future research directions.

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[1]http://www-1.ibm.com/software/solutions/soa/innov8/index.html

[2] http://www.iseamethod.com/

[3] http://www.sharkworldgame.com/

[4] www.keepaneyeout.fr/

2   **Background**

2.1 Serious Games and Gamification

Serious Games [6][11] are commonly defined as : "computer program, which aims to combine both serious aspects (Serious), such as but not limited to, education, the learning, communication, or information, with fun springs from the video game (game)".

Werbach and Hunter [12] define gamification as: "the use of game elements and game design techniques in non-gaming environments."

The authors explain that fun is a valuable tool that firms can turn into a competitive advantage to accomplish organizational goals. Gamification was conceived after a reversed engineering process to understand what makes games effective and how this knowledge would be of utility in a business environment.

Although gamification uses the same elements than SGs, it should not be confused with a game. Also, gamification is not about incorporating game elements with no specific purpose and expects, it to improve user engagement and motivation, the system needs to be aligned to the organization's objectives [13]. There are also some gamified initiatives to help students perform better [14][15].

Several studies have analyzed the contributions of the SG for learning [16] [17].

The success of these training schemes is linked in particular to their captivating and entertaining nature. These factors are particularly important on a target learners accustomed from an early age to handle technological tools and video games.

This intensive use of games and technology has led to the concept of learning by the video game: Digital Game-Based Learning (DGBL)[1]. The appeal of this approach lies particularly in "Learning by doing".

The main advantages of SGs in the higher education context are [1][2]:
- **Setting in situation:** SGs offer a virtual environment allowing learners to be in entrepreneurial situation, experiment actions and to develop skills in impossible or difficult to reproduce contexts in professional life for reasons of cost, to time and safety [16].
- **Interactivity**: They motivate more learners through play, and encourage them to develop different skills. Thanks to their interactive and playful aspects (such as competition and reward) these devices encourage learners generations X (born between 1965 and 1981) and Generation Y (born between 1982 and 1999) to activate their abilities.
- **Immediate Feedback**: They propose to perform real tasks and make decisions in a virtual environment, thereby immediately see the feedback from these actions (successes and / or failures). They offer the learner the opportunity to play a role as part of a business mission of a virtual company. The player, invested in the form of an avatar, is faced with job situations where it needs to mobilize knowledge and behavior giving an overview of various aspects of a profession.

Data modeling is a difficult area of learning. Indeed, building a static representation of information necessary for a situation is not a unique solution to the problem. The same situation analyzed by various people can be outlined by separate models, which correspond to different points of view.

Various studies [18], point out that the knowledge of the concepts are not enough to appropriate modeling data from a specified location. Analysis and capacity for abstraction is needed to identify the representative information of the situation observed (or described). These concepts are difficult to transmit to via teaching [19] as there are no universal rule applicable for data modellling. The learners seek methodological tools to guide their creativity.

Other authors [20] argue that modeling is only acquired through practice and recommend the trainer to describe steps to build diagrams.

In this context, we aim to experience an educational system focused on practice via the use of an SG for learning data modeling.

2.2. Data Modeling

Since the 1970s, the design of an information system (IS) is based on the representative system models. Conceptual modeling aims to formalize domain knowledge to meet the functionality of the system to implement "the main objective of conceptual modeling is the collection and the formal definition of knowledge about the field and whose system needs to perform the functions assigned to it."[21].

Thus, the conceptual model is the formalization of the expression of user needs and allows this capacity to verify compliance of the IS field [22]. It is also a formalization of what will be the SI. It is not only a description of the area but also the support of the entire development phase and even the maintenance and evolution of the IS [23].

Moreover, nowadays, given the complexity of IS, models that are used to understand and represent them, are becoming increasingly important. However, for a model to be truly useful for development it must ensure quality.

To assess the quality of the models, general frameworks have been proposed in the literature [23] covering three aspects:
- Syntax quality: it is to measure the correctness vis-à-vis the concepts and constraints of the formalization of language model.
- Semantic quality: it is to assess the correspondence of the domain model it represents. This match incorporates the current state of the field and its evolution. It is measured using criteria such as completeness or semantic correctness. These criteria are difficult to assess, and require a perfect understanding of the field, whose knowledge is often unstructured.
- Pragmatic quality: it is to evaluate the ease of understanding of the model by her assistance. Indeed, the size and complexity of the model has a direct impact on the ease of understanding of it. Furthermore, the documentation accompanying the model, and the name of the model elements also influences the understanding of the model.

Other frameworks have been presented on the quality of models. In particular,[24], which proposed to organize the characteristics of the quality of models in six categories (content, scope, level of detail, composition, consistency and response to change).

A second category of work on quality models concerns the measurement of this quality through the development of criteria or quality indicators and metrics.

One of the more structured approaches in this category [25] provides specific criteria for conceptual models: completeness, correctness, minimality, expressiveness, readability, self-describing, scalability and normality. These criteria, however, not have been associated with metrics to measure.

In [26], other criteria such as homogeneity, size, or the simplicity of the models and queries on these models were defined.

Based on these common criteria for quality assessment of data models [27] propose taxonomy of educational differences when assessing the quality of a model data with respect to a modeling solution types. We adopted this taxonomy in our experimental protocol, to measure the differences between the models proposed by the pilot group and the solution proposed by the teacher.

Table 1: Taxonomy of Educational differences [27]

Omission of an element	The learner does not show in his diagram, part of the reference model.
Adding an element	The learner has shown in his chart, an item that is not among the reference model elements.

Transfer of an element	An element of learning the chart was shown in another part, relative to the reference model
Misrepresentation	An element of learning the diagram was presented in a form other than that described in the reference model
Direction reversal of a relationship	The meaning of a relationship-oriented (inheritance, aggregation, composition) was reversed by the learner
Erroneous multiplicity	Multiplicities of a relationship in the learner diagram differ from those described in the reference model

Some basic differences systematically induce other basic differences. For example, the difference "omission of a class" results in differences "omission of a relationship" or "transfer of a relationship." Indeed, if the student fails to represent a class, it induces the failure of relationships related to this class or their transfer to another class.

Hence the definition of a list of "complex differences", consisting of a main and basic difference of a set of concomitant differences. For example, the complex difference, "omission of a class and associated elements" consists of the main basic difference "omission of a class" and concomitant differences such as' omission of an attribute of this class "or" omission of a class related to this relationship"

From this taxonomy, we conducted a debriefing with the students in the pilot group, to measure explain the differences between the diagram constructed collectively and the reference model (see Figure 1).

3   **Methodology**

We have adopted an experimental approach to study the impact of INNOV8 usage on the DM learning. In this section, we describe the research design, the experiment procedure as well as the selected criteria for evaluating student's DM. This experiment was conducted in the context of the course "Information System Design" taught during the second year of our Business school curriculum. The course was implemented in a traditional way: lecture course, modeling exercises and lab work. The 24 students enrolled in this course were familiar with INNOV8, as they have used the game for learning "Business Process Management". Each student has to define a draft of a DM in UML language. Then, the students were asked to compare their individual models in order to propose a final solution for modeling the game domain.

At the end of the Game session, we debriefed with the students to understand the approach they have adopted to build the DM, through the use of SG and the theoretical course session attended.

In order to assess the quality of the model proposed collectively by the pilot group of learners, 3 faculty members involved in this experiment have adopted the basic differences taxonomy proposed by (Alonso et al. 2010) (see Table 1) . This taxonomy will compare the results of students to the data model proposed by teachers (reference model).

3.1. Sample

A total of 24 Master I students participated in this research project, which was conducted during the last session of the course "Information System Design" in a French business school. The students were involved in a test in situ.

The conventional format of the course involves small groups of students (N = 24), who interact with teachers in solving modeling exercises and in case studies analyses.

Table 2. Sample

Variable	Number
Total participants	249
Gender : Males Females	 109 (43,77%) 140 (56,22 %)
Average age	22 years
Experience with SG	203 (81,52%)

3.2. Serious game selection: INNOV8

INNOV8 is an SG developed by IBM in 2007 as part of their "Academic Initiative" program. IBM has developed a second version in 2009 used by many universities worldwide. Version 2.0, which was selected in our experiment, is a 3D game for business process modeling and optimization. INNOV8 offers to the learner an avatar to meet various stakeholders of a fictitious company "After Inc" and to collect different information from the multiple company services. It is a single-user system, where the player takes the role of a consultant who has to model and reconfigure the process of a call center to optimize the company business processes (see Figure 1).

Figure 1: INNOV8 screenshot

In order to achieve its mission, the player has to complete certain tasks and collect information from other actors from different departments of the company, throughout the scenario, the player has to:

- Choose the right strategy to meet specific needs,
- Choose the budget to be allocated to different sectors of the company,
- Reconfigure a process to achieve specific goals,
- Interview company employees to get information

The player controls his character, while other characters are present in the company. Advices are given to the learner throughout the scenario, such that finding documents or interviewing other virtual employees. In most cases, following these dialogues, important information is communicated to the user in order to make decisions. Information provided during the interviews is very often keys to find the optimal solution to the problem. Indeed, it is often necessary to find a tradeoff i.e., a tradeoff between the number of employees to be assigned to a certain task and the level of their skills under a budget constraint. Afterwards the player's decisions are simulated (3 attempts) before submitting its response. A non-optimal solution impacts on the entire business process.

4. Results

The students have played INNOV8, in order to remember the process of the game. Then they replayed several times and have considered several possible scenarios in order to identify the components of the data model (figure 1). In a first stage, the students have identified the main UML classes including: the avatars (the employees of the organization and the player), the scenarios (three Business processes), specialized in texts or videos Tutorial classes explaining the purpose of each scenario and the strategy (solution provided by the player to solve the game).Then, the students have identified structural relationships between the identified classes as well as the associations of the DM.

After identifying the relationships between classes, they have completed the diagram with attributes. For example, the avatar class is characterized by an Id and a name. Finally, the students determined the cardinality of the model.

Figure 2: DM collectively constructed by the students
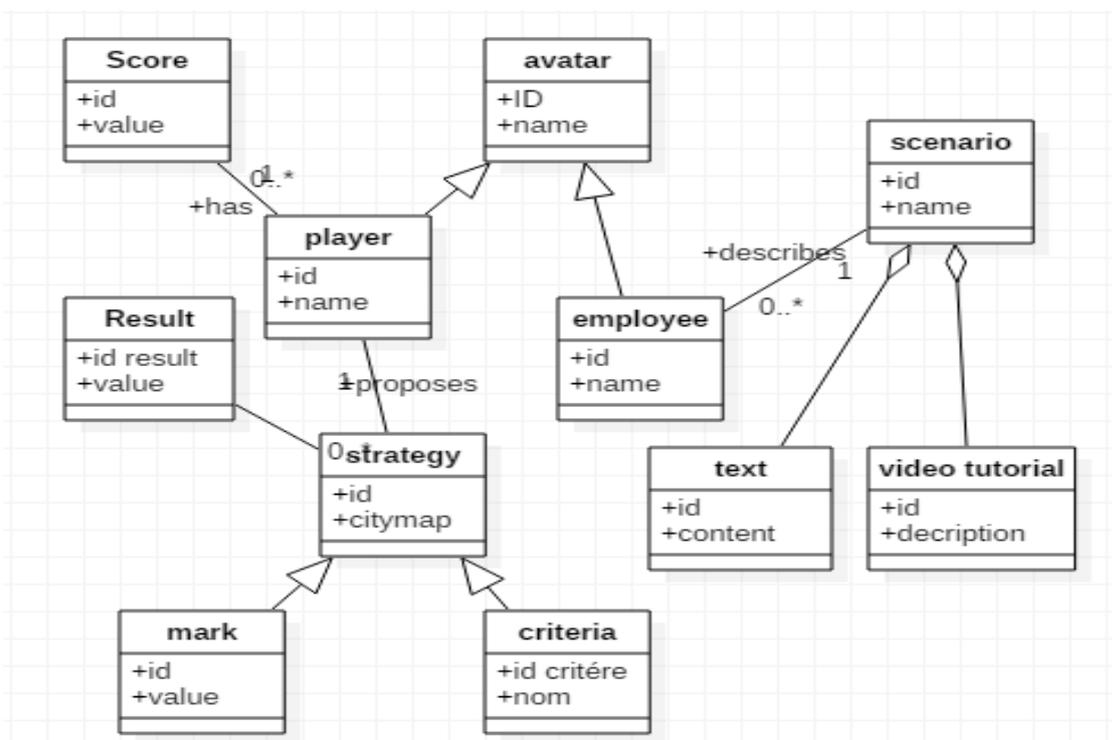
In order to assess the quality of the data model built collectively by students, we have compared it to the reference data model built collectively by 3 teachers who participated in this experiment (Figure 3). We then compared the two models using the taxonomy of educational differences (see Table 1).

Figure 3: Teacher's proposal of DM

(Reference DM)
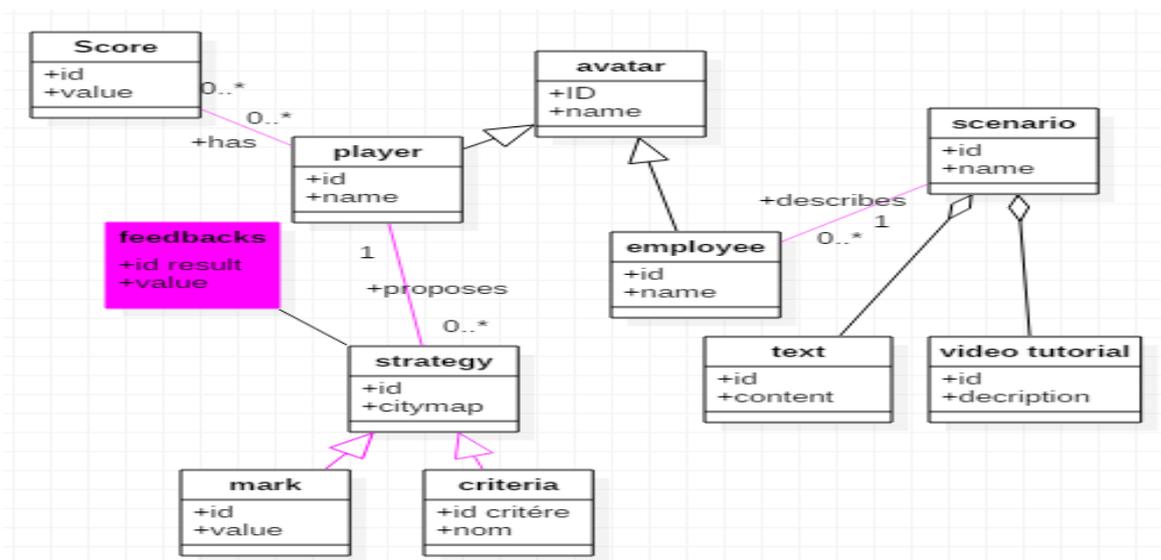
The simile of reference model to the student's model is presented in Table 2.

Table 2: Student's model assessment

Evaluation criteria	Description of the evaluation criteria	Student's model assessment
Omission of an element	The learner does not show in his diagram, part of the reference model.	1 omission unidentified feedback class
Adding an element	The learner has shown in his chart, an item that is not among the elements of the reference model.	1 added: adding redundant class result with the score class
Transfer of an element	An element of learning the chart was shown in another part, relative to the reference model	0

Misrepresentation	1 added: Adding redundant class result with the score class	Representation of an inheritance relationship in the form of a composition relationship
Direction reversal of a relationship	The meaning of a relationship-oriented (inheritance, aggregation, composition) was reversed by the learner	0
Erroneous multiplicity	Multiplicities of a relationship in the learner diagram differ from those described in the reference model	2 unidentified multiplicities

5. Discussion

Our key research questions were about identifying if it was appropriate to use SGs to teach Data Modeling. We found that the DM proposed by the students had a good quality. The model assessment depicted in table 2 shows that the data model proposed by learners has generally few differences from the reference data model.

From a syntactical viewpoint, the proposed model was correct; we have noticed that there is no transfer of elements of the model and no reversal of the direction of relations. From a semantic viewpoint, information objects identification (UML classes) was particularly well controlled by the students (one class of omission and one redundant class). We also found that the binary relationship between the identified classes was also well modeled. This is a major difficulty in modeling data for the choice of classes as it requires an effort of abstraction from the learners. The concrete context of the game has been useful for viewing and manipulating examples of information objects in each scenario, which facilitated the work of abstraction by learners. Two main shortcomings were identified in the model proposed by the students:

-Confusion between inheritance relationship and composition (1 misrepresentation): structural rules are not clearly explained in the scenarios of the game

-Identification of cardinalities: management rules are not explained in the scenarios of the game like in a conventional modeling statement.

We have debriefed with the students in order to analyze their opinions about this experiment. Their feedbacks were quite positive. They were more satisfied with this learning experience than the conventional modeling exercises. The experience should also be enjoyable and attract the attention of the learners. Here are some excerpts from the student's comments:

"SG usage or DM is really exciting, I now understand what it is a UML class, it would be great to use a game for the final exam!".

"The application of the course concepts was very fluid with the game. This lesson was much more fun! I feel more motivated to work on this modeling exercise"

This research has practical relevance as well. A better understanding of the outcomes of learning with SGs usage for the IS courses helps business schools to make better decisions about their learning strategies. Knowledge about some of the important characteristics of learning with SGs also contributes to the development of this learning technology. Designers of SGs would do well to design more games for the conceptual modeling learning.
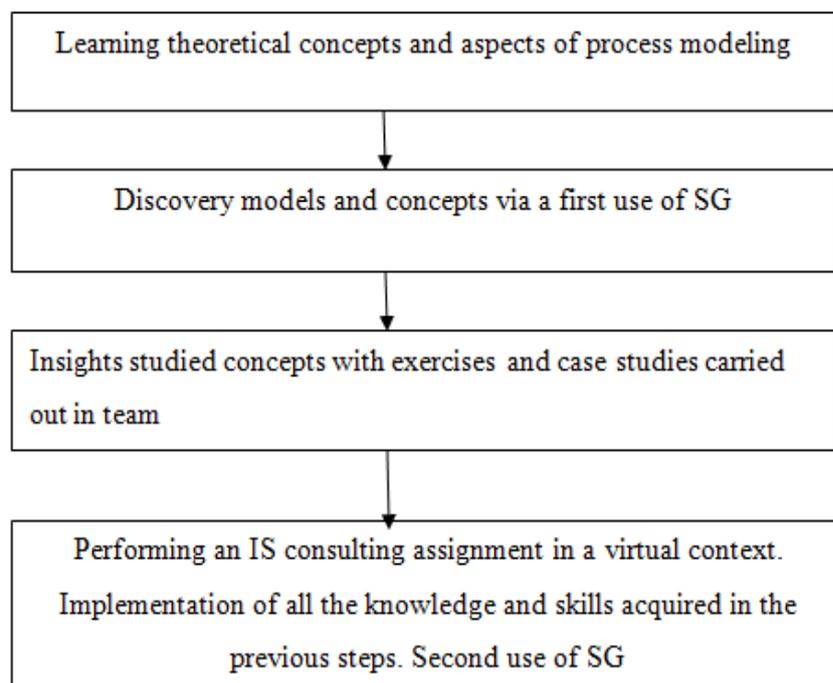
INNOV8 was appreciated in the context of applying the theoretical concepts of IS design. However, the game did not provide theoretical knowledge. Thus, we have imagined a new course design method in order to integrate this SG within the IS design course. We have therefore proposed the following agenda (see figure 4).

The SG will be used in two distinct periods of training.

First, after the introduction of Business Process Management theoretical concepts. This first experience of the SG will be the opportunity for the learner to discover, through this virtual environment, the various concepts and models studied during the first stage of the course. This will initiate the reconfiguration and process optimization through its first virtual junior consultant experience.

After this introduction to SI consulting business, exercise sessions and case studies will be conducted in small groups to deepen some aspects of the audit, reconfiguration and optimization process. This group work, will allow participants to be active in their learning and learning by doing. In the final stage of training, when the learner has acquired extensive knowledge on process management, the Serious Game is used again. This second experience of SG allows for virtually live the learner a mission organization consultancy entrusted to him and to better understand that during the initiation phase, the activities performed to optimize the faulty process (in the case of INNOV8, the call center).

Figure 4. Design of an educational process that integrates the use of INNOV8

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┌─────────────────────────────────────────────────────────┐
│  Learning theoretical concepts and aspects of process    │
│  modeling                                                │
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│  Discovery models and concepts via a first use of SG     │
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│  Insights studied concepts with exercises and case       │
│  studies carried out in team                             │
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┌─────────────────────────────────────────────────────────┐
│  Performing an IS consulting assignment in a virtual     │
│  context. Implementation of all the knowledge and        │
│  skills acquired in the previous steps. Second use of SG │
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6. Conclusion

There is a consensus that serious games have great potential as a tool for learning. However, their effectiveness in terms of outcomes is still little studied due to the complexity of the assessment.

This paper presented the results of our ongoing research on the use of SG under the teachings of conceptual modeling. We focused on assessing the quality of learner models based upon consensual theoretical criteria in the field of data modeling. Preliminary results were quite positive. We also found a better participation and involvement of learners in the proposed work compared to other traditional courses based on practical exercises and case studies. In particular, the pleasure dimension of the game has led to increased motivation of learners in finding the solution to the exercise.

Our future research will concern the renewal of this experiment as part of our teachings in the management school. Our goal is to refine our preliminary results by comparing traditional conceptual modeling learning to

Digital Based Game Learning. In addition, future researches will consider learning assessment at the individual level to avoid going wrong due to collective intelligence impact.

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