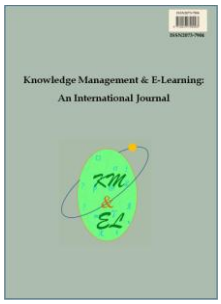
Knowledge Management & E-Learning



ISSN 2073-7904

Designing learning scenarios for serious games with ARGILE

Nour El Mawas
LUNAM Université, Université du Maine, France

Recommended citation:
El Mawas, N. (2014). Designing learning scenarios for serious games with ARGILE. *Knowledge Management & E-Learning*, *6*(3), 227–249.

Knowledge Management & E-Learning, 6(3), 227–249

Designing learning scenarios for serious games with ARGILE

Nour El Mawas*

Laboratoire d'Informatique de l'Université du Maine (LIUM), EA 4023
LUNAM Université, Université du Maine, 72085 Le Mans, France
E-mail: nour.el_mawas@univ-lemans.fr

*Corresponding author

Abstract: The design of Serious Games for training in complex areas of expertise presents many difficulties related to trainers' participation in the design phase, the formalization of scenarios describing highly complex situations, the limited number of scenarios in Serious Games due to their high costs, and the low re-use level of real-life scenarios. This study proposes functional and technical infrastructure with ARGILE (Architecture for Representations, Games, Interactions, and Learning among Experts) for design of Serious Games. We illustrate our solution applied to a project in the sustainable development field.

Keywords: Serious games; Knowledge engineering; Co-design; Discussion forum

Biographical notes: Nour El Mawas received a PhD degree in Computer Science from the UTT at Troyes in 2013. Her work was about the design of Serious Games for expertise training in complex situations like Crisis and Sustainable development. Her main propositions were the ARGILE approach to design participatory and knowledge-intensive Serious Games. She is currently a researcher at Université du Maine. She is continuing in the e-learning field, especially in the design of Technology-Enhanced Learning systems.

1. Introduction

e-Learning refers to the use of computer network technology, primarily via Internet, to deliver information and instructions to individuals (Wang, Ran, Liao, & Yang, 2010). e-Learning applications have been increasingly developed to support learning in various aspects. Among them, Serious Games (SG) are all about leveraging the power of computer games to captivate and engage end-users for a specific purpose, such as to develop new knowledge and skills (Corti, 2006).

SG has been adopted by organizations in many fields like education, professional training, safety, health, communication or civil security education. The fact that SGs deal with many serious topics poses several problems regarding the design of these games. In our research, we are particularly interested in the design of SGs for the training of different categories of people, in domains where the transmitted knowledge are complex and embedded in practical activities. In general, the design of games relies on the expertise of game designers. But in our case, the design is not based only on game designers' skill.

In this context, the paper aims to solve problems related to the design of SGs in complex areas featured by the lack of trainers participation in the design phase, the absence of formalization of scenarios describing highly complex situations, and the high cost of designing SGs for training purposes. The following issues immediately arise: how to apprehend the complexity in SGs? What are criteria allowing experts to be masters of their game design and to easily add, modify or delete a scenario? How to enhance the collaboration between the actors (designers and players) in order to develop the fairest games rules and improve learning from games? The purpose of this study is to address these issues by proposing a new design methodology for SGs based on language items and cooperative work.

First, we will propose the participatory architecture for co-design of games by designers, experts, and players. Second, we will propose knowledge-intensive games for the training of professionals in complex areas where knowledge is inexplicit and complex. Stakeholders involved in our approach are experts and learners. There are many SGs used for learning and training purposes but these games only cover a limited number of scenarios due to their high cost. Our approach will offer an increased number of scenarios in order to meet the pedagogical needs of experts. To do that, we need a functional and technical infrastructure which can generate a wide range of possible scenarios and allow experts to add new scenarios without IT assistance. Our suggestion stresses the need to co-design and annotate rules and game objects by trainers and learners.

The paper is organized as follows. Section 2 proposes the theoretical background of the study. Section 3 presents several existing methodologies for design of SGs. Section 4 details our scientific positioning and defines our approach of "participative and knowledge-intensive" SGs. Section 5 illustrates the application of our approach in a project named Defismed in sustainable development. Section 6 presents our evaluation method on design levels. Finally, section 7 summarizes the conclusion of this paper and presents its perspectives.

2. Theoretical background

In this section, we discuss theoretical background directly related to the design of participatory and knowledge intensive SGs. In order to choose the appropriate learning environment to train experts in complex situations, we examine the difference between Video Games, Simulators, and SGs. We privilege that players build their knowledge by themselves and we refuse any knowledge transmission that's why we present the relation between SGs and Knowledge Engineering. In our work, we grant a particular importance on interaction between trainers and learners so we look at the relation between SGs and Forum Interaction.

2.1. Games and learning

The human brain works more effectively when we have fun. There is a scientific basis behind the use of art, theater, color, emotion, social learning and even games for learning purposes (Rose & Nicholl, 1998). The idea that SGs facilitate learning has been examined in several domains, for example, languages and health (Mandin, 2010), economy and management (Blunt, 2009), and learning programming (Muratet, Torguet, Jessel, & Viallet, 2008).

According to Lave (1988), learning is not something that happens in independent isolation, or just inside the head, but instead is shaped by the context, culture and tools in

the learning situation. His situated view of learning maintains that people learn as they interact with and within a community of practice while participating and shaping their history, assumptions, cultural values, and rules.

Jonassen, Davidson, Collins, Campbell, and Haag (1995) explains that games enhance situated learning. Players create community of practice including their beliefs and behaviors. Online games and forums may support situated learning by allowing players to communicate, learn, and share/build knowledge in specific contexts. When people play together and try to found solutions to problems they are facing, the proposals of each create socio-cognitive conflicts and a dynamism that enables them to find solutions to which neither player will not be able alone to find in an another context.

McLellan (1996) uses the term "coaching", inspired from athletism to present the change of the instructor role from a knowledge holder to a knowledge coach. This is a tutor format at which the learner, helped by someone more competent than him, will be able to interiorize advice and appropriate them. Players do that spontaneously during their interactions by looking to more competent players and by asking them hints and tips to progress in the game. The mentoring between players present an important element for learning, it's one of the keys for socio-constructivism researches. According to Bruner (1983), mentor acts as a mediator between learners' initial competences and other competences developed later, allowing them to develop knowledge and helping them to implement resolution procedures.

In our approach, we support the idea that players must develop their knowledge: They are not passive; they act as if they were in the center of the game. So they can build their own experiences and knowledge. In order to choose the most suitable learning environment for our approach, we will study the difference between Video Games, Simulators, and SGs.

2.2. Video games, simulators, and SGs

Djaouti (2011) explained the difference between Video Games and SGs. He illustrated his ideas on two different games in the example *the Trauma Center: the Second Opinion* game and the *Pulse* game (Fig. 1).

Fig. 1. The video game Trauma Center: Second Opinion (left side), SG Pulse (right side)

The game Trauma Center presents a surgeon performing various operations. Some think that this game is a SG for training experts in health field, but the medical area

is only a context for the entertainment content and the game wasn't designed for utilitarian purposes. That's why the game *Trauma Center* is considered as a Video Game. However the game Pulse can be used to train players about emergency situations related to real case studies. There is a utilitarian goal behind the game, the game *Pulse* is considered as a SG. In summary, when the object of the game is only to entertain and amuse the player, this is a Video Game. In contrast, when the game is based on a playful aspect and a utilitarian aspect, this is a SG.

But that doesn't mean Video Games cannot be diverted to serve for serious purposes (Djaouti, 2011). For example, the *Buzz! Quiz TV* game was used by history and geography teachers who create personalized questions in order to return to concepts explained in the course sessions. Another example is the *Karaoké Singstar* PS3 game used as a course support to improve the English pronunciation of students. We find that some usage cases allow using Video Games, primarily designed to entertain players, for serious purposes.

Now, we examine the difference between a Simulator and a SG (Alvarez, 2007). According to Oxford dictionaries, *a Simulator is a machine designed to provide a realistic imitation of the controls and operation of a vehicle, aircraft, or other complex system, used for training purposes*. This definition identifies the common point between a SG and a Simulator. It's the virtual world. However, a Simulator is not designed to allow user a pedagogical evaluation of his actions (for example, win points). A user flight simulator doesn't have a specific purpose; he can freely fly in all directions or set a target that he must pass under a bridge without crushing.

The question raised in this context: is a Simulator designed for a serious purpose considered as a game? To answer that question, Alvarez (2007) takes the example of the America's Army game. America's Army can be considered as: (1) a Video Game if players download the game and play it for its fun aspect, (2) a SG if players play for its fun and utilitarian aspects, (3) a Simulator if it's used in military training courses and player does not care about the fun aspect.

Table 1
Difference between video games, simulators, and SGs

	Fun aspect	Utilitarian aspect	Clear objective
Video Games	X		X
Simulators		X	
SGs	X	X	X

Table 1 shows the difference between Video Games, Simulators, and SGs. In our approach we need that our learning environment includes fun and utilitarian aspects. He must have also clear objectives. In addition, SGs are used as a learning environment because they accelerate learning, increase motivation and support the development of higher order cognitive thinking skills (De Freitas & Jarvis, 2007; Hays, 2005). So we choose the SG as a learning environment in our research work.

In the next section, we study the relation between SGs and Knowledge Engineering.

2.3. SGs and knowledge engineering

In our approach, trainers don't transmit knowledge; players build their knowledge by themselves! That's why we present here the relation between SGs and knowledge engineering.

Giasson (1991) distinguishes three types of knowledge to be acquired by learner: the declarative knowledge (what, the essence of things), the procedural knowledge (how, the know-how, the sequence of actions), and the conditional knowledge (when, conditions of using declarative or procedural knowledge, how to, if). Declarative knowledge is closely linked to procedural knowledge, as when our mind simulates the concept of "car", generally the simulation of behaviors to drive that car, or other affordable actions related to that concept are involved (Anolli & Confalonieri, 2011). SGs are suitable to effectively maintain, support, and augment declarative and procedural knowledge. When we talk about knowledge, we don't mean game knowledge but knowledge to be acquired by players.

SGs enhance acquisition and presentation mechanisms like iconic representation, spatial representation, inductive discovery processes, and interaction. SGs develop learners' capacity to understand the iconic representation (the meaning behind icons, diagrams, pictures...).

Greenfield, Camaioni, Ercolani, Weiss, Lauber, and Perucchini (1994) compared the performance of two groups playing the memory game Concentration: the first group was playing this game in board format while the second group used the computerized version. They noticed that the second group of players tended to use much more diagrams and images in order to describe and explain what they had seen on the screen. Greenfield et al. (1994) concluded that presentation skills are influenced by the increased use of images and non verbal supports provided by SGs.

SGs develop the ability to construct spatial integration of computer screen displays. The increasing utilization of the nonlinear organization of computer programs in software is making the ability to construct iconic spatial representation ever more crucial for dealing with this medium (Greenfield et al., 1994). Hyper print and hypermedia, where the information is arranged complexly and in non-linear spatial configurations, require the ability to integrate all this information in order to be able to use them efficiently. People playing an arcade computer game were tested on a mental paper folding test (Greenfield et al., 1994). The results show that a SG utilizes and/or develops related visual-spatial skills that are more general than the game itself. This shows empirical evidence that players of three dimensional games use and develop skills required by television information processing.

SGs don't tell players the game rules in advance (Greenfield et al., 1994). The player must figure these rules out by observation, trial and error, and hypothesis testing. That's why the player develops a process of inductive discovery: he receives visual/audio data on the screens and he must formulate general rules, patterns, and strategies in order to progress in the game. According to Greenfield et al. (1994), this process of inductive discovery has two main components: (1) a purely inductive component within the player goes from specific to general; and (2) a more deductive component in which the generalizations from the first component become hypotheses to be tested with specific data.

2.4. SGs and forum interaction

Many tools allow interactions between participants like wiki, instant messaging, private messaging, and online forum. We choose to use the online forum for two reasons. First, participants don't have the same viewpoints. The interaction tool must allow open debate and exchange between them, so we cannot use a wiki. Second, we focus on the collaboration between designers and the continuous update/ versionning of games rules so the online forum is the most suitable tool in our approach.

The discussion forum is one of the most popular technologies used for the diffusion of e-learning. Its origins began with the launch of Internet. Bullen (1998) discusses how Internet and Computer Mediated Communication (CMC) can promote learning in learners groups. Garrison (1993) finds that discussion forums have the potential to change the type of distance teaching. They provide an opportunity for learners to collaborate and create mutual understanding by building learning communities.

Mason and Kaye (1990) explain that forums provide opportunities for dialogue, debate, and conversational learning: learners develop a sense of community while maintaining access to thought and ideas of other students. Collins and Berge (1995) show the advantage of the CMC while explaining its potential to release education of the time and distance constraints. Dehler and Porras-Hernandez (1998) prove that discussion forums promote collaboration between learners and improve learning from experience.

Mangenot (2004) stresses the structured nature of exchanges: the forum can be consulted by participants when they want. In addition, it allows a structured vision of different contributions. Mangenot (2004) highlights two characteristics in the instructional design on forums. These characteristic are the chronological flexibility and the permanence of written word which improves information access. The IT system acts as a collective memory that helps to develop a more complex object of thought. The collaboration is an important skill developed by learners through forums (Swan, Shen, & Hiltz, 2006).

This state-of-art allows us defining solid bases for our approach. In this paper, we want to prove that the mix of disciplines such as SGs, Learning, Knowledge Engineering, and Forum Interaction can solve the problem of training professionals in expert areas where knowledge are complex and involved in practical actions.

3. Related work

In this section, we consider existing design methodologies for SGs (El Mawas, 2014). That's why we present the approach centered on the use of a technical tool, the content centric-model, DODDEL Model, design patterns for SGs, methodology of generic frame game, the triadic game design model and the engineering process for SGs.

Robertson and Nicholson (2007) propose the approach centered on the use of a technical tool. The design process is based on six steps: the exploration, the ideas generation, the game design, the game implementation, the game testing, and the evaluation. They have tested the validity of this model by observing children using their tools for the creation of video games. These experiments have demonstrated the pedagogical value for creating video games in schools. Rather than restrict the use of a game as a pedagogical resource, the creative process itself becomes a learning vector.

The content-centric model (Moreno-Ger, Martínez-Ortiz, Sierra, & Fernández-Manjón, 2008) is an approach to design SG assuming that the realization of the SG

combines at least two types of skills: game experts and developers able to technically build the game. According to this principle, if the game experts are not supervised, the project will face technical limitations. However, if the programmers define first technical limitations, experts' creativity will be restricted. The proposed model is entirely based on an iterative cycle; it requires technical skills to evolve with the design of SGs.

McMahon (2009) proposes a Document-Oriented Design and Development of Experiential Learning (DODDEL) to develop SGs. He suggests designing a SG in four steps: the situation analysis, the design proposal, the design documentation, and the production documentation. The experimentation showed that the DODDEL model defines a common base facilitating internal communication of designers and guides the creative process of people who never realized a SG before.

Huynh-Kim-Bang and Labat (2010) have suggested the design patterns for SGs to meet specific design issues such as "How to ensure consistent progress for learner?" Each solution is illustrated by an example of the SG in order to be easily usable by designers. These design patterns of SGs can be used during the stages of "the concept of a game invention" described by other models, they can, for example assess the relevance of designer ideas, or suggest for him some ideas.

Sauvé (2008) proposes the methodology of generic frame games based on "generic shells of educational games". This approach is to take an existing game, and to empty its contents (information conveyed by the game) in order to keep only its structure (how to play). "The generic frame game" thus obtained can then be enriched by a new content, including educational content. More specifically, it comes to designing the "fun" part of an educational game, to enabling teachers to concentrate on the "serious" part, allowing them to simply create educational video games.

Harteveld (2010) discusses the triadic game design mode. He focuses on three general boundary criteria of a SG Reality, Meaning and Play. He illustrates why tensions between these dimensions make it difficult to balance and create harmony in a SG. This approach Works really well for games for sense-making and understanding concepts. For us, this approach is very abstract to put a game into practice. Furthermore, we needed an approach to transfer complex and expert knowledge involved in practical activities.

Marfisi-Schottman (2012) presents a detailed complete industrial circuit for creating a SG model. This model is based on the specification of a serious content with a client, and then calls on pedagogues to develop a SG which the functioning will be detailed through many documents. This formal pedagogical engineering model is used to represent teaching structures. The main advantage of formalizing a pedagogical scenario is the possibility to automatically evaluate it through dedicated technical tools.

These design methodologies for SGs enables us to define important criteria for designing participatory and knowledge-intensive SGs. The methodology must be simple to use, promote collaboration between designers, guide designers in the design phase, and involve experts.

Across the table 2, we found that only the engineering process for SGs meets these criteria. But despite that, we have not been able to retain this approach because we need other key criteria for designing participatory and knowledge-intensive SGs. The system design should also be a support to the evolution of complex knowledge and designers viewpoints. It must also involve the learner in the design phase and promote constructivist learning through interaction between players. In our work, we focus on SGs for training in a professional field. Our goal is to have relevant game scenarios targeting complex and informal knowledge acquired when professionals practice their trades. This

led us to think deeply about a solution of co-designing this type of game which allows the construction of knowledge by all instructors, experts in the field and they can change, at any time, a scenario or add a new one or even improve existing rules in the game. The notion of co-design in a participative approach goes back to the 80s projects, related to reflection on the democracy, in domains like the repair of locomotives or the publishing world in Scandinavian world (Ehn & Badham, 2002) or the design of information and cooperation systems (Winograd & Flores, 1986). These authors underlined the necessity of including very early all actors concerned in the design. In this study, players were regarded as the centre of design, and the games were co-designed with the players.

Table 2
Existent design methodologies for SGs

Principles	Simplicity	Collaboration between designers	Design guide	Experts in design phase
Approach centred on the use of a technical tool	X	X	X	
The content-centred model				X
DOODLE model	X	X	X	
Design patterns for serious games			X	
Methodology of generic frame games	X			X
The triadic game design model			X	
The engineering process for serious games	X	X	X	X

In agreement with Social Semantic Web Approaches (Zacklad, 2003) the co-design must be also accompanied by the construction of semantic structures of actors such as "maps" of their knowledge in connection with their practices. It allows the actors themselves, to map the shared items and to organize their cooperation space, even "to appear" this organization in continuous process.

To highlight all these ideas we are going to detail in the next section our approach that meets all these requirements and provides innovative solutions in this domain.

4. The ARGILE approach

4.1. Overview

ARGILE (Architecture for Representations, Games, Interactions, and Learning among Experts) offers a methodology to design participatory and knowledge-intensive SGs (El Mawas, 2014). The space of "participative" SG is for us a co-designed space and which has to propose rich functions. It must allow not only confront multiple players, that use existing objects of this space, but also that the space of the game can be easily co-built by a wide group, by an addition, a modification and a discussion of new objects, knowledge and rules. The space of the game is thus participative at the same time for the group of players and for that of designers. These two groups are not divided up moreover totally: certain players, for example most experimented or creative, having the idea of improvements or new services, could be urged to join the group of designers or tend to press on him to obtain changes.

With the emergence of Web 2.0 technologies, there has been a recent transformation of e-learning from a central controlled education system to an interactive and conversational learning network (Wang, 2011). The development of these participation architectures was consolidated by the success of Web 2.0 applications but the realization of similar architectures for SGs still raises numerous problems. Indeed, it is necessary, at the level of infrastructure, to take into account the large number of players, to introduce a certain flexibility to take into account contributions of the multiple actors (players and designers). Furthermore, the actors have to cross their skills in situations for which knowledge and data are very numerous and strongly evolutionary, that is the case in games, where scenes and their items are numerous.

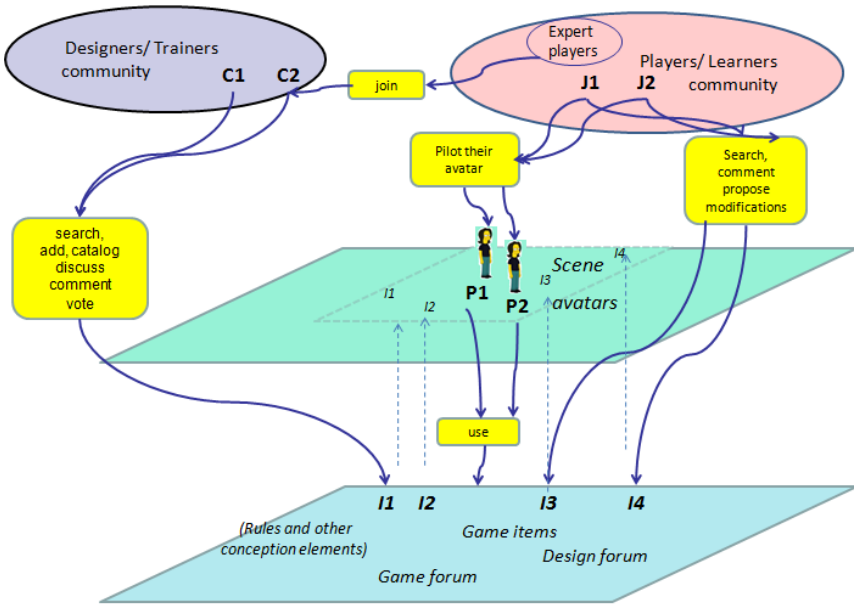


Fig. 2. Participatory architecture

The Fig. 2 illustrates the infrastructure and the participative aspects at the level of both communities: co-designers and players. At the infrastructure level, Knowledge Organization System records the game items, the exchanged messages by actors, etc. The authorized actors can look, add, catalogue, discuss, comment items. Intermediate plan is the one of the game. From the game, players can look and comment items.

For designers a permanent discussion forum must be able to organize on any object of the game in particular on every rule connected to an object, in particular when the game is used, because at this moment the differences of interpretation, opinions and approaches are the easiest to express and to discuss. The game has to base, on one hand, on a database cataloguing and returning easily accessible and editable game items (including rules, designed as editable contents elements) and on the other hand the forum.

If we consider a game scene, this one is going to be constituted at first by knowledge elements and rules specified by trainers and designers, for example rules governing the penalty of an action on an object in terms of "points". Then, the scene is going to be played and the rules instantiated. The designers have to specify on one hand rules and items of the game, and on the other hand rules of the educational evaluation included in this game (in particular values such as the number of won or lost points, which are visible to the player, facilitating in particular his motivation in game, his auto training, etc.).

The architecture of the software platform proposed to the designers (Fig. 6) has to allow editing these diverse specifications, finding easily knowledge, discussing them item by item, reaching the moderate values of attributes, etc.

From their part, the players also can look for items and use them to treat assimilate and comment them for example to confront their experiences, exchange hints and tips. It will be interesting that the players can reach certain parts of the design forum.

Via the forum, the players can discuss, between them and with the designers, in an asynchronous way, on the rules of an action, the won and the loss of points, know and criticize the reason of this rule, etc. In the forum a mark allows to spot if messages are posted by a player or by a designer; the designers can, if they wish it, mask some of their exchanges to the players.

4.2. The design forum

The proposed architecture is going to offer to the designers a design forum which includes (El Mawas, 2014):

- A specification system directed to a teamwork susceptible to associate skills resulting from several disciplines (jobs of expertise field, trainers of the field, pedagogy specialists, graphic designers and scriptwriters),
- A navigation system in the game objects (this point is particularly crucial in the applications of knowledge-intensive in game, which contain numerous objects and rules),
- A discussion forum type (Fig. 3).

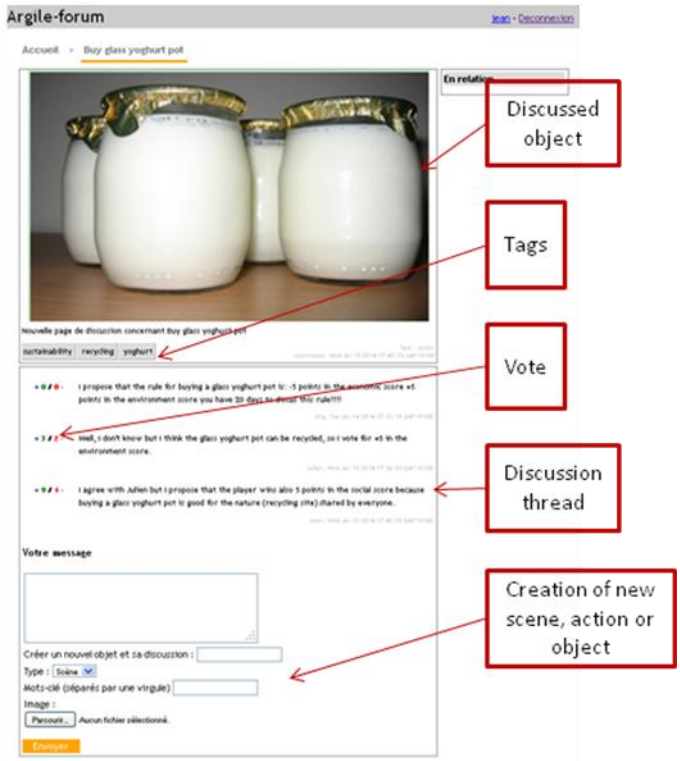


Fig. 3. Rule discussion of the action 'Buy glass yoghurt pot' in the developed ARGILE forum

The process used for the creation of a game scene by a designers group may be as followed (These activities can be conducted in parallel):

- Casebook, can create playable situations (especially brainstorming), then more detailed casebook of actors situations through knowledge engineering methods
- Selection of some elements from experience by the group, then organization of these elements before insertion in a scenario and pedagogy. This step takes the form of a collaborative work space (semi-structured) for writing short specification documents (mostly textual, some mock-ups ...). Detection items, formatting associated specifications (detail, rules ...): scenario elements, etc... Then focusing on an item or a specification, the designer can find all related items, specifications, or comments. This work includes the pedagogical specification (rules elements, evaluation elements...).
- Creating association links between items, tags and items cartography depending on any helpful keyword.
- Discussion at any time about items on designers' discussion forum.
- Anticipated test of game scenarios (for example on paper) with players while unrolling scenarios, rules...

- Specification (text, rules), indexed on items, additional elements concerning scene image, specific HMI rules of the scene, icons allowing symbolic or reduced visualization of some elements ...
- Contribution of documentary resources appearing in the scene.
- Graphical designing and editing of scenes.

Integrated via a common repository with specification systems, topic map and the game functioning, the designers' forum presents a great value. In complex covered areas (sustainable development, crisis management ...), actors think globally and act locally in accordance with rules which may depend on places, seasons and many other factors. So a designer, who is defining objects and rules scene, needs a design forum for discussion between peers. For example if the community adopts the principle that a rule must not have "veto" of any other designer, all designers will be invited to join the "design forum" to discuss new rules and find the necessary compromise for their implementation in the game.

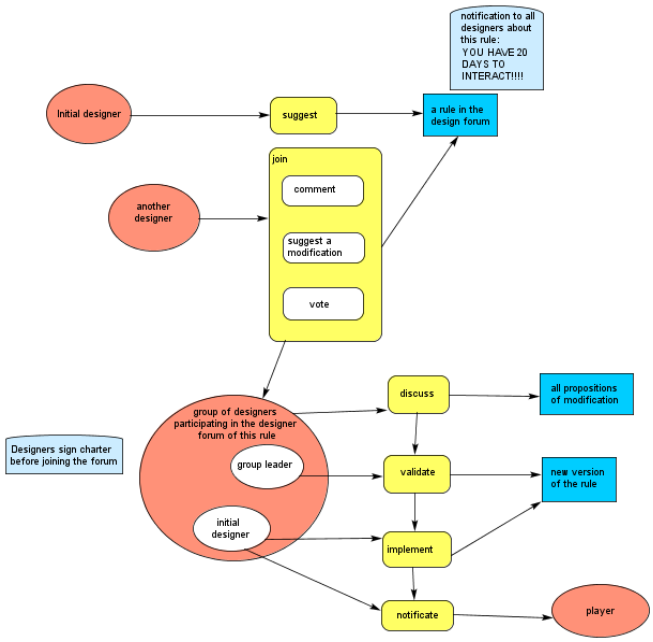


Fig. 4. Designers activity model

Fig. 3, for example, shows the rule discussion of the corresponding action "Buy yoghurt in glass pot" (learning best practices of sustainable development) in the developed ARGILE Forum. The initial designer suggest for this action to win five points on the environment level and lose five points at the social level, without affecting the score at social / culture level. Other designers comment, vote and give their contributions for 20 days before the rule implementation of the first version in the game. After this period, designers who participated in the design forum of current rule form a group to discuss all proposed modifications. Then, the group leader validates the first version of the rule before implementing it in the game. New version of the rule appears as a message in the thread with a green font. This allows you to see the different versions of rules over time.

Fig. 4 shows the activity related to the co-design of the rule. A SeeMe diagram (Herrmann, Hoffmann, Loser, & Moysich, 2000) is used for the representation of roles, activities and entities. We distinguish several roles in this model: the original designer, the design group (possibly with a team leader) and the player. Note that the designers have a forum thread for each object and the rule itself is part of the message in the thread, which solves the problem of versioning rules. This rule can be enabled or changed over time due to our flexible infrastructure. Whenever an original designer implements the first version of the rule on an object, a thread is opened in the forum, and the players are notified.

4.3. The game forum

Before presenting our game forum, we want to explain that discussions between players don't make the game easier. Players' discussion forums are increasingly used by the MMORPGs Players' Communities. Fig. 5 shows a part of the "Wowhead forum", created by World of Warcraft (WOW) players. This page is dedicated to the "Thorium" topic. The complete page contains hundreds of knowledge elements like comments, discussions; screenshots... This example is similar to what we want to do with "participative rule".

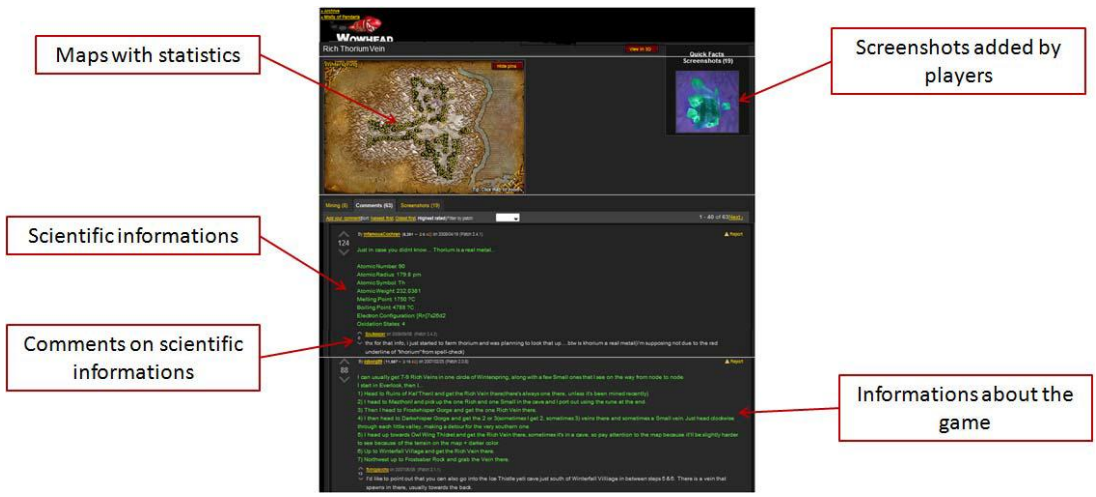


Fig. 5. Wowhead forum

WOW is neither a "SG" nor a "useful games". Knowledge on "Thorium" does not represent any scientific Knowledge, but players' behaviour is as serious as in a SG! (What defines the player and the playful character is that he is inside the game and takes seriously its purposes, whatever is this game). In this example, like in Wikipedia, crucial knowledge to operate the game is cooperatively constructed by the player's Community. Players complete for example the geographical map with statistics about the regions concerned by a given crucial resource (here, the "Thorium"). Note that WOW is a commercial product (Blizzard), but the Wowhead forum is organized by the Players community to exchange Knowledge independently from the WOW society, and sometimes in conflict with official WOW knowledge (e.g. WOW do not diffuse statistics on "Thorium" localization).

In our approach, the player can turn to the other side of the mirror to explore game's rules related to objects in the scene (El Mawas, Cahier, & Bénel, 2012). He can click on the object to see the rule associated to this object. He can also comment on this rule, and suggest improvement or propose modification. Also, he can exchange with other players "hints and tips". A designer appreciating a player's proposal for changing a rule cannot alone modify this rule, because changing a rule requires the discussion with other designers. In order to encourage players to contribute and improve the game, designers should discuss players' proposals and decide on possible actions.

4.4. Technical architecture

Our technical architecture (Fig. 6) depends on the particular status held by game rules in our approach. To be edited by non IT-specialists, these rules must be managed as data and not as programs anymore. In addition, they are a reference point for the topic map, the forum, and the score calculation. That is why they need to be a share service. In a more classic way, another service allows the management of players' actions. This service doesn't allow only the mutual awareness between players but also allows to designers accessing to a scoreboard for the use traces analysis.

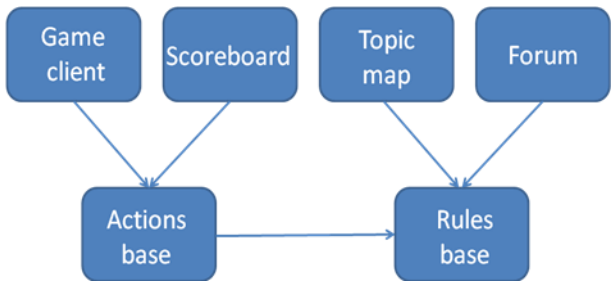


Fig. 6. ARGILE technical architecture

4.5. Knowledge formalization with Hypertopic model

CouchDB ensures a static and dynamic description of an avatar. The static description concerns his identifier and the scene where he is. While dynamic description concerns his position, the execution dates of his actions and his score. CouchDB facilitates the retrieval of information by using attributes. For example, a player can easily identify connected players in a specific scene. Zacklad (2003) proposes an appropriate categorisation to share knowledge and information in multiple viewpoints and collaborative work context. This Socio Semantic Web categorisation is not based on formal semantics but on a human interpretation and a semiotic substrate serving as a base for multiple interpretations.

Zhou, Bénel, and Lejeune (2006) proposes Hypertopic, an appropriate knowledge model to the Web context in which every user can contribute to the content and tap into the collective intelligence. Hypertopic describes an item by topics, attributes, and resources (Fig. 7). For each item, relevant topics are listed to define related subjects. These topics are associated to viewpoints, taking into account users and potential groups. Attributes and their values provide further explanations to extend every item by specific information. Resources can be photos, URLs or links to documents.

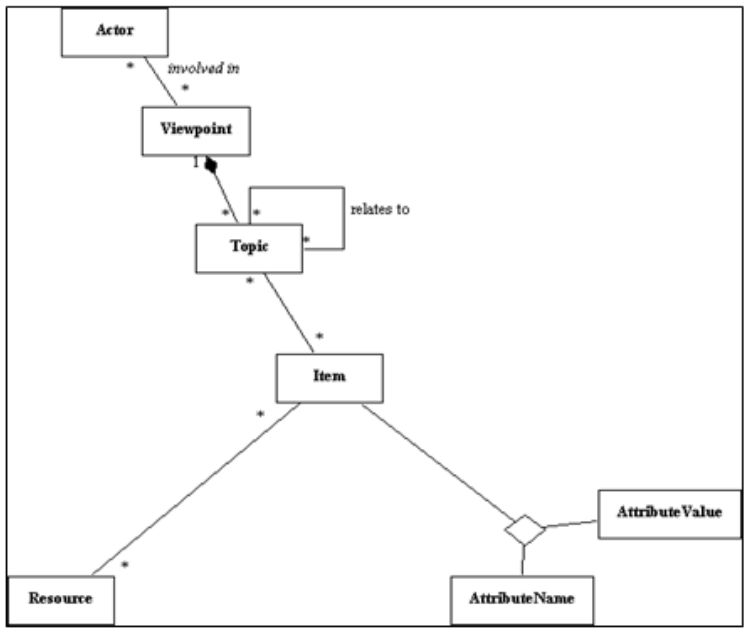


Fig. 7. Hypertopic knowledge model

Table 3
Correspondence between CouchDB and Hypertopic

CouchDB	Hypertopic
Document (avatar, scene, scene object, rule)	item
Attribute	Attribute name
Value	Attribute value
Attached resource	Resource
Attribute type	Topic
View	Viewpoint
Designer, Player	Actor

CouchDB is compatible with Hypertopic model (Table 3). Hypertopic proposes categorization by topics, in particular by insisting on viewpoint context which is very important in our approach of co-designing rules and game elements.

The categorization of presented items can be extended by users' viewpoints. An item can be associated with more than one topic from different viewpoints. For example, an American refrigerator and a typical refrigerator can be referred to a refrigerator from the "household appliance" viewpoint. However, they will be classified in two different

categories from the "energy class" viewpoint: the typical refrigerator belongs to the A+ energy class while the American refrigerator belongs to the B+ energy class.

This type of categorization illustrates the value of the viewpoint concept to organize knowledge on items more flexibly. In addition, items categories are dynamic, based on users opinions. Hypertopic allows the collaborative participation of different users to search and drop an element from existent viewpoints, and even creating a new viewpoint, without changing knowledge and information structures.

In the next section, we present the use of ARGILE on a real project in sustainability called Defismed and we explain why our approach is important in this context.

5. A use case study: The Defismed project

Defismed is a project supported by UNESCO and some NGOs (Non-Governmental Organizations), for the knowledge vulgarization on hundreds of projects of current R&D around the Mediterranean Sea in sustainability (El Mawas, 2014). It aims to reduce the fracture separating the researchers and the civil society by proposing a collaborative program for sharing exemplary innovations of the two parts. An objective is to use the SG to vulgarize scientific knowledge, favour interculturalism, confront view points of the waterside countries, and to popularize the initiatives of local actors in sustainable development at the Mediterranean world. Through an avatar, and certain playful situations, the citizen can become aware of problems, he can also visit scientific projects, follow thematic routes to find answer to certain questions.

Micro-games will be available on the Web through icons placed on a map of the Mediterranean, or through projects, issues and topics listed in Web2.0 mode via dynamic topics map. To find the game scenes, besides the geographic navigation, the system provides this navigation from several view points.

The objective is that a large number of micro-games are developed for Defismed, by using a generic platform of tools which integrate ARGILE. These micro-games are well developed with an increased relevance and a reduced cost on the actors' initiative such as research teams in environmental science, NGOs and decision makers in local communities, trying to transpose via the game their priority objectives of communication with citizens. Due to ARGILE, these partners can eventually, as co-designers helped by «assistants of valuation " create, modify and update easily scenes considered under their responsibility, to edit scenes items and documents integrated into image, by forms of rapid prototyping accessible to non IT specialists.

Our participation architecture allows treating cases where good practices and rules are uncertain, progressive and controversial. Thanks to topics maps, it is possible to embed the playful discovery of scientific knowledge with "debates networks", joining similar experiences of "ideas web" that began to develop (Park, 2008), as Cohere or Debate graph, aiming also the field of sustainable development.

6. Experience and evaluation

We have explained in section 5 why our approach of participative and knowledge-intensive SGs is suitable in the field of sustainable development. In this section, we

describe tests to check the impact and usefulness of our proposal to help experts in the designing of participatory and knowledge-intensive SGs.

6.1. Evaluation methodology

6.1.1. Participants

A case study is carried out with 18 designers in the context of Defismed project. The case study offered feedback on the practical use of ARGILE Forum; the usefulness of ARGILE Forum's features and the opinions of designers concerning these new ways to design SGs (Table 4).

Table 4
Evaluation codes and labels

Criteria code	Criteria Label
C1	Practical use of ARGILE forum
C2	Usefulness of ARGILE forum's features
C3	Integration of ARGILE forum in the design phase of a participatory and knowledge-intensive SG

The experience is about using our developed ARGILE forum for two weeks to define game rules for a participative and knowledge intensive SG that aims to learn players, good practices in sustainable development.

Designers in our experience were 13 students and five researchers from EMESD department at UTT. We have specified, through googledocs, general rules of the experience and a user's guide on ARGILE forum. Then designers have used ARGILE forum to precise and define game rules. Designers' mission was to define game rules to furnish an empty house without heater, furniture and decoration. Rules must take into account energy expenditure, CO2 footprint, economic expenditure, ecological dimension, social aspect...

6.1.2. Data collection

A parent directory called "*jeu sérieux UTT sur le thème de la ville et de l'habitation*" was created with the game scene to allow different designers to add, discuss and vote on items, sub-scenes and actions. To manage different discussion threads (pages and subpages about game's name, multidimensional points system, heater, furniture, household appliances, decorative items) we have classified designers into six groups. The group responsible for a page / subpage provides textual elements related to an item, attributes, values and related rules. In addition, he validates rules once the deadline for discussion and voting is reached.

A designer can discuss proposals of other designers on all forum pages related to this experience. He can criticize, provide ideas for improvements and vote for rules in order to make the game more consistent.

Table 5
Questionnaire addressed to designers

Criteria code	Questions
C1	- Q1: Do you find it easy to connect to the forum? (Yes, No, No comment) - Q2: Do you think that ARGILE forum needs prerequisite knowledge? (Yes, No, No comment) - Q3: The interface is easy-to-read and comfortable? (Yes, No, No comment) - Q4: Do you think that it is easy to create a new scene/action/object? (Yes, No, No comment) - Q5: Do you find the manual on googledocs is helpful to use the forum? (Yes, No, No comment) - Q6: Which forum's functionalities do you desire that they be explained?
C2	- Q7: What functionalities did you used within the co-design of a scene/object/action? (Sub-scene creation, action creation, object creation, description of added sub-scene/action/object, adding keywords tags, attaching a photo, adding a comment, using vote system) - Q8: Do you find the functionality Sub-scene creation useful in the co-design of your game? (Yes, No, No comment) - Q9: Do you find the functionality action creation useful in the co-design of your game? (Yes, No, No comment) - Q10: Do you find the functionality object creation useful in the co-design of your game? (Yes, No, No comment) - Q11: Do you find the functionality description of added sub-scene/action/object useful in the co-design of your game? (Yes, No, No comment) - Q12: Do you find the functionality add keywords tag useful in the co-design of your game? (Yes, No, No comment) - Q13: Do you find the functionality attach a photo useful in the co-design of your game? (Yes, No, No comment) - Q14: Do you find the functionality add a comment useful in the co-design of your game? (Yes, No, No comment) - Q15: Do you find the functionality vote system useful in the co-design of your game? (Yes, No, No comment)
C3	- Q16: Do you find ARGILE forum helpful to access to rules, actions, knowledge, and games objects? (Yes, No, No comment) - Q17: Do you find ARGILE forum helpful to distance co-designing? (Yes, No, No comment) - Q18: Do you think that ARGILE forum facilitates collaboration between designers? (Yes, No, No comment) - Q19: Do you think that ARGILE forum allows acquiring new knowledge about sustainability through discussions threads? (Yes, No, No comment) - Q20: Do you find that ARGILE forum is helpful to structure designers' ideas on scene design? (Yes, No, No comment) - Q21: What are the particular strengths of ARGILE forum? - Q22: What are the weak points in ARGILE forum?

At the end of the experiment, the participants were called on to answer a questionnaire (Table 5) containing 22 questions and were given the opportunity to make comments and suggestions and mention difficulties encountered. In order to facilitate the interpretation of data collected from questionnaire answers, we classified the questions according to evaluation criteria, as show in Table 4, which also gives possible answers for each question.

6.2. Results and discussion

Designers gave us their opinions on using ARGILE forum by answering the questionnaire. The questions and the designers' answers are summarized below.

The first part of questions was based on the criteria Practical use of ARGILE forum (C1) (Fig. 8).

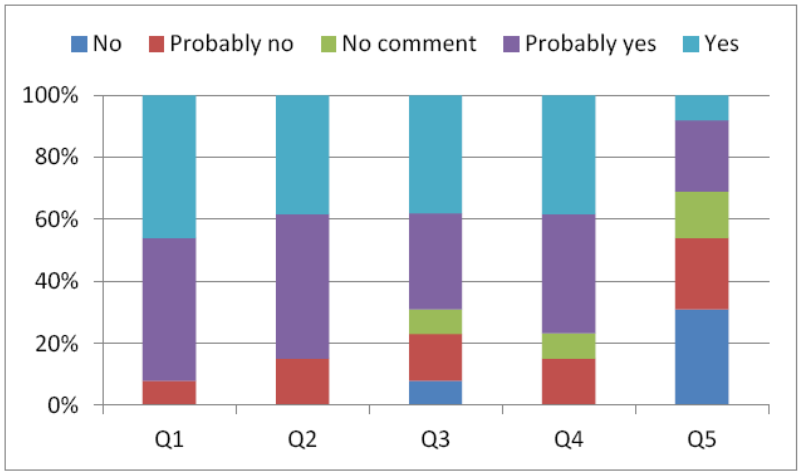


Fig. 8. Practical use of ARGILE

In general, designers consider that ARGILE Forum doesn't present difficulties in accessing the forum (92%). 84% of designers think that ARGILE forum doesn't need prerequisite knowledge. 76% of designers are satisfied about the interface and the creation of a new scene/action/object. The manual on googledocs isn't very efficient to use the forum according to 54% of designers: it's often the case with current generations who tries directly new tools without the need for any manual. Our design methodology is therefore simple to use which wasn't the case the *content-centred model*, the *design patters for serious games, and the triadic game design model* (see table 2).

The second part of questions was based on the criteria *Usefulness of ARGILE Forum's features* (C2). Among functionalities offered by ARGILE forum, which are the most common used? And therefore what are the proposed activities to design the game? Regarding Q7, we note that the predominate functionalities are "adding an object", "adding key words tag", "adding a comment", and "using vote system". Functionalities which need more specifications (like "adding an action" to an object, "adding an item description" "attaching a photo", and "adding a sub-scene") are only partially exploited.

Fig. 9 clearly shows the response to the usefulness of different functionalities in ARGILE. Designers' satisfaction is high for all functionalities except "the sub-scene creation). It's likely that this functionality presents difficulties because it requires some

experiences in designing SGs. Indeed, creating a new sub-scene is not enough to the participation of all designers. It must be included from a pedagogical perspective with predefined objectives.

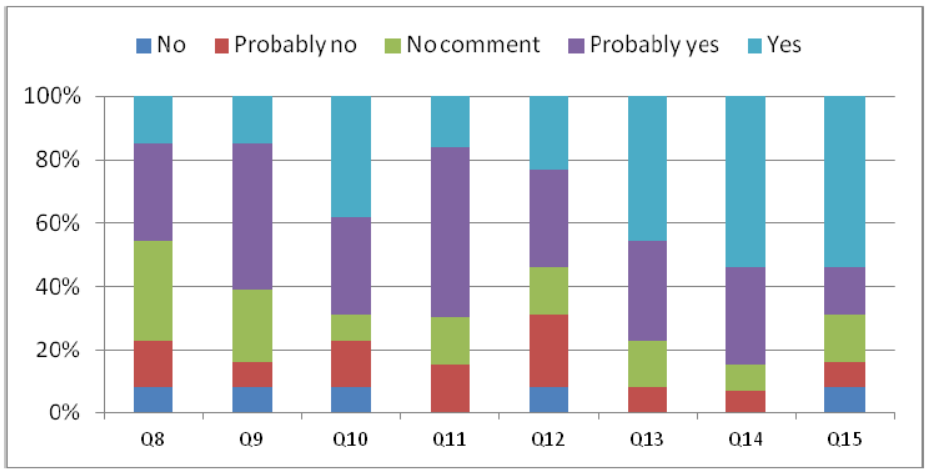


Fig. 9. Usefulness of different functionalities in ARGILE

The last part of questions was based on the criteria *Integration of ARGILE forum in the design phase of a participatory and knowledge-intensive SG* (C3) (Fig. 10). Questions aim to know what the impact of the ARGILE forum is on the game design and what its added value is for designers. The added value for designers is clearly the fostered collaboration between them (85%), the facilitation of remote work (85%) and their guidance on the scenes content (62%). 31% of designers think that ARGILE is less useful to acquire new knowledge. This is because designers in our experience were students having similar ideas, in the same age range, and with the same educational background. So designers could not exchange experience and quire new knowledge from their similar profiles. 23% of designers think that our approach does not facilitate structuring of ideas. That is, in fact, related to the absence of an ergonomist when developing ARGILE.

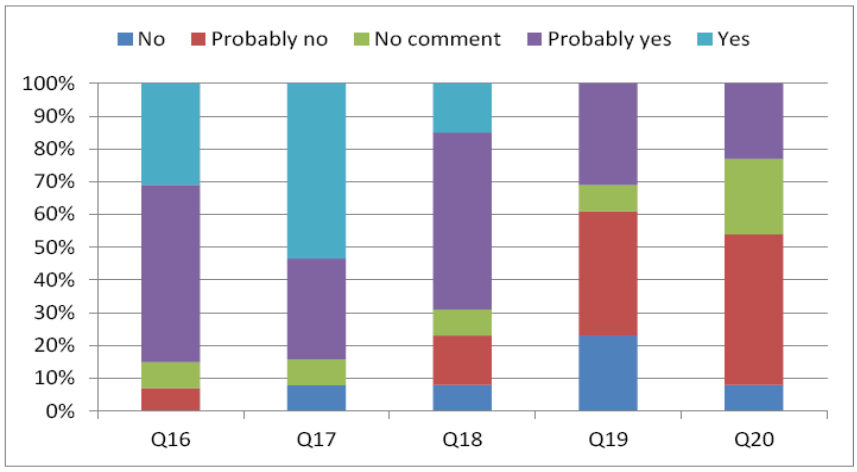


Fig. 10. Integration of ARGILE in the design phase

Thus, ARGILE promotes collaboration between designers which is not the case with the *content-centred model*, the *design patterns for serious games, and the triadic game design model*. It also guides the design phase of SGs unlike the *content-centred model*, and the *methodology of generic frame games* (see table 2). Through this experimentation, our approach proves that experts are important actors in the design phase of SGs while their presence was not possible in the *approach centred on the use of technical tool, the DODDEL model*, the *design patterns for serious games, and the triadic game design model* (see table 2).

To summarize, we propose a design methodology for participatory and knowledge intensive SGs. This methodology is based on the learning dimension through SGs, the construction of players' knowledge by themselves, and the importance of discussion between trainers and learners in the design phase. Our methodology experimentation was positive in general. It allows collaboration, remote working, and discussing expert knowledge: some designers group have begun to do complicated structure on the forum but when they have seen other groups, they had successfully organized game items differently and simplify their structure. In addition, ARGILE facilitates the design of participatory and knowledge-intensive SGs: during the two weeks of experimentation, designers created 36 game items and discussed them through the forum.

7. Conclusion

This study addresses the problem of designing participatory and knowledge intensive SGs. The main questions of the study are how to address complex knowledge in SGs, what are the approaches allowing experts to design their instructional scenarios by themselves, and how to promote collaboration between designers/players in order to establish fair rules and increase learning among learners. We investigate the problem from its theoretical background, and we consider existing methodologies for the design of SG in order to see if any existing approach can meet our requirements. Unfortunately no one can respond to our needs in terms of the support of complex knowledge in continuous evolution and debate between designers, the implication of learners in the design phase, and the building of players' knowledge. To achieve this, the ARGILE approach is proposed as functional and technical solutions to our problem. This solution allows experts to be the game designers. Using ARGILE, rules are managed as data and not as programs anymore so experts can modify or add a scenario without the intervention of an IT specialist. We present in this paper the experimentation of our approach on the design level, designers were students in the sustainability department. Our perspectives are extending the experimentation on real experts in sustainability. We are also interested in testing our approach on the learner level and his learning improvement through the participation in the design phase and the discussion of games rules with other players/designers. We think that discussion through the forum makes the learners masters of their own learning and promote the collaborative model of learning communities.

Acknowledgements

The author would like to thank Jean-Pierre Cahier, Nada Matta, and Aurélien Bénel for their valuable guidance and support to this research work.

References

Alvarez, J. (2007). *Du Jeu vidéo au serious game: Approches culturelle, pragmatique et formelle*. Thèse de doctorat spécialité science de la communication et de l'information, Université de Toulouse II (Le Mirail), Université de Toulouse III (Paul Sabatier).

Anolli, L., & Confalonieri, L. (2011). Learning, dynamic assessment and serious games. In A. Méndez-Vilas (Ed.), *Education in a Technological World: Communicating Current and Emerging Research and Technological Efforts*. Badajoz, Spain: Formatex Research Center.

Blunt, R. (2009, December). Do serious games work? Results from three studies. *eLearn Magazine*.

Bruner, J. S. (1983). *In search of mind: Essays in autobiography*. New York, NY: Harper & Row.

Bullen, M. (1998). Participation and critical thinking in online university distance. *International Journal of E-Learning & Distance Education, 13*(2), 1–32.

Collins, M., & Berge, Z. (1995). Introduction: Computer-mediated communications and the online classroom in higher education. In M. Collins & Z. Berge (Eds.), Computer mediated communication and the online classroom. New Jersey: Hampton Press.

Corti, K. (2006). *Games-based learning; a serious business application*. PIXELearning Limited.

De Freitas, S., & Jarvis, S. (2007). Serious games - engaging training solutions: A research and dvelopment project for supporting training needs. *British Journal of Educational Technology, 38*(3), 523–525.

Dehler, C., & Porras-Hernandez, L. H. (1998). Using computer mediated communication (CMC) to promote experiential learning in graduate studies. *Educational Technology, 38*(3), 5–55.

Djaouti, D. (2011). *Serious game design: Considérations théoriques et techniques sur la création de jeux vidéo à vocation utilitaire*. Thèse de doctorat spécialité informatique, Université de Toulouse III - Paul Sabatier, Toulouse.

Ehn, P., & Badham, R. (2002). Participatory design and the collective designer. In *Proceedings of Participatory Design Conference* (pp. 1–10). Malmö, Sweden.

El Mawas, N. (2014). An architecture for co-designing participatory and knowledge-intensive serious games: ARGILE. In *Proceedings of the International Conference on Collaboration Technologies and Systems (CTS 2014)*. Minneapolis,USA.

El Mawas, N., Cahier, J.-P., & Bénel, A. (2012). ARGILE: Towards constructed knowledge games. In *Proceedings of the 17th International on Computer Games (CGAMES)*. Louisville, Kentucky, USA.

Garrison, D. R. (1993). A cognitive constructivist view of distance education: An analysis of teaching-learning assumptions. *Distance Education, 14*(2), 199–211.

Giasson, J. (1991). Stratégies d'intervention en lecture: Quatre modèles récents. In C. Préfontaine et VL Lebrun (dir.), *La lecture et l'écriture - Enseignement et apprentissage* (pp. 219–239). Montréal: Les Editions Logiques..

Greenfield, P. M., Luigia, C., Paola, E., Laura, W., Bennett, A. L., & Paola, P. (1994). Cognitive socialization by computer games in two cultures: Inductive discovery or mastery of an iconic code? *Journal of Applied Developmental Psychology, 15*, 59–85.

Harteveld, C. (2010). *Triadic game design. London*. UK: Springer.

Hays, R. T. (2005). *The effectiveness of instructional games: A literature review and discussion* (Technical Report No. 2005-004). Naval Air Center Training Systems Division: Orlando, FL.

Herrmann, T., Hoffmann, M., Loser, K.-U., & Moysich, K. (2000). Semistructured models are surprisingly useful for user-centered design. In *Proceedings of Fourth International Conference on the Design of Cooperative Systems* (pp. 159–174).

Huynh-Kim-Bang, B., & Labat, J. (2010). Design patterns in serious games: How to mix fun and pedagogy? In *Proceeding of 10th International Conference on Intelligent Tutoring Systems (ITS2010)*. Pittsburg, USA.

Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. (1995). Constructivism and computer-mediated communication in distance education. *The American Journal of Distance Education, 9*(2), 7–26.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge University Press.

Mandin, S. (2010, January 14). Jeux sérieux : Quels apprentissages? *Agence des usages TICE*.

Mangenot, F. (2004). Analyse sémio-pragmatique des forums pédagogiques sur Internet. In J. M. Salaün & C. Vandendorpe (Eds.), *Les défis de la publication sur le Web: Hyperlectures, cybertextes et méta-éditions* (pp. 103–123). Villeurbanne: Presses de l'Enssib.

Marfisi-Schottman, I. (2012). *Méthodologie, modèles et outils pour la conception de Learning Games*. Thèse de doctorat spécialité informatique, Institut national des sciences appliquées de Lyon, Lyon, France.

Mason, R., & Kaye, A. R. (1990). Towards a new paradigm for distance education. In L. Harasim (Ed.), *Online Education: Perspectives on a New Environment* (pp. 15–38). New York: Praeger.

McLellan, H. (1996). *Situated learning perspectives*. Englewood Cliffs, NJ: Educational Technology Publications.

McMahon, M. (2009). *Using the DODDEL model to teach serious game design to novice designers*. Presented at the ASCILITE 2009, Auckland, New Zealand.

Moreno-Ger, P., Martínez-Ortiz, I., Sierra, J. L., & Fernández-Manjón, B. (2008). A content-centric development process model. *Computer, 41*(3), 24–30.

Muratet, M., Torguet, P., Jessel, J. P., & Viallet, F. (2008). Vers un jeu sérieux pour enseigner la programmation. In *Association Française de Réalité Virtuelle, Augmentée, Mixte et d'Interaction 3D (AFRV 2008)*.

Park, J. (2008). Topic maps, dashboards and sensemaking. In *Proceedings of Topic Maps Research and Applications conference (TMRA 2008)*.

Robertson, J., & Nicholson, K. (2007). Adventure author: A learning environment to support creative design. In *Proceedings of the 6th International Conference on Interaction Design and Children*. Aalborg, Denmark.

Rose, C., & Nicholl, J. M. (1998). *Accelerated learning for the 21st century: The six-step plan to unlock your master-mind*. New York: Dell.

Sauvé, L. (2008). Concevoir des jeux éducatifs en ligne : un atout pédagogique pour les enseignants. *Communication du Colloque Ludovia*.

Swan, K., Shen, J., & Hiltz, S. R. (2006). Assessment and collaboration in online learning. *Journal of Asynchronous Learning Networks 10*(1), 45–62.

Wang, M. (2011). Integrating organizational, social, and individual perspectives in Web 2.0-based workplace e-learning. *Information Systems Frontiers, 13*(2), 191–205.

Wang, M., Ran, W., Liao, J., & Yang, S. J. H. (2010). A performance-oriented approach to e-learning in the workplace. *Educational Technology & Society, 13*(4), 167–179.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition*. Norwood, NJ: Ablex Publishing Corporation.

Zacklad, M. (2003). Communities of action: A cognitive and social approach to the design of CSCW systems. In *Proceedings of GROUP'2003* (pp. 190–197). FL, USA.

Zhou, C., Lejeune, C., & Bénel, A. (2006). Towards a standard protocol for community-driven organizations of knowledge. In *Proceedings of the 13th International Conference on Concurrent Engineering* (pp. 438–449).