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► **To cite this version:**

Lahcen Oubahssi, Guillaume Loup, Claudine Piau-Toffolon, Oussema Mahdi. ADDEGames: An Assistance Design tool for Digital Epistemic Games. The 18th IEEE International Conference on Advanced Learning Technologies, Jul 2018, Bombay, India. pp. 103-107. hal-01775217

HAL Id: hal-01775217

<https://hal.science/hal-01775217v1>

Submitted on 20 Feb 2024

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ADDEGames: An Assistance Design tool for Digital Epistemic Games

Lahcen Oubahssi, Guillaume Loup, Claudine Piau-Toffolon and Oussema Mahdi
Le Mans Université, LIUM, EA 4023, Laboratoire d'Informatique de l'Université du Mans,
Avenue Messiaen, 72085 LE MANS CEDEX 9, France.
{lahcen.oubahssi, guillaume.loup, claudine.piau-toffolon, oussema.mahdi}@univ-lemans.fr

Abstract—Helping learners to easily develop their skills and adapt to their new profiles, are among the biggest challenges of the actors of the training field. The JEN.lab project aims to offer innovative perspectives for learning based on the design of digital epistemic games. Though designing activities are complex especially for teachers. The research effort presented in this paper is part of the JEN.lab project. We aim to study problems related to modeling and designing digital epistemic games (DEG). We propose a co-design process and an assistant tool to guide teachers to design DEG, called ADDEGames.

Keywords : *Digital Epistemic Games, ADDEGames, co-design process, Assistance Design tool*

I. INTRODUCTION

Helping learners to easily develop their skills and adapt to their new profiles are among the biggest challenges of the actors of the training field (learners, teachers...). Many works are addressing the problem by providing solutions in the form of attractive learning systems [1][2]. Within this context, *JEN.lab project* aims to offer innovative perspectives for learning based on the design of digital epistemic games [1][2] that foster epistemic interactions [3] mediated by digital technology. *JEN.lab project* also consists of techno-pedagogical realizations breaking with the serious game approach from the educational perspective (immersion in complex and authentic situations rather than interactions with a video game) and from the technologies used (relying on mixed reality rather than a baseline modeled from a computational point of view). The work presented in this article is part of this project. Our research effort covers the modeling and designing of digital epistemic games (DEG). More specifically, we study how to help teachers to design DEG.

We present, in this paper, an iterative co-design process and an environment to help and guide teachers in designing “*Digital Epistemic Games*” (DEG). This work is based on two examples of DEG, which were modeled in this project (RearthM3 and Insectophagia games) [4]. To model these two DEG examples, co-design workshops were organized with the teachers / trainers and researchers in a design-based research methodology for prototyping (3 iterations) of mixed reality learning situations. This allowed us to implement two DEG prototypes supporting the games, along with the reports that describe them. These reports are revised after each iteration. The prototypes have been tested in ecological conditions. The article is structured as follows. In the next section we introduced the concept of Digital Epistemic Games, its characterization and the JEN.lab project

methodology. The sections that follow are dedicated to the presentation of a model of DEG, a co-design process and a tool ADDEGames to assist teachers. Finally, we draw a conclusion and present our future works.

II. RELATED WORK

A. Digital Epistemic Games (DEG)

If taken a closer look at existing teaching tools, the category of "epistemic games" remains little known, even though many experiments have already been carried out [5]. The concept of "*epistemic games*" was proposed by Collins and Ferguson [6] to describe the investigative activity of science. According to them, learning should not be limited to the acquisition of a simple scientific method, but rather to the real problem assessment based on complex rules and strategies. Shaffer [2] proposed to expand the epistemic gaming model by proposing to combine several disciplines (e. g., geometry and chemistry) in a single scenario. Furthermore, it invites us to study these issues through different communities of practice. It also demonstrates that epistemic gaming allows the learner to assess complex problems while taking into account different methods of dealing with them. Thus, the main advantage of this pedagogical approach is that it allows students who cannot yet do an internship in a company to practice thinking like professionals [7].

Even if an epistemic game can be realized without support, a real evolution of these games called "*Digital Epistemic Games*" has made it easier for learners to immerse themselves in these role-playing games through technology [8]. Land Science, for example, offers a virtual work experience in which students act as interns in an urban-planning company. Taking into account the needs of the population as diverse as employment, housing or pollution, learners must provide a new map of the neighbourhood that satisfies the most communities. The designers propose a web game interface that is limited to a schematic representation of the neighbourhood. In addition, discussions with the different protagonists must be exclusively by email or chat. Although the primary objective of these tools is to facilitate telework, this is at the expense of a more realistic representation. However, the evolution of technologies has led to the evolution of game interfaces that Hinske et al [9] call "*pervasive games*" where this term includes: mixed reality games or mobile games.

As this type of tool has demonstrated positive effects on learning [10], recent work has led to the development of the concept of "*pervasive digital epistemic games*" [11]. This

type of epistemic game does not limit itself to proposing new material supports to the learner but to extend its perimeter of play to bring closer to the real conditions of a professional. Thanks to new technologies, game extensions are possible on the spatial, social and temporal dimensions. The RearthM3 game [4] [11] allows learners to program exploratory probes and to reflect on the location of a colony based on the knowledge of different communities. A pervasive version of the game offers a virtual environment that continues to exist outside the classroom and that you can immerse yourself in using a helmet. Experiments were conducted in an ecological environment and showed an educational contribution through increased engagement of learners.

The lack of definition of the digital epistemic game leads us to associate a more general definition with a list of specificities to the latter. Although there are many definitions of serious games [12], the latest proposition is: “*any meaningful use of computerized game/game industry resources whose chief mission is not entertainment*”. Thus, since digital pervasive digital epistemic games and digital epistemic games, have pedagogical objectives and digital media, they fully meet this definition and can be qualified as serious games. Moreover, based on literature, a serious game can be considered as a digital epistemic game if: (a) it proposes the solving of complex problems [7], as in Digital Zoo¹; (b) it supports the learner in an authentic and realistic context [13], as in Clim@ction²; (c) it is based on multidisciplinary activities [14], as in Urban Science³; (d) it concerns the solving of non-deterministic problems [7], as in Clim@ction; (e) it is based on an “epistemic framework” [2], i. e., when the learner must conduct his or her reflection based on the knowledge, skills and values of the professional he or she embodies [15], as in Science. net⁴. All of this information defines the main characteristics of DEG but does not directly offer a method to design them.

B. The JEN.lab project

Existing design-oriented studies are limited [16] but educational design is an integral part of the work all teachers perform [17] and there is a shortage of relevant practical and conceptual tools to support teacher design [18] [16]. Within this context, one of the main aspects of the JEN.lab project is to develop DEG and study the process of designing DEG. The methodology of the project is based on the collaboration of practitioners (teachers and researchers) with real school contexts (secondary education). Thereafter, the objectives are both pragmatic (producing innovative digital applications adapted to the teacher's expectations) and theoretical (developing new models for instruction and learning). As a result, the methodology is influenced by both the design-based research approach [19] [20] and the participatory design from the Human Computer Interaction

field [21]. Design-Based Research (DBR) is contributive, collaborative, iterative and tested in naturalistic contexts [20] [22] [23]. It consists of conducting an iterative process that aims to design educational artefacts such as techno-pedagogical devices or educational programs and their implementation at various levels (i.e. for formal learning: classroom activity, interventions in school or curriculum). This design process is combined with the analysis of the results of educational practices carried out collaboratively by researchers and practitioners. In the field of Technology Enhanced Learning, DBR has close relationships with software design methodologies that aim to take into account end users all along the development process such as Agile methodologies [24] and user-centred design methodologies [21].

III. DEG CO-DESIGN PROCESS

According to the methodology of the JEN.lab project, we organized workshop design sessions of DEG along the project with researchers and teachers. These design sessions were dedicated to defining learning objectives, the game universe and the gameplay. A prototype has been developed for each game and experimented in naturalistic conditions by the teachers involved in the design phase.

The design process resulting from these workshop sessions is an iterative co-design process. As suggested by findings from design studies: the design is an iterative endeavour, characterized by an evolving understanding of the problem and its context, drawing on precedent and experience to develop an appropriate solution, subject to constraints on resources [25] [26] [18]. At the beginning of the sessions both researchers and teachers were involved in the process, but later, teachers were the main actors. Design of learning games and DEG in particular is a complex process involving designers from different domains and know-how [27]. Based on some research works [28] [29] [30] highlighting the importance of tangible tools in this process, DEG.cards were proposed by the research team to help designers coming from different domains to communicate and share their expertise. DEG.cards may foster creativity but also integrate needs and constraints of the DEG. DEG.cards propose information of different conceptual levels and can be used all along the design process according to the level of maturity of the design by the team [30]. Four types of cards were proposed with skills, gamification, technological and social themes. But these tools were not sufficient to design a DEG. Designers have to be creative and in the same time respect the main characteristics of DEG. Designers need some tool to help them to organize and guide them in this activity [18] [16]. One of the results of the JEN.lab project presented in this paper is a collaborative and iterative design process of DEG and a DEG model. This process represents a set of phases and steps to help and guide teachers and game-designer to design an epistemic game that meets the teacher's educational goals. This process represents a guide enabling a quick elaboration of a detailed specification, which eases the development of the DEG by taking into account the DEG

¹ Digital Zoo: <http://edgaps.org/gaps/projects/digital-zoo-2/>

² Clim@ction : <http://eductice.ens->

[lyon.fr/EducTice/recherche/jeux/jpacl/climaction/2011-2012/](http://educTice/recherche/jeux/jpacl/climaction/2011-2012/)

³ Urban Science: <http://edgaps.org/gaps/projects/urban-science/>

⁴ Science.net: <http://edgaps.org/gaps/projects/science-net/>

constraints such as pedagogical inputs. We note that this guide / process is not intended to provide steps and methods for establishing the DEG graphic style. To develop this process, we participated in design workshops that aim to model DEG examples. During these workshops, we tried to identify the different tasks to be carried out by the teachers and the difficulties encountered. We also note that during these workshops, the design forms, the DEG.cards and the DEG characteristics are available to teachers, which allowed guiding them during the different phases and stages. We note that this process conformed to the main results of the teacher's design process derived from the study [16] which is breadth-first, top-down and iterative. Figure 1 illustrates the six main phases of the proposed process repeated iteratively:

- Phase 0: the objective of this phase is to present the DEG concepts to the teachers who would like to define their first DEG (objectives, characteristics, constraints to respect).
- Phase 1: allows teachers and game-designer to specify who will participate or use the DEG, and identify potential resources to be used at the DEG. The DEG characteristics to be validated during this phase are: the number of players / learners, the duration and the number of sessions, the tools, the devices (or platforms) that can be used.
- Phase 2: the objective of this phase is to define the pedagogical objectives and the characteristics of the game. It consists of four steps. In a first step, teachers define the disciplines involved in the game (at least two disciplines are compulsory). Secondly, they choose communities and professions to which the players belong. Thirdly, they write the global scenario of the game. And at the end of this phase, they have to choose the most reliable characteristics of the game. There are many DEG characteristics to validate during this phase like the multidisciplinary approach, the epistemic frame of the game, the community of practice, and the authenticity. We note that in this phase, the teachers may use the DEG.cards to define the concepts to use in their game, in particular for identifying the educational interests and game mechanics.
- Phase 3: the objective of this phase is to write a storyboard organizing the game characteristics previously chosen in phase 2. It consists of three steps, as a first step, the teachers identify the various missions or steps of the game. In a second time they have to specify for each mission or level, its scenario context, its description, its educational interests and its gamification. At the end of this phase, overall scenario has to be finalized, specifying also the overall context and its description, pedagogical interests and gamification. There are many DEG characteristics to be validated during this phase, including epistemic framework (authenticity of interactions in the situation), the multidisciplinary on all the steps, if the problem is complex and non-deterministic (at least for the final

task), social interactions (configuration, type of mechanics), etc.

- Phase 4: the objective of this phase is to propose the learning scenario planning, specifying the role of each actor of the game, and make a time allocation for all the game missions or levels. The DEG characteristics to be validated during this phase are: the session's duration, the devices (or platforms) that can be used.
- Phase 5: the objective of this phase is to identify the recommendations on the interfaces, the interactions, and the documents of each storyboard step.

We propose in each phase a set of objectives and constraints that are related to the phase and that validate the DEG characteristics. We have formalized these constraints as a form to complete.

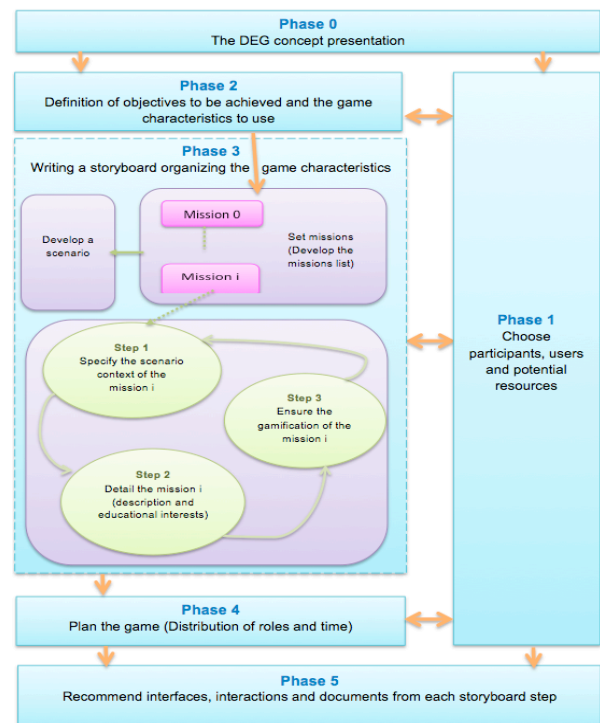


Figure 1. The DEG co-design iterative process

IV. ADDEGAMES : AN ENVIRONMENT TO HELP TEACHERS DESIGN THEIR DEG

A. DEG Model

Before developing the ADDEGames tool, we initially developed a DEG model from the two examples of DEG designed during the co-design workshops. Indeed, the analysis of the different co-design workshops and the development of the DEG co-design process, allowed us to identify the different pedagogical concepts constituting the two DEG examples. We have grouped these concepts into a model named DEG model. Our goal is to identify the pedagogical language embedded in a DEG and to develop a conceptual model to develop an environment that supports

our DEG co-design process. Figure 2 illustrates the main concepts of our model. A DEG consists of one or more missions/levels. Each mission/level is associated to one or more working sessions, one or more educational interests and one or more game mechanics. In a work session, there may be one or more learning scenarios. Among the DEG characteristics to be respected, it must be associated with at least two communities and two disciplines. The main DEG users are trainers and learners; we can also have other external participants. Finally, we note that the use of DEG.cards is an essential element to help teacher to model a DEG, especially to specify the educational interests and game mechanics.

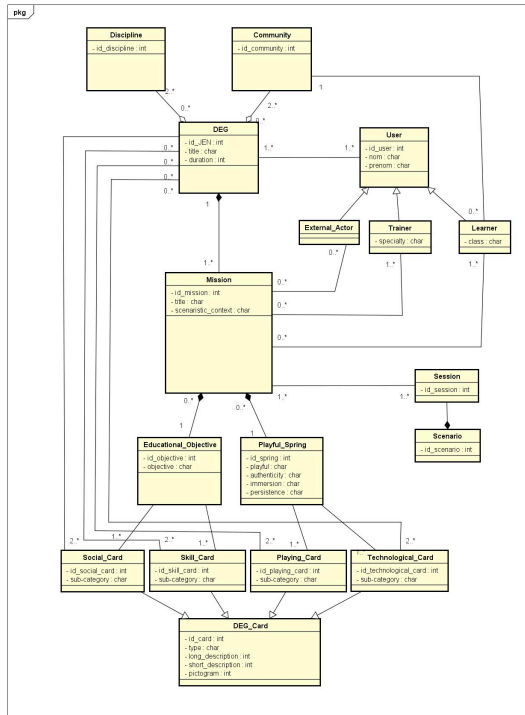


Figure 2. The DEG model

B. The ADDEGames functionalities

To evaluate our co-design process, we have developed the ADDEGames tool; these functionalities are the result of the materialization of a set of scenarios described during the design workshops. ADDEGames provides an environment to: (a) Help teachers to easily design their DEG; (b) Allow to model a new DEG or to adapt an existing one; and (c) Generate a specification, which gathers different DEG design elements.

The main ADDEGames functionalities are:

- DEG management, is dedicated to the creation of new DEG by specifying its title, description, and users who participate in its modeling. It also allows to edit, display, delete an existing DEG or share it with other users of the tool.
- Editing DEG, is for modeling the game in five main phases that constitute our co-design process. For

example, in Phase 1, the designer-teacher can indicate the number of teachers, learners or actors who will participate in his DEG, the duration, the number of sessions, the tools, and the devices to use during the game. In phase 2 the designer specifies the disciplines, communities, synopsis, etc. Phase 3 is for defining the missions/levels of game by specifying for each one, its scenario context, its description, and different aspects characterizing DEG like gamification, authenticity, immersion, persistence, etc.

- Disciplines management, enables users to create a new discipline, edit it, display it, or delete it.
- Community management, allows users to create a new community, edit it, display it, or delete it.
- DEG.cards management, is for managing the different categories of the cards. Users can create a new card, edit it, display it, and delete it.
- Management of user profiles, allows users to create, modify or delete the users' profiles in the tool (teacher, game-designer, administrator).

At any moment of the design process, teachers can download a document describing the DEG in a PDF format. We note that, the co-design process and the DEG model guided the design of our ADDEGames tool as well as the specification of its technical architecture. Its development was carried out on several iterations (in Agile mode). At the end of each iteration, the teachers participate in the validation of the developed elements and make suggestions for improvements. Figure 3 illustrated the main interface of ADDEGames tool.

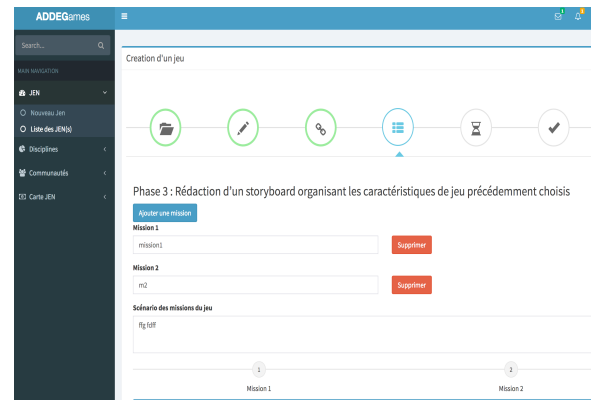


Figure 3. The main Interface of ADDEGames

V. CONCLUSION

The JEN.lab project reaches its final phase. One of the main objectives was to study the design process of digital epistemic game. We presented in this paper a part of the research results that include a model of DEG, a co-design process and an assistant tool to help teachers in their design activities. The resulting tool, an online form, provides a specification of a DEG. Teachers may adapt an existing DEG specification or develop a new one. The Co-design process and the DEG model have been elaborated during the

workshop design sessions according to the methodology of the project. Some design sessions have been dedicated especially to the elaboration of this process and the environment to support it with teachers and researchers. The teachers were proposed to re-design their games with the game design environment developed ADDEGames. Three iterations have been organised. The main remarks are related to adding of notes to explain the concepts of DEG to be provided during the design steps, the navigability through the different parts (steps) of the process. The teachers appreciate the DEG.cards and in particular their use in their paper-based format but express the difficulty to pass from this form to the computer-based designing environment and suggest to add QR-code on the cards which could be flashed and integrated automatically in the tool. More experiment sessions are planned to improve the DEG design tool with the teachers involved in the project but also with new teachers/designers to experiment the design process for new DEG.

ACKNOWLEDGMENT

The JEN.lab project is a multi-disciplinary project funded by the French Research Agency (ANR-13-APPR-0001). The authors want to thank all the persons who have contributed to this project.

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