

## Keep it simple – lowering the barrier for authoring serious games

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### Abstract

*Background.* Despite the continuous and abundant growth of the game market the uptake of serious games in education has been limited. Games require complex technologies and are difficult to organise and to embed in the curriculum.

*Aim.* This article explores to what extent game templates and game authoring processes can be designed that can be easily adopted and adapted by teachers while only using openly available tools.

*Method.* It discusses the design and first evaluation of two game platforms: ARGUMENT, based on a wiki, and ARLEARN, a toolkit based on openly available Google technologies. ARGUMENT is a text-based game challenging students to take a position on a given topic. ARLEARN offers an explicit mobile and virtual gameplay environment and a defined authoring process to create game scripts.

*Results.* ARGUMENT and ARLEARN have been evaluated in four small-scale studies, where educators designed game scenarios and students played the resulting games.

*Conclusions.* The results indicate that both tools are useful instruments that can be operated by teachers to build games and game-like educational activities and, additionally, are a valuable step to gain experience with serious games.

### Keywords

ARLEARN, Authoring, Location-based games, Openly available tools, Serious games, Wiki-games

Serious games have a longstanding tradition in education and training. Still, their use, as compared to the continuous boost in the games market ('GlobalCollect', 2013; 'PWC', 2010; 'National Gaming Survey', 2009), is very limited (Arnab et al., 2012; Ten Brummelhuis and Van Amerongen, 2010). Reasons for this, apart from practical issues such as financial barriers, are:

- The *high technical demands*. Simplicity versus accuracy in designing games or simulations is a long debated issue (Goosen et al., 2001). Still, games development is complex (Westera et al., 2008) and hard to realise within educational budgets and limited technical expertise.
- The difficulty to *organise/customise serious games* in a way that they fit into the educational process (Klopfer, Osterweil and Salen, 2009). In many cases, games are either designed for a specific purpose (and thus not customisable) or they require specialised customisation skills (which can hardly be done by a teacher/educator, who is usually not a game designer/developer).
- The difficulty to *support serious games*. Support by teachers is not straightforward (Van Rosmalen et al., 2008). As the amount of learners simultaneously supportable is limited and most teachers are unfamiliar with serious games, the amount and quality of feedback a learner might receive is low. Feedback, however, is considered a key condition for learning (Mory, 2003; Hattie & Timperley, 2007; Butler & Winne, 1995). Different approaches (Leutner, 1993; De Jong & Van Joolingen, 1998; Leemkuil, 2006) have been suggested to improve learner support.
- The lack of *standards for serious game design*. Though approaches toward the standardisation of serious game design exist, they are neither widely accepted nor brought into practice (Kelle et al., 2011; Schmitz et al., 2011).

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In this article, we address the problems of *high technical demands* and *the limited capacities of teachers* to create, customise, and support games. Instead of enforcing teachers to get acquainted with complex, and technically highly demanding serious games, we propose to make available relatively simple serious games that can be easily adopted *and* adapted by individual teachers, requiring only access to openly available technology, while still remaining interesting for learners. Hence, we aim to *explore* to what extent openly available tools can be used to introduce serious games in education. More specifically, our research questions are:

- (rq1) To what extent is it possible to create appropriate and representative game scenarios with commonly available tools?
- (rq2) To what extent are teachers able to design and create serious games with these tools?
- (rq3) How do learners perceive these games?

To answer these questions, we followed a design-centred research approach and investigated two opposite ways of using openly available tools to build games:

- In case one, we explored the use of a wiki for the creation of games. A wiki is an example of a widely used and easy to use tool that does not require any technical development. We use wikis because no particular tools and skills are required, apart from text creation and template-based structuring.
- In case two, we explored the use of the openly available Google stack of tools and services Google App Engine, Google StreetView, and Google Android (Google, 2012) to ease the development of advanced games within a ‘simple’ game environment. The use of the selected Google tools should make it possible to use rich but free functionality in combination with relatively easy to make game scripts. In comparison to wikis, ARLEARN represents a more advanced facility that requires teachers to design and structure a game process.

Our research started from the observation that although games nowadays are commonly associated with complex, immersive worlds featuring high quality graphics and smooth and fast interactions, that this is not the only way to consider games. Games such as board games, with a relatively simple set of rules, have been popular for centuries. The main underlying game principles such as competition, individual challenge, collaboration, and recognition by others (Pernin, Michau, Mandran & Mariais, 2012) have shown to be motivating and successful. The main goal of our study was thus to explore to what extent teachers will be able to design and utilise games for their pupils by using the described tools.

In the domain of computer-based games we can find many examples of games using simple or common technologies, for example email (e.g. Play by Email games; Lindahl, 2012) or, more recent, twitter (<http://playgen.com/play/twitter-game/> or <http://tweepi.com/blog/2011/07/4-most-addictive-twitter-games/>). Though no literature could be found on their use in education, examples such as Artwicate (@artwicate), which intends to assist in learning a new word each day, or Twitbrain (@twitbrain), which posts a math problem to be solved as quickly as possible, clearly have an educational potential. Similarly a variety of simple, highly appreciated online puzzles such as word games exists that, though designed for entertainment, may be used in education. Well-known examples are mobile games such as Wordfeud (a scrabble-like game), Ruzzle (a word game to create as many words as possible with the letters of a 4\*4 board in a given time) or Draw Something (a social drawing game to guess words). At the more advanced level, various dedicated tools for making a serious game exist. Some tools constitute of engines with templates which teachers can modify within given constraints or to which they can add their own content (Hummel et al., 2013), some have relatively simple editors which do not require specialised expertise (Torrente et al., 2010; Overmars, 2004). However, in these tools it still remains a challenge to make use of advanced 3D-technology as is common in many commercial games.

Many other platforms and technologies offer open authoring solutions for games. The ARIS toolkit (Gagnon, 2010) offers authors the possibility to create mobile games. However, game distribution is limited to mobile devices from Apple only. Toolkits to simplify the creation of mobile learning content (such as Junaio, Wikitude, or Layar) often leave the gaming aspect to the developer (Madden, 2011). Other openly available game creation platforms, which operate cross-platform, rather address technical game developers and require high technical skills. A typical example for this category is Gameplay (<http://www.gameplay3d.org/>) of Research in Motion.

Our specific interest of adopting a design-centred approach was to explore to what extent both the wiki and the Google tools allowed the development serious games that meet the expectations associated with games (Westera et al., 2008) *and* that can be easily used and adapted by teachers. We started our research with wikis because of their simplicity and their wide spread use in education. To explore more advanced game scenarios we then selected a stack of Google tools and services and built our application on top. Among these open and popular

tools, Google StreetView was chosen to study its potential to embed 3D-technology in serious games. Android was chosen as a mobile platform supporting augmented reality views. Google App Engine was chosen as scalable backend technology, capable of serving mobile and virtual clients. In this case we limited the exploration to study if teachers were able to design a game for and in this setting.

The article is structured as follows. First, we introduce the game scenarios used. Then, we introduce the technologies and architectures used as game platforms: Wikispaces for the ARGUMENT game and ARLEARN for the remaining game scenarios. We further describe the corresponding authoring approaches. Subsequently, we discuss the evaluation of ARGUMENT in a pilot study with a group of students of our Master programme Learning Sciences and the application of ARLEARN in three small scale pilots involving teachers and students of Cultural Sciences as well as trainers and employees of UNHCR. We conclude with a discussion of our findings.

## **Wiki-games: the ARGUMENT game model**

### **Game-Scenario used for wikis**

To explore the use of a wiki, as a first step a game scenario was designed and developed which students could evaluate and which could be used as a template for teachers to build their game. In the game, called ARGUMENT (Van Rosmalen & Westera, 2012), teams of players argue pro or against a given statement following a fixed set of rules. Depending on their performances players receive scores. ARGUMENT intends to elevate the learners' ability to get into details over a chosen topic, that is, to find and connect information, to discuss and defend the topic, to dispute issues raised. It starts with a proposition linked with the domain of study. This proposition is the basis for four rounds of arguing. In round one, each team writes a short essay on the proposition (either pro or contra). In round two, players write five ARGUMENTs in favour of their position. References to strengthen ARGUMENTs and fake ARGUMENTs (ARGUMENTs that are seemingly valid but are not) bring in, if accepted, additional points. In round three, the teams challenge the opponents' ARGUMENTs. Finally, in round four the teams write their final, short essay summing up their ARGUMENTs. In each round a team can gain points for its contribution. A Hall of Fame is administered to show the team scores. All details of the game are explained in the wiki including team composition, position to defend, background information, game rules, scores and scoring. Finally, each round is followed by a discussion either in a forum in the wiki or in the classroom. Full details of the game are in the (Dutch) game template (ARGUMENT, 2010).

### **Common technologies used in the WIKI-game ARGUMENT**

*ARGUMENT* is an online game that makes use of the collaborative nature of a wiki. A wiki is essentially a website with allows for creating, editing, linking and navigating pages. Wikis are around for over a decade and fit into the web 2.0 paradigm of user created content. They are widely used in education for a variety of applications (see e.g., Ayers & Ortega, 2010; Riehle & Bruckman, 2009) including notes sharing, collaborative writing, shared learning tasks, or getting used to ICT. Most wikis can be edited with the help of simple editors to make creating and sharing all kinds of contents (text, pictures or videos) easy for students and teachers. Wikis are often configurable with respect to access rights or functionality (e.g., table of contents, tag clouds, or discussion forums). We use Wikispaces (2012) as platform for the ARGUMENT game, as it is a popular wiki-site, which assists teachers by offering free accounts and extensive ideas and references on how to use a wiki in education (be it not for gaming).

### **Creating and authoring a wiki-game**

Teachers interested in creating their own wiki-game can either use the template version of ARGUMENT (<http://wiki-games-ARGUMENT-sjabloon.wikispaces.com/> in Wikispaces or the Handbook: Van Rosmalen & Westera, 2010) or choose to reuse an existing game from a number of ARGUMENT game instances. The template version contains a copy of all predesigned pages of ARGUMENT and on each page an instruction of how to make a new instance of ARGUMENT. If the teacher chooses to use the template she or he has to formulate a new position statement to be discussed and find, if required, a list of supportive materials. The handbook includes, besides a complete copy of the template:

- A detailed description of ARGUMENT.
- A brief introduction to Wikispaces, focused on being able to create a wiki-game.
- A general introduction to creating a wiki-game (figure 1), including suggestions to create new kinds of wiki-games.
- Evaluation results of the first version of ARGUMENT.

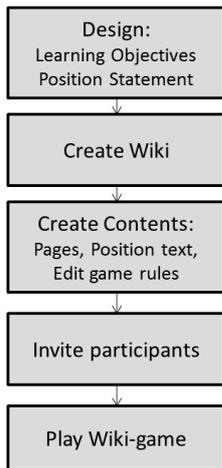


Figure 1: ARGUMENT authoring and application process

The wiki-game itself has to be constructed by the teacher in Wikispaces or their preferred wiki environment. Figure 2 displays a game created within the wiki using the ARGUMENT template.



Figure 2: Playable ARGUMENT game

## Virtual and augmented reality games using ARLEARN

### Game-Scenarios used for ARLEARN

To explore the use of the chosen Google technologies, three serious game scenarios have been analysed and designed for evaluating the so-called ARLEARN game concept. In line with the used technologies the three scenarios comprise respectively a location-based virtual scenario, a mobile scenario, and a mobile, location-based scenario:

- *A location-based virtual scenario: The Amsterdam Grachtengordel case.* A police story in the drug milieu is used to motivate cultural heritage learning content about Amsterdam. This game scenario follows an expository approach where learners use Google StreetView to virtually visit real-world locations.
- *A mobile platform game: The UNHCR hostage taking game.* This crisis intervention game represents a hostage taken situation, that forces participants to act. It is based on process-design and events: external events and decisions taken influence the game process. By using mobile devices the game is embedded in a real world situation.
- *A location-based mobile game: The Florence fieldtrip case.* Using an excursion pattern a city quiz tour is modelled, where an educator assigns problems to student groups, which have to solve them at the actual locations the tasks refer to.

## Open technologies used in ARLEARN

Google offers freely accessible tools for various purposes including Gmail, Google Docs, Google Maps (Google, 2012) and provides open APIs (Application Programmer's Interface) to be used by developers creating connected services and tools. StreetView, offered by Google as an add-on to Maps, offers navigable, 3D-like visualisations of the environment, displayed from a user point-of-view, allowing navigating as if moving around the actual scenery. These tools have already attracted game developers to create game prototypes, for example a racing game and a flight simulator based on Google Maps (Scott, 2012; Caswell-Davies, 2012). Also for StreetView, experimental games have been developed (Clapp, 2012). However, the use of StreetView for serious games is still in its infancy.

We defined and implemented a serious gaming platform (called ARLEARN) for games taking place in a virtual environment (StreetView) or in reality (mobile devices). ARLEARN is designed to meet a number of requirements, which we could not find to this extent and in this combination implemented in other openly accessible platforms so far: multi-user support, allowing players in different roles and teams; support for mobile and web-based clients; support for mixed reality scenarios including player decisions as well as predefined game processes; support for game re-use and logging of all game activities for reflection purposes (Ternier et al., 2012). We have implemented ARLEARN as an open source project (ARLEARN, 2011) that permits others to reuse and contribute. In an iterative, user-centred development process (Van Rosmalen et al., 2011), ARLEARN has been developed to support various kinds of clients (Android-based mobile client, StreetView-based virtual environment).

An ARLEARN game is a reusable game logic description that can be instantiated in numerous game-runs. Within a game, an author defines media items (including multiple-choice questions, video objects, and narrative items), dependencies between items (action-based, time-based, or logical combinations), game score rules and progress rules. Core concepts, which can be defined by authors to be used within games thus comprise:

- *NarratorObjects* are used to display content. Special forms are *VideoObjects* and *AudioObjects*, containing video and audio content respectively.
- *MultipleChoiceItems* are used to ask questions, model decisions and provide interaction.
- *PickupItems* and *DropZones* can be used to model resources and their transportation to destinations.
- *Dependencies* are used to model game flows.
- *ScoringDefinitions* and *ProgressDefinitions* are used to model game success and progress.

A game run defines users grouped in teams. While playing, users generate actions (e.g., “read message”, “answered question”) and responses. This output is also managed within the realm of a run. More technical detail on the concepts behind ARLEARN can be found in (Ternier et al., 2012).

## Authoring for ARLEARN

ARLEARN has been designed with non-technical authors in mind, who should be able to create interactive learning content and learning games. The authoring process for ARLEARN consists of the steps depicted in fig. 3. It will be detailed in the remainder of this section. In practice, due to the prototypical nature of ARLEARN's authoring tool, this process is usually a combined effort of game authors and technology specialists, where the author is generally responsible for game scenario, storyboard and partially the game script, while the technology specialist supports the scripting and the generation of game run and playable game.

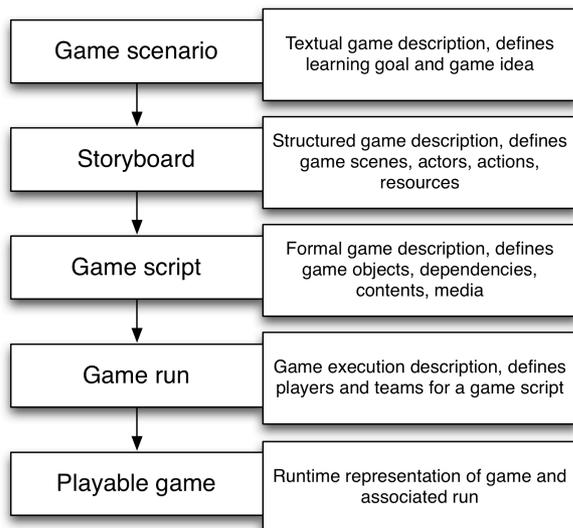


Figure 3: ARLEARN authoring and application process

The authoring process starts with the game idea described in a short textual game scenario. This approach has been based on interviews with teachers and technology enhanced learning researchers (Van Rosmalen et al., 2011). The scenario is a prose game description (see textbox 1) and does not yet include technical details but allows discussing the game play and deciding upon it. Textbox 1 displays a small excerpt from the complete game scenario used for the *Amsterdam Grachtengordel* game, in order to exemplify the style of describing the scenario. For simplicity reasons, the example only includes short descriptions of the learning goals, which are concerned with cultural and historical knowledge about Amsterdam during the 1970's.

Textbox 1: Example game scenario (translated excerpt of the original)

Detective Ada Jobse is looking for a load of hashish that is smuggled in 1973 with a fishing boat from Lebanon (true story). She searches for the drugs and aims to get the dealer. In addition, there are several wrong tracks. The quest takes her through various locations for where information has to be collected, processed and tasks have to be solved. Ada finds out, that the drugs are sold from a hospital where the poet Nico Kraaijenpoort is due to a failed attempt to trepanation (drilling hole in the forehead, to forever be high).

The locations used will be of particular cultural and historical value. The information presented will be a mixture of cultural and historical information and information contributing to solve the game challenge.

Table 1: Example storyboard (translated excerpt)

No	Story	Location	Items	Actions	Scope
1	It is the year 1973. You are police inspector Ada Jobse. An anonymous witness has informed the Amsterdam police that large amounts of marihuana are smuggled in Dutch fishing boats from Lebanon to IJmuiden, in the north of the Netherlands.	Police headquarter	Background introduction Story introduction Dialogue with colleague	Start at Police headquarter  Read introduction about story and game  Get dog to help you find the marihuana.	Every player can get the dog.
2	The marihuana is distributed in Amsterdam. Inspector Jobse tries to find out from where the marihuana is stored and how it is sold.	Haarlemmerpoort. Jobse considers the possibility of the import of the drugs via boats into the	Item about the history of the Haarlemmerpoort. This used to be one of the main entrances by boat to the city of	Go to Haarlemmerpoort  Read introduction about the smuggling of	

		Amsterdam canals.	Amsterdam. Photo material, text material, video?	marihuana in fishing boats in the 1970s.	
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Once the game scenario is described, it can be transformed into a storyboard document. The storyboard is a semi-structured template, which already describes concrete game scenes, resources involved, actions and their consequences (table 1). The storyboard serves two purposes. Firstly, it informs the scripting step about which objects to create and how. Secondly, it is a mapping instrument, to match elements of the game scenario to the technical concepts of the ARLEARN platform. Both purposes are essential for the quality of the resulting game, as they indicate how well the technical concepts and limitations of the platform are understood by the author and how well the game scenario can be mapped upon these concepts.

To transform storyboards into playable games, we introduced a simple scripting mechanism for the authoring of games and game runs. Of course, as mentioned in the introduction, at this stage we do not yet expect teachers to formally write these game scripts. Instead, our goal is to gain insight in the way educators design games (in terms of the storyboard) and to transform these storyboards in game scripts with the help of experts. We aim to have a simple mechanism to author games without any requirements to the tools used (apart from a text editor), while still allowing to create a dedicated authoring tool set in a second step. Thus, the scripting mechanism represents an intermediate step toward an authoring tool for educators.

A game script for ARLEARN is a collection of statements describing the game items and their dependencies. ARLEARN reads the script to instantiate the objects. In the same way, game runs can be scripted. A game run is an instantiation of a game and defines the players and their teams. It also schedules the point in time, when the game run starts.

Once the script is created and implemented and the corresponding game runs are created, the game can be played in the ARLEARN platform. The platform infers the game logic based on the game and executes the script using the game item definitions, their dependencies, their visibility scopes (e.g., whether they are available per game, per team, or per player), the player and team definitions of the run and the game state inferred from the game progress so far.

The following figure displays a screenshot of the final game played in the StreetView-based ARLEARN client (virtual environment).

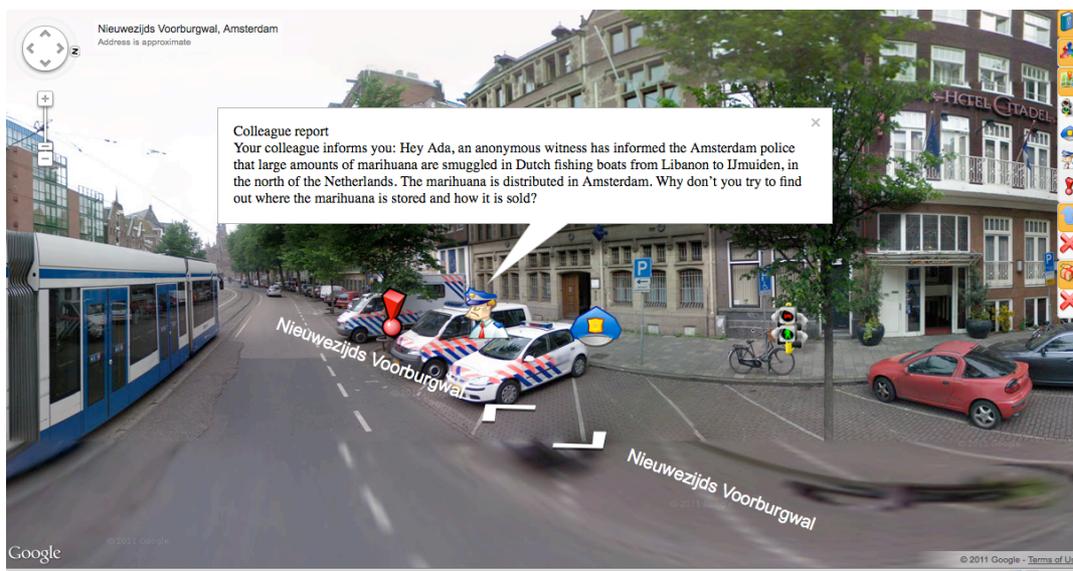


Figure 4. Screenshot of the Google StreetView based ARLEARN client

In the other two ARLEARN cases (Florence and UNHCR), a similar authoring process applied. However, in these cases, the mobile ARLEARN client has been used to deploy the games. The following figure depicts the mobile client, with a scene from Florence on the left and two scenes from UNHCR on the right, which give an impression of the different interaction modes available (map-based overview, task-list, content interaction).

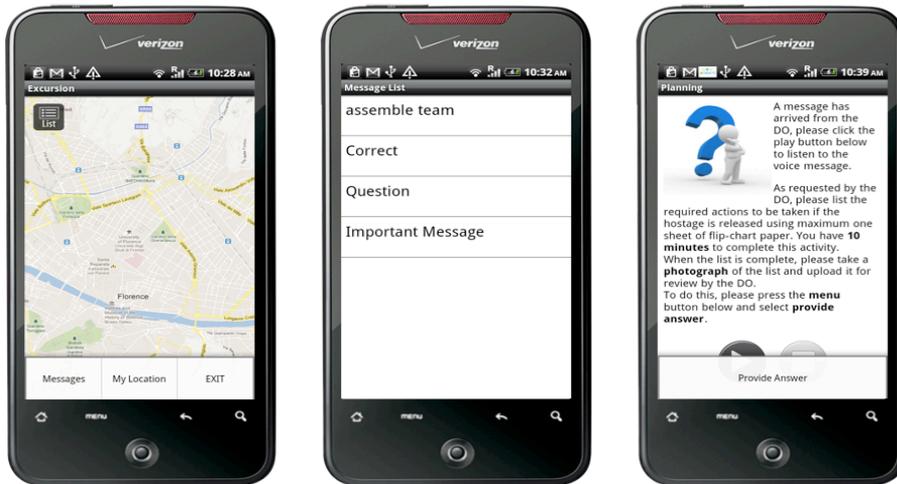


Figure 5. Screenshots of the ARLEARN mobile client

## Debriefing

Debriefing generally describes "*the occasion and activity for the reflection on and the sharing of the game experience to turn it into learning*" (Crookall, 2010). As this article is on authoring of serious games, we consequently looked at the options available for game authors to include debriefing in their game designs. Both tools that we used throughout our study, support in-game and post-game debriefing. However, they do this differently, as highlighted in the following.

*Debriefing in Wiki-Games.* In the wiki-game ARGUMENT, debriefing is an inherent part of the game design. Participating players are constantly interacting with opponents through written statements and thus need to reflect upon and share their own ARGUMENTs as well as the opponents' ARGUMENTs. Consequently, the wiki-game tools support this in-game debriefing process, as participants have to explicitly document their ARGUMENTations. In addition, each round is followed by a discussion either in a forum in the Wiki or in the classroom. One team is assigned to open the discussion reflecting on specific statement or the process of the game as decided by the teacher. Finally, all player decisions and ARGUMENTations, which are documented within the wiki, remain available after game termination. This documentation can be referred to post-game in a debriefing process.

*Debriefing in ARLEARN.* ARLEARN offers several technical possibilities to include debriefing into the game design. Assessment results and other forms of structured feedback can be gathered by utilizing single and multiple-choice forms within game designs. In line with (Bedwell et al., 2012), recorded data of such assessments can be used for debriefing. Also, structured feedback can be utilized as an instrument for in-game reflection: the outcomes of the single and multiple-choice forms can be automatically assessed and evaluated and the follow-up game process can be dependent on these outcomes. Furthermore, the game author can decide to use unstructured feedback mechanisms, which ask students to deliver feedback in the form of texts written, pictures taken or audio/video recordings made with their mobile phone. While these forms of feedback cannot be analyzed automatically (the game engine can only recognize, that feedback has been given but not assess the quality), they can be useful for post-game debriefing processes: the materials collected during the game process can foster the discussion during a debriefing phase.

In summary, both platforms allow for in-game and post-game debriefing through different technical means. The platforms share the idea of documenting player decisions and player feedback, which can later be used in post-game debriefing. This way, debriefing barriers as listed by (Dieckmann et al., 2012) can be addressed, as discussions have concrete starting points by looking at the materials provided. This is also in line with experience made by (Oertig, 2010), who claims, that especially people not used to speak in front of larger groups may benefit from technology-supported debriefing sessions. However, in both of our platforms the authors are responsible for including debriefing processes properly into their game design in a way as for example described in (Ledermann, 1992) or (Steinwachs, 1992). We believe, that this enables authors to use debriefing tailored to their specific learning objectives, as required by (Peters & Vissers, 2004).

## Materials and methods

Based on the authoring and gaming experiences according to our research questions rq1-rq3, it is our intention to improve the design of our game authoring prototypes. Consequently, we performed separate evaluations for the

four different cases in order to gather qualitative feedback. In all studies, we examined the authoring tools and process and collected learner feedback for the resulting games using questionnaires (asking for personal details, the gaming experience, and the learning experience involved with the games at hand) or structured focus group discussions.

We performed the studies involving seven students from our master programme in learning sciences for the ARGUMENT game, two groups of students and two teachers from cultural sciences of OUNL for the Amsterdam and Florence games, and seventeen employees from UNHCR for the hostage taking case. In this section we will explain the corresponding study designs, describe the participants and layout the evaluation approach used to address the research questions.

## **Study design**

### *Authoring*

In all cases, we followed the authoring processes for ARGUMENT and ARLEARN as described before. The teachers involved in the authoring had no prior experience in designing or authoring games.

In case of ARGUMENT, the template version of ARGUMENT was used by participants in the role of teachers to develop their own version of ARGUMENT. Before creating their own design the participants first played an instantiated version of ARGUMENT to get acquainted with it (see next section).

All participants for the ARGUMENT study were students of the Master Programme of Learning Sciences of the Open University of the Netherlands. They volunteered by responding to an open invitation mailing. The average working experience of the participants was 7.5 years (ranging between starting – 15 year), divided over Higher Education (3), Primary Education (2), Company training (2). Their experience with wikis ranged from none (5) to limited experience (2). In the same line their experience with serious games varied between no experience (3) to limited experience (4).

To support the slightly more technical authoring procedure for ARLEARN, we established a procedure of increasing support toward the more technical authoring steps. In other words: the teachers designed the game scenarios and transferred them into storyboards with little help from our side (in the role of technical experts, we provided storyboard templates and reviewed storyboards for technical feasibility). We then transferred the storyboard into a game script, having the teachers monitoring/reviewing this process (in one case, tech savvy educators also worked on the scripts directly).

Two teachers from cultural science and one instructor from UNHCR participated as teachers and game authors for ARLEARN (for Florence, Amsterdam, and UNHCR respectively). For the Florence and Amsterdam cases, the teachers created the game scenarios and storyboards and selected media items to be used within the games. As technical experts we supported the translation of these materials into executable game scripts. In the UNHCR case, the instructor also performed the technical scripting tasks.

### *Learning*

Learners played these games and were asked afterwards to provide their feedback.

For ARGUMENT, learners and teachers were the same group of people, who switched roles. All of them used ARGUMENT as teachers and as students. Consequently, seven participants played the ARGUMENT game in the role of a student.

In the Florence fieldtrip case, we performed an on-sight study in Florence, which was connected to a yearly field trip to Florence of students of the School of Cultural Sciences. In the case studied, eight participating students were each given a personal set of questions, recorded by the instructor. All questions appeared in a predefined sequence. Only after answering a question, the next question became available.

In the Amsterdam case study we used the web-based ARLEARN-client (called STREETLEARN). We performed a half-day evaluation with 6 students of the faculty of cultural science. Three of the players used the game in our lab environment, while the three further players where remotely accessing the game session. The remote players where connected to us by a permanent Skype connection. We gave a short introductory presentation to the participants and then asked them to play the game. During the game we gave some support to participants and answered questions.

For the UNHCR case, an ARLEARN decision-making game was designed as a real-time simulation of a hostage taking situation using smartphone clients. In December 2011, a pilot was organised in Entebbe, Uganda. Here, three game runs were performed at the same time featuring three roles per run. In total, nine devices were used, connected via a cellular network. The resulting game was played with 17 participants (all employees of UNHCR). All participants were new to the field of mobile serious gaming with smartphones.

In all cases, we asked the participating students and teachers about their experience (see materials and methods).

## Evaluation approach

### *Materials and methods*

*Methodology.* To answer our research questions rq1-rq3, we followed a common methodology in all four cases, which had to be adapted to each case due to differences in authoring and application scenarios. We applied the methodology of (a) observing teachers as authors using the authoring tools (rq2); (b) requesting feedback from the teachers about their authoring experience (rq2); (c) analysing the resulting games according to common classification schemes (rq1); (d) applying the games to students (rq3); and (e) requesting feedback from the participating students about their experience (rq3).

*Data collection and analysis.* Main sources of data are observations made during the authoring processes and game play sessions, feedback from authors (interviews) and students (questionnaires), as well as the resulting games. Observations, feedback from authors, and the resulting games were qualitatively analysed. The student feedback questionnaires were analysed qualitatively and quantitatively.

*Limitations.* Due to the relatively small number of participants in our studies we do not claim empirical evidence for our results. Also, as this article combines outcomes of four different studies, we have to keep in mind, that contextual differences might influence the generalisability of the results.

### *Materials and methods for research question (rq1)*

In order to answer research question (rq1), we compare the resulting games from a game design perspective in order to see in how far they cover a variety of different games according to the dimensions game classification, delivery channels, immersion experiences, and pedagogic approaches as introduced and motivated below. We also compare the underlying authoring approach.

With respect to game classification, various classification schemes have been proposed so far, which focus on different classification aspects. While (Aarseth et al., 2003) focus on aspects of the game mechanics used, (Ratan & Ritterfeld, 2009) chose educational content, learning principle, target age group, and platform as dimensions. (Djaouti et al, 2011) propose to use gameplay, purpose, and scope as classification dimensions. We classify the resulting games according to the scheme proposed in (Breuer & Bente, 2010), which combines previously proposed schemes into a comprehensive one, defining nine classification dimensions: (1) platform, (2) subject matter, (3) learning goals, (4) learning principles, (5) target audience, (6) interaction modes, (7) application area, (8) controls/interfaces, (9) common gaming labels.

Milgram's Virtuality Continuum (Milgram & Kishino, 1994) presents an axis where mixed reality extends from real environments to completely virtual environments (see fig. 6). Augmented reality and augmented virtuality applications are ranging somewhere on this axis. In applications for Augmented Virtuality (AV) the concept of immersion is important. Navigating through a synthetic world, a participant can interact with either fictional or real objects. Applications for augmented reality (AR) build upon a real environment. AR applications add virtual media to a real environment, presenting information that is not visible in the real world.

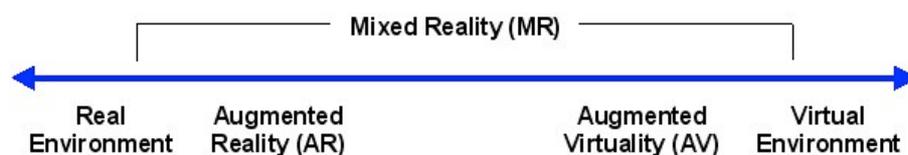


Figure 6: Milgram's Virtuality Continuum

Dede (2009) defines immersive learning as learning that involves the “subjective impression that one is participating in a comprehensive, realistic experience”. He differentiates between the following types of immersion:

- *Actional immersion* enables an individual to have experiences, which would be impossible in the real world.

- *Symbolic immersion* involves the triggering of semantic and psychological associations via the content presented.
- *Sensory immersion* replicates the experience of a remote location via visual or haptic feedback.

We analyse the range of delivery channels covered with respect to the mixed reality spectrum of Milgram’s continuum (Milgram & Kishino, 1994). The immersion experience offered by the educator created games is analysed according to the immersion types as defined by Dede (2009).

With respect to the pedagogic approaches, we look at the underlying learning model and to what extent it represents transmissive (or expository) models or rather experiential models (such as situated learning or process-based learning).

#### *Materials and methods for research questions (rq2) and (rq3)*

In order to study, if the teachers were able to use and adapt the authoring tools and instructions given to create individual educational games (rq2), we observed the authoring process and interviewed the authors about their authoring experience.

Additionally, we studied the ease of use, the quality of the instructions, and if the participating students perceived the outcomes as motivating and instructive serious game (rq3). As part of the evaluation a questionnaire on the background of the participants and their participation was used. The questionnaire consisted of open questions for collecting the participants’ reflections on their experiences and closed questions asking for the agreement/disagreement on selected statements and the designs created by them.

For the ARLEARN cases, additionally, we looked at the coverage of ARLEARN concepts in the games designed by the educators. This gives insight into the question, if the educators were able to understand and utilize the various elements of the platform.

## **Results**

### **Comparison of the different Game-Scenarios (rq1)**

With respect to research question (rq1), we firstly looked, to what extent the games created by educators cover appropriate game scenarios as described in literature. Therefore, we compare the game scenarios created by the educators involved with respect to the dimensions *game classification* (Breuer & Bente, 2010), *delivery channel* (Milgram, 1994), *immersive experience* (Dede, 2009), and *pedagogic approach* (Taylor, 2004) as introduced in the previous section (table 2). The authors of this article, which are experts in the fields of serious games and game design, have performed this comparison.

Table 2: Comparison of game classification, delivery channel, and pedagogic approach

	Wiki-games	Florence case	Amsterdam case	Hostage case
Game classification (Breuer & Bente, 2010)				
1. Platform	Web	Mobile, location-based	Web, virtual world	Mobile
2. Subject matter	Various topics covered from primary to higher education (note: elaboration below applies to ARGUMENT)	Florence	Amsterdam and drug history	Hostage taking situations
3. Learning goals	ARGUMENTation skills	Cultural heritage	Cultural heritage and history	Acting in emergency situations
4. Learning principles	Constructivist learning	Exploration	Exposition, Trial and error	Trial and error
5. Target audience	Learning science students	Cultural science students	Cultural science students	Professionals
6. Interaction modes	Multi-player	Co-tutoring	Single player	Multi-player

7. Application area	School education and Academic education	Academic education	Academic education	Professional training
8. Controls/ Interfaces	Mouse & Keyboard	Touchscreen	Mouse & Keyboard	Touchscreen
9. Common gaming labels	Discussion game	Scavenger game	Adventure game	Decision game
Delivery channel (Milgram, 1994)	N/A	Augmented reality	Augmented virtuality	Augmented reality
Immersion experience (Dede, 2009)	Actional	Symbolic, Sensory (augmented physical locations)	Actional, Sensory (virtual locations)	Actional
Pedagogic approach (Taylor, 2004)	Process-based learning	Situated learning	Expository learning	Learning through decision taking

The game designs reflect a range of structured, linear discourse games (discussion game), non-linear, location-based games (scavenger hunt), process-oriented location-based games (adventure game), and process-oriented event-based game (decision game). According to the classification scheme offered by (Breuer & Bente, 2010), the various games created represent a fair distribution across the various classification domains with respect to the learning and gaming related aspects. This shows, that the authors are able to use the tools for various games and learning topics and that the tools offer sufficient flexibility to create different games.

The three scenarios created with ARLEARN cover the range of mobile games as introduced by Nicklas et al. (2001). The range of delivery channels chosen covers the mixed reality spectrum of Milgram's continuum (Milgram, 1994). ARGUMENT does not make use of locations and is thus not categorised on this dimension.

With respect to immersion experience, the games designed and created by the educators cover the three immersion types as defined by Dede (2009): actional, symbolic, and sensory immersion (referring to the novel, intriguing consequences of actions taken; the semantic associations triggered by the content of a virtual environment; and the representation of augmented or virtual physical locations, respectively).

The games authored by educators also cover a range of different learning models. While ARGUMENT is clearly an example of a constructivist and socio-cognitive learning model, the ARLEARN authors have chosen the learning model among transmissive (or expository) models and more constructivist or socio-cognitive models (here referred to as situated learning). Consequently, we are able to claim that the realized games cover traditional and modern learning models according to Taylor (2004).

This analysis of the created game scenarios shows, that they cover a broad range of different gaming settings from a game design perspective. Consequently, we can see that it is possible to create appropriate and representative game scenarios with the openly available tools used within this research (rq1).

### Teachers as authors (rq2) and student perception of games (rq3)

With respect to research question (rq2), we analysed the outcomes of the four studies described above. Below, we describe how the authoring process described above was implemented in each case and (in case of ARLEARN) how the facilities of ARLEARN were used to implement the game. Additionally, we summarise how the students experienced the resulting games (rq3) in terms of usefulness of the approach and their perceived gaming experience. Full detail on the student view is given in (Van Rosmalen, Klemke, & Westera, 2011) for ARGUMENT, in (Ternier et al., 2012) for Amsterdam and Florence, and in (Gonsalves et al., 2012) for UNHCR. Table 3 summarizes the authoring and learning experiences discovered in the four studies, which is detailed for each case in the remainder of this section.

Table 3: Comparison of authoring and learning experience in the four cases

	ARGUMENT	Florence case	Amsterdam case	Hostage case
Authoring				
Authoring approach	Authoring of game rules and content implicit as resources	Explicit authoring process: scenario, storyboard, game script		
Application of	Authors are able to	Authors are able to	Authors are able to	Authors are able to

predefined authoring process	apply the process	apply the process. Scripting support needed.	apply the process. Scripting support needed.	apply the process. Scripting support needed. Tech savvy authors learned scripting.
Ease of authoring	Authoring considered to be easy	Authoring required some initial learning, but considered to be manageable	Authoring required some initial learning, but considered to be manageable. Main difficulty was to structure materials for a game.	Authoring considered being easy and straightforward. Scripting partly done by instructor.
Coverage of technical concepts	N/A	Low, only two concepts used	High, most concepts used in game design	High, most concepts used in game design
Student view				
Usefulness of approach	High, instructive element positively rated	High, combination of individual learning and gaming positively rated	High, concept rated as motivating and interesting	High, positive learning experience stated
Game experience	Low game experience	Good game experience despite some technical issues (GPS coverage)	Good game experience though prototypical status of game engine criticised	Good game experience, immersive situation

For ARGUMENT, the general game structure is given in the template used. Consequently, the author concentrates on the content creation and its structuring according to the game template. The authoring process for the ARLEARN cases follows a process of scenario description, storyboard definition and game script creation. While the latter authoring process offers more flexibility, it is also perceived to be more complex. In all three ARLEARN cases, the authors invested a couple of working days (three to five) to perform the authoring steps. The scripting for the final phase took around one to three working day per case. These efforts result in games, which can be played during 30-45 minutes. Compared to usual game authoring efforts, this is a remarkably low effort.

#### *Wiki-game ARGUMENT*

In this study 7 participants joined as teacher (i.e. as a game designer). All of the participants had used ARGUMENT in the role of student just prior to the design part of this study. They were asked to take this experience into account while designing and implementing their wiki-game. They worked independently to create their own wiki-game and were asked to complete this assignment within a period of 4 weeks. At the end of the period, 5 participants had completed the assignment, 4 of them created a full version, 1 concentrated mainly on suggestions for improvements, 2 participants were still working on it. The topics chosen for their wiki-games ranged from how to spell verbs (primary education), radiology, and liberty of speech to research methods (higher education). The implementations ranged from minor modifications to new designs inspired by ARGUMENT. The modifications (improvements) concerned:

- The tool used. One participant opted for Google sites, motivated by perceived better functionality and the possibilities to make a more advanced graphical design.
- The gaming element. A number of attempts were made to improve the gaming element:
  - Each player was allowed to choose their own individual topic within one central theme, this to avoid interdependencies between the players.
  - Extra bonus points for delivering in time; making the assignment of another team in case of their delivering too late; the quality of the writing itself.
  - The use of an anonymous guest player to avoid dead locks in case contributions are too late.

The participants confirmed in the questionnaire that it was fairly easy for them to create a wiki-game and to apply it to an (their) educational learning context (rq2). A wiki was seen as a useful tool, only the copying of pages, necessary to implement the game structure, was considered time consuming. One concern was that

ARGUMENT as a game did not offer a game-like feeling for students used to challenging immersive games. The overall appreciation was negative for the game element of ARGUMENT (3 negative, 3 neutral, 1 positive) and positive for the instructive element (1 negative, 6 positive). Nevertheless, the final judgement on ARGUMENT was positive despite all the inherent limitations. A larger part (5 positive, 2 neutral) of the participants indicated that ARGUMENT did inspire them to start using wikis and other (easy to use) ICT tools, as an introduction to using serious games (4 positive, 2 neutral) or use ARGUMENT or a variation of it directly (4 positive, 1 neutral). Three participants eventually chose to further engage themselves in this topic and to use the approach for a project in one of their courses of the Master of Learning Sciences. The findings with respect to game and general appreciation were confirmed in one of the projects. Werk!Woord (Van Rosmalen & Westera, 2012), a wiki-game on verb spelling was experienced by most of the learners (75%) as a nice, challenging and effective (measured with the help of a pre- and post-test) way to practise verb spelling. At the same time, only half of the learners did perceive it as a game, though the competition and the collaboration element were clearly appreciated positively (rq3).

### *Florence*

A teacher from cultural science created personalised scenarios and storyboards for the participating students, following a linear approach and leading them to various places in Florence where the students had to combine their knowledge with what they see in order to solve open questions. This storyboard, including various media (audio and pictures) was created by the teacher and encoded as an ARLEARN game by the researchers. The gameplay was implemented with the following ARLEARN object types:

- *AudioObjects* are used for open questions.
- *Dependency* objects were used to model the sequential order in which the questions appeared.

A map view shows the position of the questions, relative to the user's location. An additional list view gives access to all accessible questions. Scoring was not relevant here and hence not added to the game script. The teacher involved confirmed, that after some preparation the authoring process was manageable. However, only two of the available concepts of the platform were used and the author did not perform the scripting step (rq2).

All eight students that participated in the Florence pilot played a personalized ARLEARN game that was authored by the teacher based on the topic that they studied. The students generally appreciated the mobile game approach, which allowed them to reach their gaming and learning goals individually but still guided. Although, some shortcomings in GPS coverage in the ancient city centre sometimes caused problems with location-based features, the game was playable (rq3).

### *Amsterdam Grachtengordel*

A cultural science teacher created the game scenario and storyboard for this case, which is based on historic events: the smuggling of marihuana in fishing boats from Lebanon to the Netherlands in the early 1970s. The storyboard was transferred into an ARLEARN readable format (game script) and implemented in a virtual environment using the StreetView based user interface of ARLEARN by researchers. It is mapped to the object model with the following object types:

- *NarratorObjects* are used for all static information (texts, videos, images, and links to external websites).
- Objects of type *PickupItem* and *DropZone* model search and delivery tasks (such as find a movie ticket and hand it in at the movie entrance to be admitted to a movie).
- *MultipleChoiceTest* model interactive situations (dialogues, decisions) and they test the player's learning progress.
- *Dependency* objects help to model the story line. That way, some objects only become available after finding objects, delivering them, answering questions or accessing specific information.
- *ScoringDefinition* objects and *ProgressDefinition* objects are used to model the game state.

The teacher involved confirmed, that after some preparation the authoring process was manageable. The main difficulty reported was that the structuring of learning material for a game requires an approach different from the preparation of other learning materials. Nearly all concepts of the platform were used in the resulting game. The teacher did not perform the scripting step (rq2).

A group of six cultural science students played the game. We received positive feedback for the concept and idea behind ARLEARN and for the game experience. Some critical remarks concerned the current prototypical status (rq3).

### *UNHCR Hostage Case*

Prior to developing and playing the hostage taking script with ARLEARN, UNHCR had already a storyboard that they used to train their employees. This storyboard roughly followed the structure presented previously and implemented an extra role column, indicating to which game role (“staff welfare”, “head of office”, “Security Officer”) the content is shown. This storyboard was encoded by the researchers and further extended and altered by tech savvy educational designers at UNHCR (Gonsalves et al., 2012).

The gameplay is implemented in the object model with the following object types:

- A *VideoObject* with a plea for help was played at the start of game.
- *NarratorObjects* broadcast information or simulate incoming calls and information requests (*AudioObject*).
- Objects of type *MultipleChoiceTest* allow players to make decisions, while *Dependency* objects help to model the decision making structure by allowing contextualized feedback to erroneous answers.

The instructor of UNHCR stated, that he found the authoring process to be easy and straightforward. An educational storyboard he already owned could to a large extent be reused for the ARLEARN game. The instructor performed parts of the scripting process himself (rq2).

Of the 17 participants, 14 participants reported a positive game and learning experience and the experience of immersive situations; two participants reported mixed results and 1 participant reported negatively (Gonsalves et al., 2012) (rq3).

### **Result Summary**

With respect to the research questions formulated in the introduction, we can summarize our results as follows.

(rq1) With both platforms (ARGUMENT and ARLEARN) we were able to successfully implement games based on openly available technologies. For ARGUMENT no technical developments took place, the game rules were applied to an existing tool. Although the ARGUMENT games were playable and motivating, this simplest case of game implementation gained low game experience. For ARLEARN, a game platform has been developed on top of the selected technologies. This improved the players’ game experience at the cost of increased authoring complexity. Still, the authoring effort remained acceptably low.

(rq2) In both platforms the involved teachers were able to author games. The games have been successfully created and consequently played by students. In all cases, the authors followed the authoring processes as outlined according to authoring instructions given by experts. The ARLEARN approach of scripting games involved more support to the teachers in order to clarify the general approach, technical limitations and conceptual constraints of the platforms. The implemented games successfully used all main concepts of the ARLEARN platform (Object types, dependencies, multi player settings).

(rq3) The participating students have been assigned to games in both platforms. While for ARGUMENT the gaming experience was rated low, the overall assessment of its usefulness was still positive. For ARLEARN, the student experience depends to a larger extent on the storyboard at hand, as the scripting approach offers a larger variation of game scenarios. Participants reported the immersive element of ARLEARN games and their motivating aspects as positive experiences.

### **Discussion and conclusion**

The first study, also taking into account the participants prior experience with ARGUMENT as a student, indicates that ARGUMENT enables the learner to get a good understanding of a chosen subject and supports the acquisition of complex skills such as arguing. Although ARGUMENT (and in the same line the wiki-game Werk!Woord!) does not fully meet the expectations of a serious game created by commonly available games, it is positively appreciated by the learners. Whereas it seems that ARGUMENT successfully adopts gamification, it is not game enough to challenge students’ game expectations as is phrased in “since you learn something of it” or “because it is an assignment”. Obviously, to some extent the game perspective may be leveraged by designing and developing additions to a wiki, for example by making use of widgets at the risk of unnecessarily complicating the development of wiki-games. The study also indicated that ARGUMENT was easy to adapt to the individual teacher’s needs. ARGUMENT inspired the participants to start using wikis and ARGUMENT itself as well as other serious games. Finally, whereas we are hesitant to add too specific functionality to a Wiki,

we are exploring how to build a simple tool for scripted game-based collaboration. Whereas the design is straightforward with a Wiki, the follow-up by the teacher (i.e. checking if everyone acts as supposed) may cause a lot of manual work. Therefore, aligned with other work (Hummel et al., 2013) we are preparing a simple tool with a very focussed scope on collaboration scripts.

With the ARLEARN toolkit we mainly try to address game experience and user interface interactivity while offering an efficient authoring process that can be mastered by educators. The results of the ARLEARN studies indicate that teachers are interested to include the proposed technologies in their teaching practice. However, they still doubt if they are able to create interesting learning scenarios on their own. Also the request for more formal learning support (assessment, teacher dashboard) indicates that for a transfer of ARLEARN into teaching practice more development work and evaluation research has to be performed. One observation motivates continuation: when teachers are able to transcribe their game ideas in storyboards, the effort for adapting these ideas into realistic scenarios and for transforming them into ARLEARN scripts appears to be acceptably low. The experience and feedback gathered from the ARLEARN authoring sessions, did already lead to the development of a graphical authoring environment, which eases the game implementation step by offering a graphical interface to do the scripting. It offers access to the list of general items of the current game, a dependency modeller to specify dependencies between items, and a content editor.

Our current research focus thus follows two core directions: (1) the continuous development and improvement of our authoring tools and processes toward an end-user friendly suite, and (2) the development of tailorable game templates, which allow users to select appropriate templates for their gaming scenario in mind to further simplify and speed up the game development process.

Together, obviously within the constraints of being small, mainly qualitative studies, the studies indicate that existing technologies and openly available tools can be used to build and apply serious games and *game alike* activities and therefore should be considered as an interesting alternative for the introduction of serious games.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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