Learning about Cultural Heritage by Playing Geogames

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Abstract. Context-aware and location-based information systems with conventional or AR visualization are a well-proven means for enhancing the experience of a tourist visiting a cultural heritage site. A less explored way for achieving immersion in the spatial environment is provided by location-based games which offer the additional advantage of being entertaining. In this paper we describe a subclass of location-based games, Geogames, which are characterized by a specific spatio-temporal structuring of the game events. We show that the spatio-temporal structuring permits to easily integrate educational content into the course of the game, making Geogames an ideal medium for edutainment. We report on our experiences with using the game GeoTicTacToe for teaching school children. Furthermore, we present a didactical workflow and four example didactical patterns that permit to exploit the edutainment potential of Geogames. The outcome of two empirical case studies indicates that enriching Geogames with educational content does not take the fun out of the game.

1 Introduction

Although the traditional CD-based audio guide is still in use in many museums and cultural heritage sites, progress in computing has opened up other and better ways to satisfy the information needs of the visitor, namely context-aware and location-based information systems (e.g. Cheverst et al. 2000). The visitor's experience can be further enhanced by perceptual immersion in an artificial environment. Virtual reality permits the user to experience a heritage site or object which is far away or does not exist any longer (e.g. Gaitatzes et al. 2001). Other research aims at designing augmented-reality guides for on-site exploration of cultural heritage such as the Archeoguide system installed as a prototype at the archeological site of Olympia, Greece (Vlahakis et al. 2002). Augmented-reality in this context not only enables a user to perceive the (virtually enhanced) cultural object itself, but at the same time allows to apprehend the embedding of the object in its environment, e.g. to feel the sun and the wind at the site of Olympia.

This total immersion into the environment is also one key success factor of location-based games, i.e. games played on mobile devices using localization technology. In contrast to traditional computer or console gaming, these games require players to move in a real world gaming area, thus implying the locomotion and the physical effort characteristic of any sportive activity. Location-based games may be supported by computation-intensive technology like augmented-reality (e.g. ARQuake, Thomas et al. 2000), but the vast majority of location-based games has requirements for computational resources that can be satisfied by personal digital assistants or even simple GPS handhelds (e.g. Geocaching). What makes those games entertaining is in the first place an interesting game concept that coordinates the actions of players in an intelligent and challenging way. A major reason for enjoying location-based games is their embedding in a real world setting: instead of staying at home and diving into a virtual world, these games get the players involved in exploring an urban environment.

In this paper we discuss the usage of a certain class of location-based games called Geogames in an edutainment context, namely for the learning about built heritage in an urban environment. Geogames are a potentially infinite class of games that arise from mapping classic board games to geographic space (Schlieder et al., 2006). As our running example we will use the GeoTicTacToe game played in the historic centre of Bamberg, a UNESCO world heritage site. We explain why certain properties inherent in every Geogame make this class of games an ideal medium for the presentation of cultural heritage. A didactical workflow and four didactical patterns for the mediation of knowledge about cultural heritage are described. A first case study conducted in cooperation with the Heritage Documentation Centre of the City of Bamberg studies the appeal of Geogames to school children. A second case study in the city of Coburg confirms the main finding: integrating educational content into a Geogame does not eliminate its entertaining aspect.

The rest of this paper is structured as follows: in section 2 we shortly summarize the Geogames framework and introduce the Geogame GeoTicTacToe. Section 3 explains how to use Geogames for the presentation of cultural heritage. A didactical workflow and didactical patterns are shown. Our preliminary case studies are described in section 4, while in the last section we discuss related work, with special emphasis on the field of mobile edutainment, and give an insight on future research issues.

2 Geogames

The Geogames framework describes a special class of location-based games, which are created with the metaphor of classic board games being mapped to the real world. Thus, board positions which were relevant on the original game board are now assigned a geographic coordinate (*locations*). For taking their turns, *players* are required to move between these locations and pick up, dispose or change *resources* which are distributed over the locations. Resources may be real objects or virtual resources only displayed on the mobile device which players carry with them. Although real world game boards may be of any size, for the rest of this paper we will assume city sized game boards. All players are moving concurrently, so that the turn-

taking restriction of the original board game is lifted making Geogames interesting from a game theoretical point of view. For a formal definition of Geogames see Schlieder et al. (2006).

A transition of classic board games into location-based games, named spatialization, provides a rich pool of challenging games, if one major problem is being solved: in the line of Nicklas et al. (2001) we detect that "lifting turn-based restrictions can make a game unfair". Consider a location-based variant of TicTacToe displayed in figure 1: like in the classic board game, two players, X and O, are trying to place three marks, X or O, in a row, a column or one of the two diagonals to win the game. Furthermore, we determine for the right hand side of figure 1 that player X moves faster than player O. Without turn-based restrictions this leads to a simple winning strategy for player X and lets the game deteriorate to a non-challenging race: Player X can simply run from location 1 over 4 to 7 without player O having any chance to hinder him from winning the game.

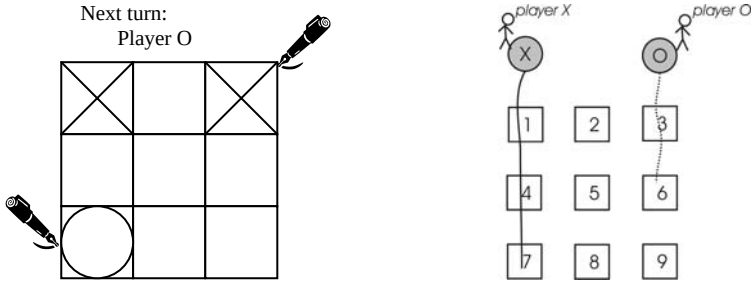


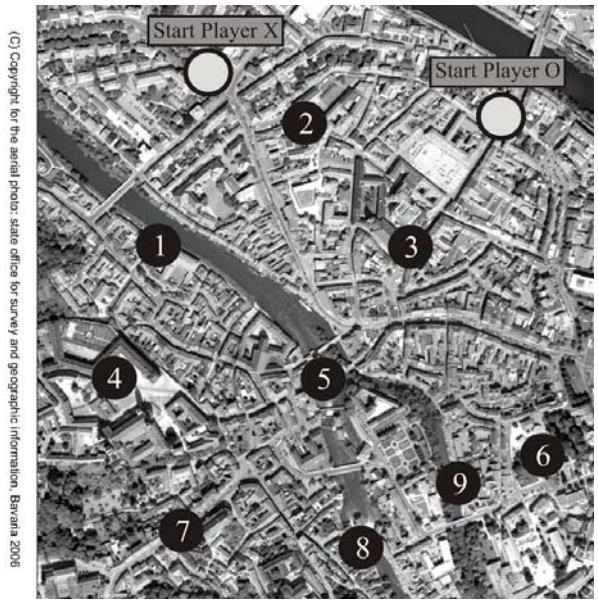
Fig. 1: Board game Tic Tac Toe (left) and the spatialized version GeoTicTacToe (right)

Designing fair and challenging Geogames is not a trivial task. A Geogame is considered *challenging*, if it equally demands the players' acting and reasoning skills to win the game. Consequently, neither a pure chase game nor a live version of chess would fulfil this definition. To balance a Geogame between a pure racing game and a pure strategy game, a surprisingly simple solution is proposed: a game designer must include a *synchronization time interval (syncTime)* in his rule set. Players now must wait at a location until the syncTime is over before they can move again. Depending on the length of the synchronisation time interval the game can be tuned between the two mentioned extremes. The syncTime parameter must be chosen individually for each Geogame to keep it challenging. With the Geogames tool (Kiefer and Matyas, 2005) a game designer can compute the syncTime parameter for every constellation of locations and speed differences of the players, making adjustments to new game boards an easy task.

The syncTime approach allows a game designer the free choice of geographic footprints, because locations on a real world city game board will probably never be arranged in a regular 3x3 square like that on the right hand side of figure 1. Road networks, hills, parks and other obstacles will make some coordinates impossible and additionally hinder players from moving in air-line distances. Figure 2 shows an example game board in the UNESCO world heritage city of Bamberg: the free choice of geographic footprints allows the game designer to assign the nine locations to cultural points of interest like the cathedral or the historic city hall. Even for a distorted game

board like this, the Geogames tool will compute an appropriate value for the syncTime parameter.

In the line with findings of Schwabe et al. (2005a), Geogames should preferably be played in teams of two or three players, resulting in a deeper gaming experience than being played alone, so "player X" in our examples may consist of three players moving together as a team. The possibility to play with virtual resources will prevent harm from sensible cultural heritage sites, like e.g. medieval buildings and other protected sites.



1	beautiful view ("little Venice")
2	statue of Botero (contemporary art)
3	church St. Martin
4	cathedral
5	historic city hall
6	statue and theatre of E.T.A. Hoffmann
7	church "Obere Pfarre"
8	millers' bridge
9	historic craftsmen buildings

Fig. 2: GeoTicTacToe game board in the UNESCO world heritage city of Bamberg

3 Presenting Cultural Heritage

The syncTime interval in Geogames does not necessarily have to be implemented directly as idle wait time, but can also be integrated indirectly through other game elements. Think, for example, of solving mini games before moving on or searching for elements hidden on the real-world game board, e.g. for an RFID to set a game field. Another solution we propose in this paper is the embedding of educational content into the syncTime interval. With the wait time being an integral part of the game rules of Geogames, fun, entertainment and the educational content seamlessly merge to create a true edutainment experience.

In the following we will subsume under the term educational content or learning any kind of knowledge mediation from simple fact learning, like in Meisenberger and Nischelwitzer (2004), to communicating background information on cultural heritage

sites, or even a deeper understanding of an epoch or architectural style. An important subtask in our case study was not only the presentation of cultural heritage, but also to communicate the idea of the UNESCO world heritage list (http://whc.unesco.org/en/list/). After the game, the participants should be able to answer questions like "What are the criteria for a site being nominated for the list? Which specific criteria were relevant for the city of Bamberg? How can we see these criteria in the building in front of us?"

The combination of the game conceptual perspective and the didactical perspective is illustrated in Fig. 3. On the one hand we find the game concept responsible for the entertainment aspect, on the other side a didactical concept covers the educational aspect. Although both define their own goals, they melt together when used in combination with a location-based game, e.g. a Geogame like GeoTicTacToe. The rules of the game should assure that a win can either be achieved by superior strategy or by superior knowledge to keep players motivated for learning. For instance, we decided for GeoTicTacToe that in the case of a draw situation the player with more correct answers will be the winner. In general, the overall winner should be determined as a combination of "winning by board game rules" and "winning by superior knowledge".

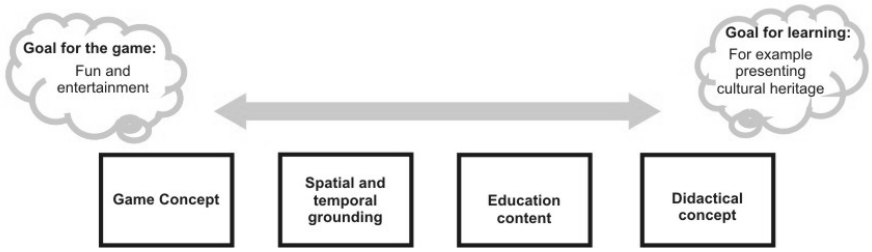


Fig. 3: Combining location-based games and education

Coming from the didactical perspective, educational content has to be developed and adjusted for mobile devices. In section 3.2 we describe some recommendable patterns that can be followed for the communication of cultural heritage, which can also be easily adjusted to different educational content. From the game conceptual perspective, Geogames imply two key features, making them especially useful for presenting cultural heritage sites and communicating the cultural heritage idea:

Spatial grounding: Players of a Geogame have to wait the syncTime interval at various discrete locations to set a virtual marker (X or O). We fill this wait time with educational content specific for the respective location, ranging from simple questions about facts (like on the edification of the cathedral of Bamberg) to transfer questions (like on the recognition of a baroque facade). This connects the knowledge to learn with a real world place the players actually visit, making the knowledge livelier and consequently more memorable. In section 1 we called this effect "immersion into the environment" when describing the augmented reality system Archeoguide. In our case of Bamberg a player could for instance physically experience the distance be-

tween a medieval bishop with the cathedral and a palace on the hill, and the normal craftsmen who were working down at the river. The spatial grounding is particularly effective if players have to gather information actively at the location, e.g. by asking the man at the cash desk of a museum or reading an information panel on a medieval building.

Temporal grounding: Closely connected to the spatial grounding of the educational content, players do also acquire and learn the location specific knowledge at the same time they are resided at that location on the real world game board. This means that getting and experiencing the knowledge are not separated in time, but happen simultaneously.

The spatial and temporal grounding include the configuration of the real world game board to locations of interest for the game, in our example cultural heritage sites (see Fig. 2). The same is the case with the educational content, which has to be adjusted to the overall context the game is taking place and the locations chosen for the real world game board. Because the used didactical concept is crucial for any kind of knowledge mediation we further divided this process in three sub phases.

3.1 Didactical workflow

To achieve a maximum learning effect on the side of the participants, we use three phases for knowledge mediation (see Fig. 4).

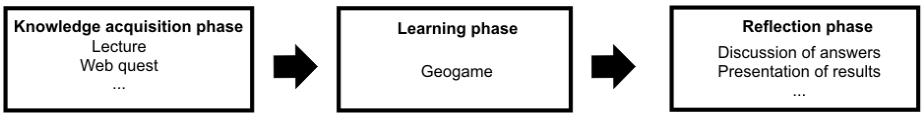


Fig. 4: Phases of the didactical workflow

Before the actual start of the game (knowledge acquisition phase), the participants are offered the possibility to gather the knowledge he or she will need in the second phase (learning phase). In our current setting we work in close collaboration with teachers, cultural scientists and monument conservators, who prefer knowledge transfer over traditional lectures. Other possibilities for this phase include self learning techniques like (guided) web quests, learning videos or self-playing PowerPoint presentations. The positive aspect of a lecture is that the lecturer can easily adapt the style of the presentation depending on the reactions of the actual audience during the lecture, like in our case a group of high school pupils who live in Bamberg and already know the city. On the other hand this is no practicable solution for a general tourist context, where a considerable amount of visitors should be able to play the game spontaneously. In this case we propose the Geogame to be played after one of those guided city tours frequently attended by tourists. A quicker and more game play oriented solution would be to integrate all the background information into the intro of the game, like playing a short video clip on the mobile device.

In the second phase the participants play the Geogame. Figure 5 illustrates the game flow in principle: players begin the game at predefined starting locations at the same time (see Fig. 2) and are then free to move to an arbitrary location on the game board. When arriving at a location, the mobile device displays the associated educational content, in this case a simple multiple choice question. Players have time at least the duration of syncTime to figure out the answer – either by pure knowledge from the first phase, or by gathering the information on site (or by a combination of both). After answering the question and when syncTime has passed, the players are free to move on to the next location.

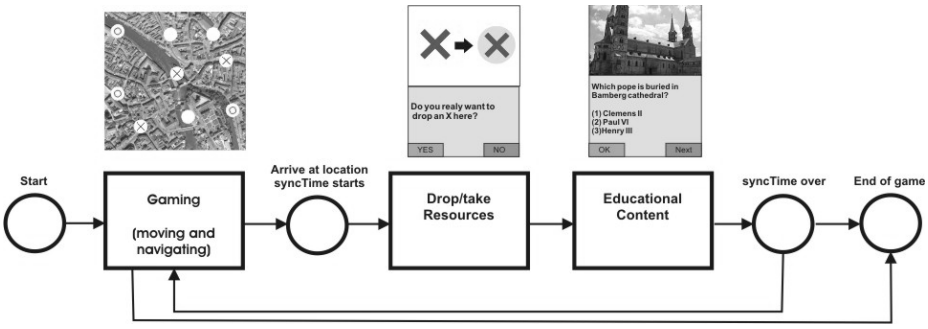


Fig. 5: Game flow of a Geogame

Because of the game rules of Tic Tac Toe, a player can arrive at a maximum of six different locations in the course of one GeoTicTacToe game. This is the case when one team wins at the last free location of the game board and the other team only managed to go to three location in that time. More common is the case that the game ends in a draw, leading to an arrived location share of five to four. Additionally, a player cannot visit a location, if the other player has already set an X or O there. This leads to a situation in which not all questions were presented to both players in the second phase. To provide all knowledge equally to all players, they meet after the game in a reflection phase where they have the possibility to discuss and present the answers and experiences with the other players, thus learning new knowledge about places they have not been to. In a tourist context it would certainly be quite unsatisfactory not having had the possibility to visit all important sights, but a Geogame could in this case be played as an add-on after a guided city tour.

3.2 Didactical patterns for knowledge mediation

As we have seen so far, Geogames provide a unique way for communicating world heritage and deepen the learning situation for the information corresponding to it. To fully use the potential of this new knowledge mediation form we discovered four didactical patterns, which we use for instance in our Geogame GeoTicTacToe. Although there are surely more patterns possible, we found that particularly these four support the spatial and temporal grounding of Geogames.

Fact pattern: The simplest pattern is posing questions on hard facts, like "Which pope is buried in Bamberg cathedral?" or "Which of the following religious orders had a settlement in Bamberg?" This kind of knowledge is most appropriate to be presented in form of multiple choice questions (Fig. 6). In addition it is also a good method to encourage the players to get in contact with local people and ask for the correct answers.

Geographic coherence pattern: This pattern fosters a better understanding and experiencing of (cultural) geographic coherences. Figure 6 shows an example of this pattern. Here the centre of Bamberg is separated in three main parts, the Theuerstadt, the island town and the episcopal town. A player who is standing up the hill in episcopal town with a good view on the whole city can be asked to identify the other parts by looking around the scenery. Just using a simple fact pattern on this subject would surely not create such an experience.

Fig. 6: Four didactical patterns for communicating cultural heritage

Present-Past pattern: With the multimedia possibilities of a mobile device, knowledge about past conditions can be illustrated visually at significant locations on the game board (Fig. 6). A player could for instance be displayed a photo of a district taken during the Second World War and be asked to describe the differences to nowadays' situation.

Pattern recognition pattern: The knowledge acquisition phase preceding the actual game also allows posing transfer questions and more enhanced learning tasks in the game. For example "use the digital camera of your phone to take pictures of all baroque-specific style elements of the church in front of you!" (Fig. 6).

4. Fun and Learning with Geogames: Two Case Studies

The two empirical case studies we conducted up to now had the goal to evaluate how the integration of the educational aspect would have an impact on the fun factor of the Geogame GeoTicTacToe. There were in total three games, one at the 22nd of February 2006 in cooperation with the Documentation Centre World Heritage of the city of Bamberg to communicate the idea of the UNESCO world heritage list. Two further games were organized for a Girls' Day on the 1st of March 2006 at the University of Applied Science in Coburg.

At both occasions the identical version of the game was used – identical except for the educational content.

4.1 UNESCO world heritage game in Bamberg

In this first case study the participants were school children from a local school in Bamberg. A total number of six children were competing in two teams, one team of three girls and one team of three boys. All of them were between 15 and 16 years old. The game was captured on video and a questionnaire was handed out in the discussion phase which could be taken home and sent back for the evaluation.

Table 1. Items and answers of the first case study concerning the fun aspect

Question	Answer
How did you like the game play in general? State your personal experience:	It was very interesting and fun.
	It was a lot of fun, because the game did not only take place on paper but in the whole city.
	It was interesting and fun. Indirectly also a confirmation of my athletic abilities. But winter is not a good time for this game: cold fingers.
	Interesting, versatile, diversified. Physically demanding. Simple game brought in an exciting context.
	Good.
Do you want to play Geogames once more in the future?	Yes (four times)
	Yes, if there were more "scenarios" (game boards). Playing with always the same game board would get boring in the end

One questionnaire was not returned. The questionnaire was constructed with open questions. Because of this and the preliminary nature of this case study, Table 1 shows only the items most relevant for the evaluation of the fun factor of the game and summarizes the given answers.

4.2 Teaching Girls about GPS

In our second case study, a total of 11 girls of the age from 10 to 14 attended. We split them into two groups, so that a maximum of three girls were in one team in a game. This left us with a distribution of six girls in the first run and five in the second. Because this time the educational context was GPS functionality, unfortunately we did not have a spatial and temporal grounding of the questions, so that the educational aspect was only evaluated with subjective questions. Besides for open questions, we used a five point Likert scale in this questionnaire. Possible answers ranged from 1 = totally decline to 5 = totally agree. The questionnaire was presented to the participants after the discussion phase. Table 2 shows the ratings as well as additional relevant items and answers of the questionnaire. Again video material was captured.

Table 2. Rating of the fun aspect of GeoTicTacToe

	M	SD
The game was much fun.	4.4	0.6
Today I have learned something interesting about GPS	4.2	0.7
GeoTicTacToe has deepened my knowledge about GPS	4.5	0.7

Questions	Answers
Would you want to play GeoTicTacToe once more in the future?	Yes (11 times)
What is more fun for you:	
1.) *Normal computer games*	4 times
2.) *I do not know; I have not played computer games*	3 times
3.) *A location-based game like GeoTic-TacToe*	4 times (3 times selected in combination with another option)

4.3 Discussion of the results

Our collected data in combination with the captured video material clearly indicates the fun potential of Geogames in the edutainment context. Aside from complaining about the weather conditions (case study 1) all given answers were positive. The pupils of case study 1 also mentioned correctly that the physical abilities are one major feature of GeoTicTacToe, as being fast is necessary to win a Geogame. Here the video material shows some nice examples of a race situation between the two rivalling teams. This is also the case for the strategic elements in Geogames: lively discussions about the next move can be observed between the team members. There were also discussions on the correct answers for the questions. This strengthens results mentioned in Schwabe et al. (2005) that playing a location-based game in teams contributes to the immersion into the game.

Taking the ratings of case study 2 into account, our proposed edutainment workflow is in the first place fun to play and we also got no negative feedback about the integration of the educational content in GeoTicTacToe. The participants in all case studies suggested that they want to replay the game or similar Geogames, further fortifying the thesis that integrating educational content in Geogames does not reduce the fun factor of these games. One participant of case study 2 even made the suggestions that "*this will be surely the next killer-application for tourists*".

Although the positive answers about the learning effect indicate the worth of our presented didactical workflow, there is clearly more sophisticated research necessary to strengthen this thesis. Such an evaluation would have to compare the learning effects of our Geogame approach with that of traditional forms of knowledge mediation. In our specific case, a control group comparable to the gaming group would need to be taught the same educational content with a classic guided tourist tour or a school lecture. Some weeks after the experiment, one group who has played the game

and the control group would be tested about the educational content to evaluate the long-term learning effect. Up to now, our test groups did not have enough participants for such an experiment. Comparable experiments on mobile and location-based learning (e.g. Schwabe and Göth, 2005b) had the same problems in gathering an appropriate amount of participants for the evaluation.

5. Related Work and Future Research

Using our proposed didactical concept in combination with a Geogame like GeoTicTacToe can greatly enhance the presentation of cultural heritage. Furthermore, we presented four didactical patterns which let the players experience the various aspects of cultural heritage sites from different perspectives.

We also confirmed the findings of Facer et al. (2004) that learning with a location-based game adds more fun to the learning experience. In contrast to our approach, in Savannah players are part of a simulation: they are role-playing youngster lions in the savannah, rather than playing a real competitive game like GeoTicTacToe. The necessity of speed in GeoTicTacToe to be competitive with the adversary adds extra fun, especially for young people, while at the same time the syncTime assures enough time for experiencing and learning. Another issue about Savannah is portability: a Geogame like GeoTicTacToe very easily fits to almost every learning situation, while it would take much more effort to change the Savannah simulation to e.g. a "GPS simulation game". However, it is possible to create location-based games with role-playing elements which are also an instance of the Geogames class (with resources, players and locations); think of a game in a medieval city where each team incorporates one medieval population group (knights, priests, craftsmen, farmers), and changes gold pieces, goods or weapons to occupy strategically or economically important locations.

Schwabe and Göth (2005b) apply their MobileGame in the orientation days for new students at the University of Zurich. The MobileGame is a simple catch game where three groups hunt each other and simultaneously try to solve different tasks, like finding specific buildings or meeting a certain person. This game is not embedded in a whole didactical concept like Savannah or Geogames. The reported learning gains (also in Schwabe et al., 2005a) with this kind of edutainment game are therefore only minor ones.

Mobile learning, like the mobile learning engine from Meisenberger and Nischelwitzer (2004), allows users to carry their multimedia learning content with them wherever they go. However, they lack the spatial and temporal grounding of Geogames as well as the whole entertainment aspect.

Plenty of literature on computer game-based learning exists, for example Prensky (2001), which fortify the positive aspects of merging the motivational effects of playing games with the intellectual demanding aspects of learning. As in the case of pure mobile learning, stationary computer games do not inherit spatial and temporal grounding of the educational content.

Our future research includes a more sophisticated evaluation of the educational part of our proposed didactical workflow in combination with additional games in the

following months. Furthermore, we want to transfer the whole concept to other contexts than cultural heritage, which allow a spatial and temporal grounding of the educational content. In these new fields of application more didactical patterns should surely be provided. Another question would be if the proposed edutainment application and workflow generates long-term learning effects.

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