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Evaluation of "The Seafarers": A serious game on seaborne trade in the Mediterranean sea during the Classical period

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ABSTRACT

Throughout the history of the Mediterranean region, seafaring and trading played a significant role in the interaction between the cultures and people in the area. In order to engage the general public in learning about maritime cultural heritage we have designed and developed a serious game incorporating geospatially analyzed data from open GIS archaeological maritime sources, and archaeological data resulting from shipwreck excavations. We present a second prototype of the seafaring serious game, and discuss the results of an evaluation which involved a large multi-site user study with participants from three continents.

More specifically, we present the evaluation of "The Seafarers" a strategy-based game which integrates knowledge from multiple disciplines in order to educate the user through playing. A first prototype was reported in Philbin-Briscoe et al. (2017) where an expert-user evaluation of the usability and the effectiveness of the game in terms of the learning objectives was performed.

In this paper, we present how the outcomes of the evaluation of the first prototype "The Seafarers – 1" by expert-users were used in the redesign and development of the game mechanics for the second prototype "The Seafarers-2". We then present our methodology for evaluating the game with respect to the game objective of engagement in learning about maritime cultural heritage, seafaring and trading in particular. Specifically, the evaluation was to test the hypothesis that *game playing allows for more engaged learning thus improving longer-term knowledge retention*. The evaluation was conducted in two phases and includes a pilot study, followed by a multi-site, multi-continent user-study involving a large number of participants. We analyze the results of the user evaluation and discuss the outcomes.

This work is part of the EU-funded project iMareCulture and involves truly multi-continental, multi-institutional and multi-disciplinary cooperation – civil engineers and archaeologists from Cyprus, Human Computer Interaction (HCI) experts and Educationists from Bosnia and Herzegovina, Canada, and cultural sociologists and computer scientists from Canada.

1. Introduction

Underwater Cultural Heritage assets are widespread across the Mediterranean. Unlike land archaeological sites, however, submerged settlements, ancient ports and other coastal industrial installations, especially shipwrecks, are not accessible to the general public nor even to all experts, due to the hazardous environment and depth. Maritime museums exhibit photos and surfaced artifacts which provide the visitors with fragmented aspects of such sites and a partial glimpse as to how seafaring and trading was taking place between cultures and people in the Mediterranean. Some museums employ immersive and interactive technology to enhance the experience of the visitors *during*

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these visits. In particular, Virtual Reality (VR) has been used within this context and many successful applications have already been reported.

At the same time, not much attention has been given to providing pre- and after- digital experiences which can certainly complement and even enhance the experience of a visitor [wider public] during the museum visit. Through personalized experiences before and after the museum visit, which can be provided through appropriate digital technologies, the public can learn more about the artifacts exhibited in the museum and gain a more holistic view and better insight into seafaring and trading practices at the time. More specifically, using pre- and after- digital experiences provided through the medium of extensive storytelling about commerce, harbors, ship engineering, sailing, etc., the public can be made aware of the ships, ship routes and commerce on the Mediterranean during a past era. "The Seafarers" is one such digital technology in the form of a serious game that can be played with the objective of gaining this type of information, obtaining pre- and/or after- experience and thus complementing a museum visit or visits.

The content in this seafaring game is therefore completely authentic, and is based on geospatially analyzed data coming from the open GIS archaeological maritime data. Through the development of this serious game and other applications (as part of the larger iMareCulture project), this digital content contributes to the social understanding of the EU identities and cultural exchange. A first prototype "The Seafarers-1" of this game was reported in Philbin-Briscoe et al. (2017). "The Seafarers-1" has been evaluated by expert users consisting of maritime archaeologists, cultural sociologists, human-computer interaction specialists, civil engineers and computer scientists and included an evaluation of both the usability of the game and the effectiveness of the game in terms of the learning objectives which are to make the player knowledgeable about nautical/maritime practices during the Classical period and to learn about the sea routes, ship types, and commerce in the Mediterranean during that era.

The expert-user reviews reported in Philbin-Briscoe et al. (2017) were mostly positive though a number of limitations were also identified. In this paper we first present the design and development of the second, revised prototype which has been based on the experts' evaluation of the earlier version. In particular, "The Seafarers-2" has been completely redesigned and redeveloped to incorporate new game mechanics in order to take into account these comments from experts. We then describe the evaluation methodology and the results of a non-trivial user-study involving largely young participants from across three continents and spanning multiple disciplines.

Our major contributions in this work are:

- the design, development and evaluation of a serious game whose game mechanics are driven by a prior expert evaluation, whose purpose is the dissemination of maritime cultural heritage which otherwise would not be possible, and which facilitates learning about seaborne trade practices during the Classical period and to learn about the sea routes, ship types, and commerce in the Mediterranean during that period through its gameplay,
- authentic game content defined using archaeological data about seafaring and trading during the Classical period, and carefully tailored narratives which enforce the learning objectives,
- developing and integrating a new software tool for realistic weather/wind patterns based on geospatially analyzed data coming from open GIS maritime data,
- devising and conducting an elaborate and non-trivial evaluation experiment involving human participants from a wide range of disciplines and spanning across three continents.

The rest of this paper is organized as follows: Section 2 gives a brief overview of serious games of history and related work in using actual game design practice to inform the design process of serious games rather than instructional software or entertainment. Section 3 provides an overview of the many aspects involved in the design, development, and evaluation of the game. In Section 4 we present the archaeological data which is incorporated throughout the game, in Section 5 the narratives which enforce the predefined learning objectives, and in Section 6 details of the new tool which provides emulated real-time weather patterns and travel route risks based on the spatial analysis from open GIS maritime data, and ocean and weather data. In Section 7 we present the design and implementation of "The Seafarers-2" and identify the differences with its predecessor. Section 8 presents the evaluation and analysis of the results. Finally, Section 9 is the conclusion and future work.

2. Related work

The reported work has developed in the context of increasing interest in the field of serious games and games for learning that has been informed by advances in the social science of digital games and game studies and approaches in game design (Gee, 2003; Juul, 2001; Michael and Chen, 2005; Squire, 2006). The project encompasses three modalities for serious games about history. The first is the modality of playing with history, the second is playing with historiography and the third is accessibility and cultural heritage.

We are now well past the age of didactic instructional software design and instead look to techniques and insights drawn from contemporary game cultures and commercial game design to help create more robust learning experiences as part of a commonly recognizable medium (Gros, 2007; Djaouti et al., 2011). Following Gee (2003) we look to game design as a means of affording players' interrogation of the play environment to achieve specific game related goals like ship navigation between islands, making money through trade goods, etc. Learning in this context involves the active use of design elements to solve these problems and the design elements are composed from historical information. Thus, the cognitive resources players use are the historical data that compose the play environment and it is in this way that we can say that users are playing history (Rejack, 2007; McCall, 2013).

To date there has been little game design and serious games research on historical contexts of antiquity (Christesen and Machado, 2010). In addition to adapting what is already known about historical games and simulations, it is intriguing to consider "The Seafarers" as an experiment in living history or the ongoing work of making history (Kee et al., 2009; Clyde et al., 2012; Winnerling, 2014). That is, while the game works to convey historical information as resources for gameplay, it also works to present the historiography of antiquity as an ongoing, relevant and exciting field. A good example of this is the use of historical geospatial data to create seafaring route maps that bring to light the complex work of composing and interpreting such data in the first place.

"The Seafarers" is also meant to support ongoing efforts to preserve cultural heritage (Anderson et al., 2010) and in this sense is designed to appeal to broad audiences with relatively simple gameplay mechanics. The role of games in this context is less about teaching history than it is about inviting audiences to play with historical data which references heritage material that can be found in museums, visual and textual media and other heritage sites. It is interesting to compare "The Seafarers" project to a role playing game on a similar topic like Mercator (Elliot, 2009) in this sense. This pen and paper role playing game has many of the historical elements that make up the gameplay in

"The Seafarers" but by embedding the game in the context of cultural heritage (an extension of museum programming for instance) notions of awareness and referentiality are highlighted over historical accuracy.

In these ways, "The Seafarers", becomes a useful contribution to scholarship on serious historical games and player experiences with the game can be examined in ways that far exceed measures of didactic learning of historical facts (Spring, 2015).

2.1. On the evaluation of games

Numerous studies have shown that learning objects, such as computer games, which involve problem solving situations are more conducive to learning than traditional methods (e.g. Sweller, 1988; Rummel and Spada, 2005; Pearson, 2006). The results of these types of studies suggest that such learning objects reduce working memory cognitive load (i.e. the part of short-term memory that is concerned with immediate processing) and therefore facilitate the learning process. Similar to other educational and serious computer games, "The Seafarers" allows the player to develop strategies and achieve predetermined goals (i.e. gaining wealth) thus potentially facilitating the learning process.

According to Prensky (2003), a key to determining the value of computer games lies in looking at their design. The design of educational computer games should not only include rules and goals, but most importantly the games should be engaging and fun to play (Hong et al., 2009). The Seafarers was developed with these goals in mind. Even as a serious game with its principal objective of learning, we set a win condition for the player – maximizing wealth through trading. In order to do so they act as a merchant ship captain during the Classical period, choose, control and navigate the ships through the Mediterranean seas, implicitly get to know the location of ports/islands of that period, the commodities and their costs, and also learn rules about sailing, trade, etc.

There are numerous evaluations that have looked at the impact of educational games on learning, and the results have been mixed. Kim and Chang (2010) studied the impact of a Math game on 4th graders and found that the English-speaking students who played the computer math games daily in school displayed significantly lower math achievement than those who never played. At the same time they found that male students who's first language was not English and who played the math game daily had higher math scores compared to male English-speaking players who never played. Rondon et al. (2013) looked at short and long-term retention of medical students learning anatomy and physiology. The results of their studies showed that students that were exposed to the computer game-based learning method performed better on the anatomy questions in the post-test (immediately after class). Whereas students that attended traditional lectures, performed better in both post-test and long-term post-test (6 months later) when considering both Anatomy and Physiology questions. A study with Civil Engineering students found that students that participate in traditional learning methods and those that participate in game-based learning had similar learning results, however those that played games had higher motivation (Ebner and Holzinger, 2007). In terms of using game-based learning as an additional resource to traditional methods, Kanthan and Senger (2011) showed that Medical undergraduate students who used game-based learning not only improved their exam scores, but also were more engaged and had higher satisfaction.

The literature thus suggests, that game play does not necessarily improve learning, however, may make knowledge learning more fun and when used as an additional tool to traditional methods can aid in learning and knowledge retention.

3. Overview of game system and evaluation

Fig. 1 provides an overview of the components of the game and their relation. As can be seen from this figure, archaeological knowledge resulting from the underwater excavations of shipwrecks conducted by the archaeologists in our team and the subsequent analysis of the extracted artifacts forms the main source of information in the game and is described in Section 4. This knowledge is further infused by the gathered GIS data for that region which includes the weather [and more specifically the wind] patterns as well as risk maps indicating areas of high-risk such as shallow waters, or the existence of reefs. The game then serves as a learning instrument in which ship navigation, port discovery and trading are the principal game mechanics, and storytelling and narratives are used as the primary medium to communicate this knowledge to the player. Next, the evaluation of the game involves a user-study to assess whether game playing allows for more engaged learning thus improving short and long term retention of the knowledge presented through the game playing mode as compared to the more traditional mode of reading.

4. Archaeological data

Navigation and shipbuilding techniques have always been the main variables that determine seafaring activities, in the sense that such technologies can either pose restrictions or open up the road for unprecedented endeavors. For example the gradual predominance of the mortise-and-tenon joinery system during the Classical Period, led to ships with a sturdier assemblage, which could carry heavier or more voluminous cargoes. This progress contributed decisively to the enhancement of international trade during the Classical and Hellenistic periods (Pomey, 2011). Similarly, one could argue that the development of international trade created new societal needs and administrative systems, which fostered new technological advancements. This dialectic interaction was the main reason behind the choice of navigation and shipbuilding techniques as the two main pillars of research regarding the archaeological context of the narratives and the scenarios in "The Seafarers" game.

4.1. Navigation techniques

The navigational hazards and how they were dealt with, was the first aspect of seafaring knowledge that had to be communicated. Data were collected from texts regarding common navigational hazards, such as sailing close to capes or reefs, and historically documented realities, such as piracy. Archaeological evidence for shipwrecks was stored in a database, aiming to correlate their locations with weather conditions known from current meteorological data.

The question of the sailing season was examined through the prism of ancient sources and their contemporary scholarly interpretation. According to Demosthenes, the seas, at least in the Aegean, were "open" from late May until September (Homer's Odyssey - Demosthenes 56 - Against Dionysodorus 56.30), but this did not mean that navigation ceased for the rest of the year. Winter sailing activities were reduced but still occurring on the Levantine and North African coasts (Tammuz, 2005). Demosthenes (56.30) also explained how the route from Rhodes to Egypt was possible all year round and although this was a common practice at least since the Homeric times (Hom. Od. 5.270-7)(Morton, 2001; Arnaud, 2014; Davis, 2002, 2009; Mcgrail, 1996), it was probably avoided during the winter months (Morton, 2001) or for sailing close to the shore (Ward (2007); similarly navigation during the night was also avoided.

A very common research question regarding ancient seafaring is whether coastal sailing was the norm in antiquity or open-sea crossings

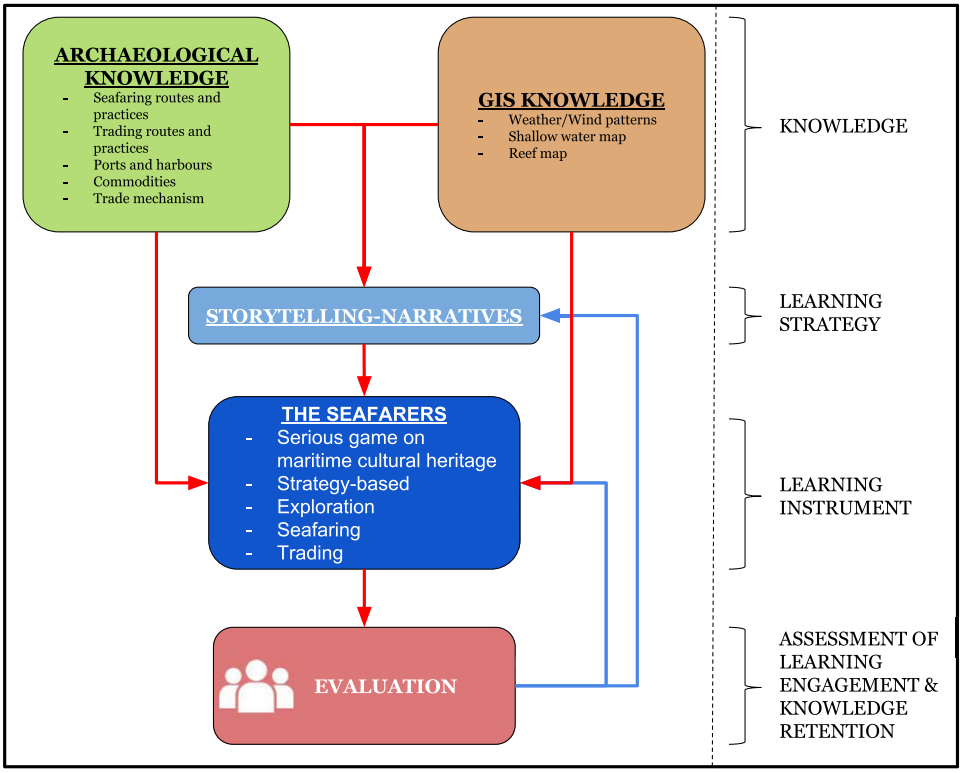


Fig. 1. Overview of the game system and evaluation.

were also possible. This binary distinction has been disregarded by modern scholarship and the prevailing theory suggests that it is more likely that ancient mariners were using a combination of the two techniques even during the same voyage (Ward, 2007; Morton, 2001). Nonetheless, the question regarding the association of each navigational approach with a respective trading pattern remains open; tramping is often associated with coastal navigation, whereas sail courses of state or directional trade ventures most probably included open sea crossings (Arnaud, 2011). In this respect, trade associations and mechanisms, as well as the agents engaged in them largely compose the cultural context of seafaring in antiquity. Such mechanisms included maritime laws, taxation systems as well as the exchange/coinage systems in different areas.

In "The Seafarers-2", the above aspects related to navigation during those periods have been included in the game in different ways, providing narratives and suitable hints from NPCs (Non Player Character) at appropriate times, weather determined travel time, varying risks depending on ship paths chosen, etc.

4.2. Trading mechanisms

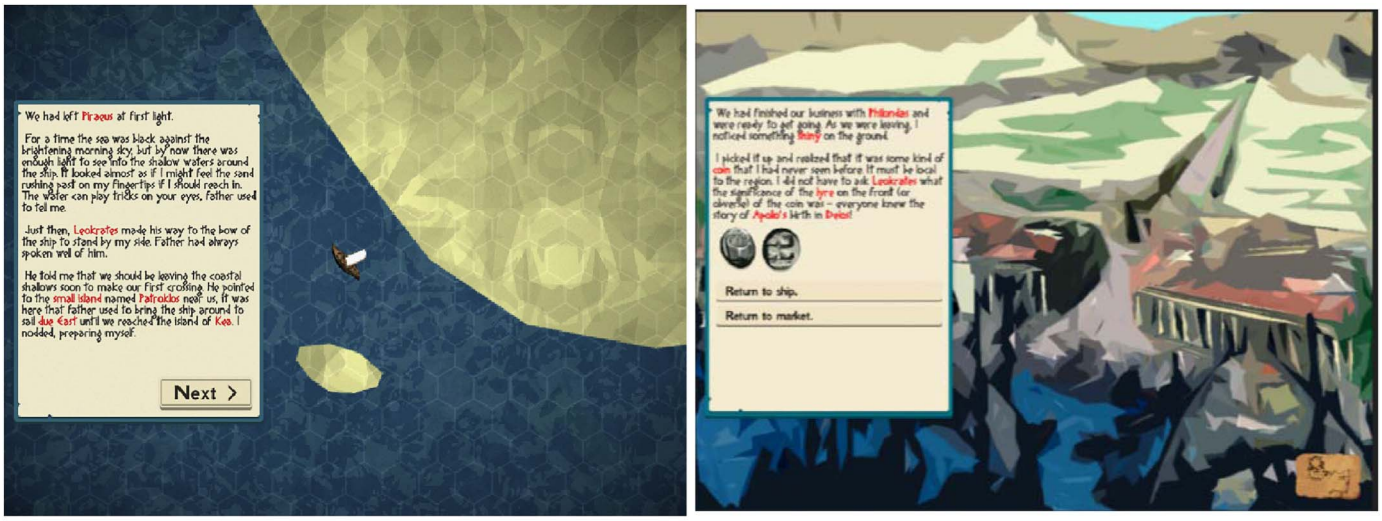
Keeping in mind that "The Seafarers" aims to be educational and to provide a view to the respective seafaring conditions, with a degree of historical accuracy, we chose to focus on long distance trade, not only because it was a predominant pattern of the Classical period, but also because it is far better documented than other exchange patterns. This choice is translated into a selection of ports and harbors with attested significance and with archaeologically documented associations with exported and imported commodities. Especially, since wealth accumulation is chosen as the main goal (win condition) for the player, the provision of such data seemed to be intrinsic for the purposes of the game. While winning the game is a secondary objective with engagement in learning about seafaring practices of that era being the primary one, the winning goal does contribute to replayability and hence more learning.

"The Seafarers - 2" incorporates the above aspects through narratives and appropriate gameplay.

5. Pedagogical aspects – narratives

The main pedagogical aspect of the "The Seafarers" is to educate the players about seaborne trading in the Mediterranean sea during the Classical period of history while playing the game. The learning strategy which enables us to achieve this goal is storytelling and narratives as shown in Fig. 1.

As stated in Lim et al. (2014), "from an educational perspective, narratives are a semiotic conduit for evoking critical thinking skills and promoting knowledge discovery/acquisition". Learning through play in serious games was emphasized in McDaniel et al. (2010) as: "The goal of serious games is to create a virtual environment in which this pathway is reversed; by encountering and solving problems in the game world, the player learns skills and builds knowledge useful for problem solving in the real world." Nowadays the traditional learning methods are often substituted with game-based learning, proclaimed as "a new paradigm of learning emerging in education, in relation to key critical concepts that centre around gamification, immersion, interface and social interactivity." Freitas and Fotis (2011). The potential of game-based learning has also been presented in Dickey (2006) and Peirce et al. (2008) elaborating the narrative game design and emphasizing the importance of personalized interactive learning experiences. The narrative in a game has a strong impact on immersion, giving the player incentive to continue playing (Qin et al., 2009). Narrative models available to game designers are also described in Reeve (2009). In "The Seafarers" the narratives fall into category of emergent narratives, as the story progression is



(a) (b)

Fig. 2. Example narratives in the game. (a) An example of a narrative used to assist the player in navigating the Aegean. (b) An example of a narrative used to provide information about the coinage at a specific harbour.

dependent on the player's interactions in the game, providing unique narrative experiences for each player (Aylett, 1999; Jenkins, 2004; Salen and Zimmerman, 2004).

"The Seafarers" gameplay is designed to make the player decide on his/her navigation using hints from narratives. It makes them a crucial part of the game. At the beginning of the game the player is informed that his father has died and he is now taking over as a ship captain. Through the narratives, displayed over the screen as short texts, as shown in Fig. 2(a), a NPC is advising the player in the art of seafaring, providing hints on where to navigate in order to arrive at a harbour. The game is designed in a way that instructions from narratives are the main drive for players towards their goal. If the player follows the hints in the narratives then he/she will arrive at a harbour where the transported goods can be traded. According to the background historical information, there are harbors which specialize in certain commodities e.g. Chios for wine, Cyprus for copper, etc. Additionally, the price for commodities varies from harbour to harbour. The player is required to consider all these parameters before deciding whether they should trade and what commodities they should trade.

Narratives are also used to inform the player of specific historical information relating to the harbour they are currently visiting. Fig. 2(b) shows an example of a narrative presented to the player while the player is trading goods on a harbour. In this narrative, the player notices something shiny on the ground and picks it up. Upon closer inspection the character realizes that this is a coin specific to the harbour. Information relating to the coinage such as the images of the obverse and reverse of the coin are displayed.

After the trading concludes the player is offered to resupply the food and water reserves on the ship. Next, the sailing continues and the player is being prompted with new narratives to assist him/her in finding their way to another harbour. If the navigation hints are not understood or not properly followed, the game can end with the player running out of supplies. Other possibilities for ending the game are mutiny among the crew or running aground and having to abandon the ship only to die of thirst on a desert island.

Players who grasp and follow the hints in the narratives should be able to safely navigate to available harbors and trade goods in order to maximize their wealth by trading. The narratives offer useful information about sailing, as well as knowledge on seafaring practices and trade skills in Classical period. They also contain gameplay control elements and often offer a choice between several options. Depending on the player's selection the gameplay is branched to a certain direction i.e. branching narratives as described in Lindley (2005).

Implementation of narratives for game-based learning in the "The Seafarers-2" confirms the potential of new learning paradigms. However, the most significant measure of success are the results of the evaluation which will be presented in Section 8.

6. Embedding route risks based on archaeological and geospatial data

One of the objectives of the game is to provide realistic scenarios of routes/trips by ships as they navigated in the seas for trading purposes. Accordingly, the time taken along a chosen route and the risks associated had to be encoded with as much authenticity as possible. Suitable data and tools have been incorporated into the game for this purpose. Data and tools were needed to be able to calculate ship routes through the Eastern Mediterranean Sea using realistic scenarios and assumptions. Within the context of this work (iMareCulture), several computational approaches were tested to provide least-cost (fastest) maritime travel routes, accounting for dynamic and realistic weather conditions. The final algorithm implemented by the embedded software tool uses time-varying, input weather conditions, arbitrary origin and destination points, and returns the number of traveling days between the two points, along with the respective route. Moreover, given only the origin point, a slightly modified algorithm returns a surface describing how far the ship may travel from the starting point in 1-2-3-4 (etc.) days. The results may also be visualized using isochrone curves. Origin and destination points are connected via the "fastest" route, meaning that the algorithm is a minimization tool. Stopovers for provisions are not considered by the present implementation of the algorithms, although the user could use the algorithm to manually plan such stops within a route.

Prior to the implementation of these methods, several approaches in the relevant literature (Leidwanger, 2013; Schäfer, 2016; Scheidel, 2015) have been reviewed. Existing approaches, however, often employ

assumptions that are far from being objective and may change according to several factors. In general, all approaches make use of generalized weather conditions, but in real world, weather conditions may change dramatically within a period of several hours; thus, this is very important in the time-scale of a cross-Mediterranean sea travel in the ancient world, which could take up to several days. Therefore realistic weather conditions were employed from real (present-day) data provided for the Mediterranean Sea with time-varying weather conditions, such as wind speed and the sea currents. Data were downloaded from OpenSkiron (), offering forecasts for the Mediterranean Sea with a spatial resolution of 12 km and a temporal resolution of 3 h. Currently, our database includes data covering a period of 5 months (April to October); data collection continues until we reach an entire year.

Regarding the traveling cost, i.e., the time required to travel from one grid cell to its adjacent cell, we have implemented two approaches: the first one, described in Leidwanger (2013), employs a linear relationship between travel speed and wind speed, for different wind angles, given in a discrete space, i.e., one linear relationship for 3 discrete ranges of wind angle (<30°, < 60° and all other angles). The other one, described in Schäfer (2016), employs a more realistic sailing diagram which is represented in the form of two polar plots, connecting both wind speeds and wind angles with the final sailing speed, as percentage of wind speed.

In a GIS context, the estimation of the fastest (optimal) route is a minimization problem. Given the weather data and a function to calculate travel cost between two adjacent grid points, an algorithm has been developed which takes as input weather conditions, origin and destination point, and returns the respective number of traveling days (in the fastest possible way), as well as the actual route traversed. The particular algorithm is a branch and bound algorithm which treats the weather grid as a graph (Shekhar and Xiong, 2007). Each grid cell is a graph node which is connected with its 8 adjacent cells forming 8 graph edges. The inter-connections between cells are also dictated by the obstacles set by land masses that are found in the sea, i.e. islands. The novelty of our problem and the respective approach towards its solution is that each edge has time-dependent cost with respect to the weather conditions that the traveler will encounter when visiting this node (Demiryurek et al., 2010).

Having dealt with the weather grid as a time-changing graph, we may employ several well-known path finding approaches for traveling graphs, such as the Dijkstra and the A* algorithm (Shekhar and Xiong, 2007). In particular, both algorithms have been employed so as to find the fastest (with the least cost) path between an origin and a destination, and also, the fastest path to all destinations within the grid for a given origin, thus forming a “surface” where each point is associated with the time needed to minimize travel/time cost from the given origin point to every other grid point; the output is a surface which may be represented as isochrone curves describing how far the ship may travel from the starting point within 1-2-3-4-etc days.

The novelty of our method when compared to other approaches, Leidwanger (2013); Schäfer (2016); Scheidel (2015) is that it can provide all possible routes from any Eastern Mediterranean point of origin (e.g., port location) to every other coastal point of region (Fig. 3a). Moreover, we try to eliminate all subjective assumptions present in state-of-the-art:

- wind and sea currents are realistic, taken from our day-to-day database, although following present day weather changes, but avoiding generic mean values of weather conditions.
- incorporating different ship behavior is easily modeled using sailing diagrams. The respective calculated routes are subject to changing weather conditions.
- different times of departure obviously result in different paths (Fig. 3).

The main assumptions of the above approach are the sailing diagrams of ancient ships and the fact that the algorithm “knows” in advance the weather progression, while the vessel's captain could rely on his experience in predicting future weather conditions. Future work includes comparing the vessel speed modeling approach of Leidwanger (2013) and Schäfer (2016). Further investigation will incorporate naval engineering expertise on the achieved speeds in relation to wind speed and sea currents, so that the sailing assumptions become more realistic. This computational approach can be modified to take into account limited knowledge regarding future weather conditions. Last, we will investigate means to incorporate additional trip constraints, such as maximum seaborne duration, and automatically creating capotage based routes. In a future implementation of the game, the fastest route could be presented to the player as a “suggested” route.

To the best of our knowledge, there have not been previously reported attempts towards embedding of such a tool within game play in seafaring games. It makes both the information being provided to the player and the game mechanics authentic and hence well purposed towards the learning objective.

7. The Seafarers

“The Seafarers” is designed as a turn-based strategy game where the player assumes the role of a merchant-captain in the Mediterranean region during the classical period. In “The Seafarers-2” the player can

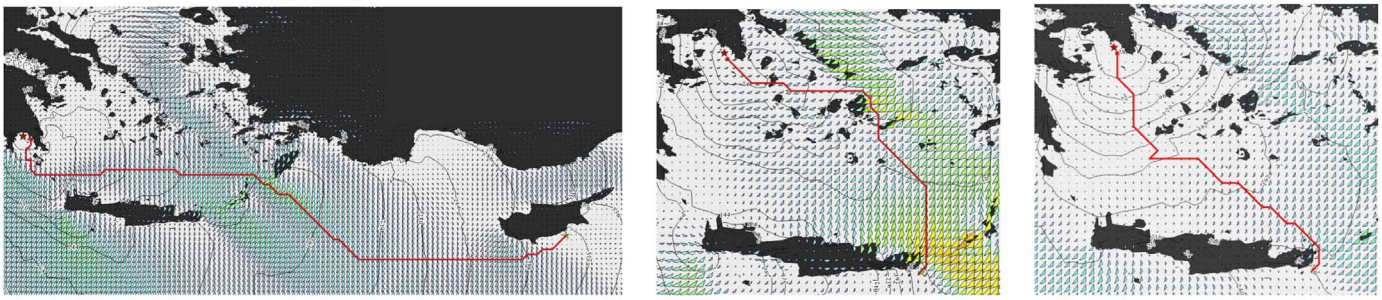


Fig. 3. (a) Example of fastest route calculation between two arbitrary origin and destination points, given the time-varying weather data; the fastest route is shown in red line, while isochrone curves display how far a ship may travel from the point of origin (south Peloponnese) after 1,2,3 etc days. Routes calculated for the same point of origin and destination, with departure times set at 9/3/2017 (b) and 9/6/2017 (c). The algorithm's results may vary depending on the time of departure and the respective weather conditions.

control only one cargo-ship which she/he can navigate. This change from Seafarers - 1 was driven by results of the expert review.

The game takes place in a 2.5D virtual world depicting the Mediterranean region at the time in question. The environment is non-photorealistic, the aesthetic style is cartoon-like, and text is presented in fonts inspired by the era as shown in the narratives in Fig. 2. Playing the game and exploring the environment, the player learns about navigation and exploration, trading, commodities, coinage, etc which can either raise cultural awareness and serve as a digital experience prior to the player visiting a maritime museum. For example, the player can gain a better insight as to which commodities were available at the time, the specialized commodities at each port, the coinage at each port, the location of the ports, simple navigation practices, etc.

From an implementation standpoint, the game was developed with Unity3D Game Engine, a proprietary game development platform from Unity Technologies. The 2D, 3D models, graphics, sound and other effects in the game were either developed specifically for this game or downloaded from open-source royalty-free online databases. The game runs on Windows or MAC OS with no special system requirements. As previously mentioned, it is a single player game with no social interaction mechanisms. The learning curve is intentionally short and the player is typically operative in less than a few minutes. The effective learning time for a first-time player as shown by the pilot study is typically less than 10 min. Player engagement is maintained by clear sub-goals appearing in the form of text-based narratives that are triggered at different time-steps in the game depending on either the progress or location of the player's ship as explained in Section 5. Furthermore, User Interface elements such as a measure of wealth and supplies, and a NPC in the form of a knowledgeable uncle on board the ship, provide information, hints and feedback to help the player avoid getting stuck in the game. The target audience is the general public (largely youth who are mostly familiar with the technology of computer games in general, and may or may not be interested in the culture of the Mediterranean sea practices). There are no knowledge prerequisites to playing the game.

From the pedagogical standpoint, the strategy-game genre was chosen since it is most suitable for implementing the constructivist teaching method: the 2.5D environment represents a tangible learning context where the player can actively build his/her own knowledge through exploration, manipulation and interaction rather than passively receive information. The learning content is organized into small units related to sub-tasks, from simple to complex. In order to fulfill these tasks the player has to navigate the ship and explore the region and trade commodities at various ports thereby gaining new knowledge and applying it to advance in the game by maximizing her/his wealth.

7.1. Expert-user evaluation

A first evaluation of the game usability and effectiveness, and of the player satisfaction has already been conducted and is reported in Philbin-Briscoe et al. (2017). The expert-user evaluation consisted of specialists from different expertise i.e. topographers, marine archaeologists, computer scientists, cultural sociologists, HCI specialists. The evaluation was carried out in the form of a single post-test questionnaire whose purpose was to measure the game usability and its effectiveness in terms of achieving the learning objective. Knowledge about specific maritime and seafaring practices was defined as the learning objective. The evaluation showed that the consensus of experts approved of the game's effectiveness in terms of the learning objective, concluding that “The Seafarers-1” successfully communicates information about seafaring and maritime practices in the Mediterranean during the Classical period. In regards to the usability the experts indicated that the lack of more precise and visible information on commodity costs and voyage preparations made learning more difficult and decreased user satisfaction. The strong points identified were visibility of the status and the context of the player/ship. A more detailed analysis can be found in Philbin-Briscoe et al. (2017). Fig. 4 shows images from the first prototype.

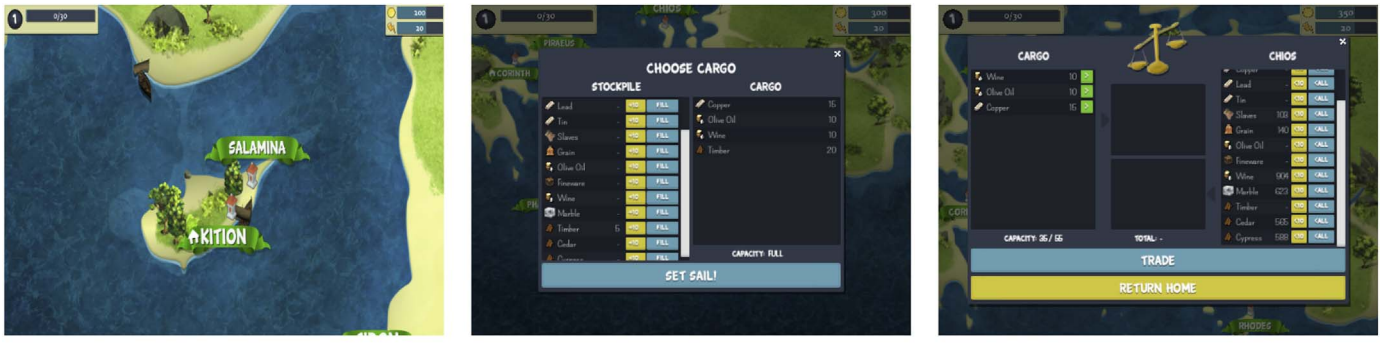
7.2. The Seafarers - Prototype #2

The feedback from the expert evaluation provided the main inputs for creating the current version, “The Seafarers-2”. Fig. 5 shows images from the second prototype. Historical and geospatial data is incorporated throughout the game. The speed of travel is calculated based on the time of travel and wind direction and a variable wind icon provides feedback to the player. Narratives use landmarks to assist the player with navigation. The map is based on GIS data and the landmarks i.e. rivers, islands, etc correspond to actual places. Each port specializes in some commodities and the prices are varying depending on the port. A short video showcasing the gameplay of the second prototype can be found https://youtu.be/gKMm7w1eJVIhere.

8. Evaluation

8.1. Experimental setting

In this work our goal was to go beyond the previous expert evaluation of the “The Seafarers-1” game and address a higher number and higher diversity of study participants. To this end a multi-site, multi-discipline, multi-lingual evaluation which included participants



(a) (b) (c)

Fig. 4. The Seafarers - 1. (a) Overall look and feel. (b) Choosing the cargo before setting sail. (c) Trading goods at the port in Chios.

(a) (b) (c)

Fig. 5. The Seafarers - 2. (a) Overall look and feel of the second prototype. Weather information from geospatial data i.e. wind direction, determines the speed of travel. Traveling with the wind results in faster journeys. Depending on the selected location the speed changes and the wind icon changes to reflect the deviation from the wind direction. Landmarks i.e. the small island, are used in the narratives for navigation. (b) Trading goods at the port in Delos. The prices for the commodities vary from port to port. Available commodities at each port depend on historical data. (c) The area in which all the ports are located. The player is free to navigate to any of the ports.

from different countries (having different historical background) and who have studied (or are studying) in different disciplines was conducted. Specifically, to evaluate the impact of playing the Seafaring game on the learning objectives we performed a multi-site study at 4 locations, Canada, Bosnia & Herzegovina, and Cyprus [Nicosia, Limassol]. The purpose was to evaluate how well participants could absorb the learning objectives about seafaring and maritime practices in the Mediterranean during the classical period and if acquiring this knowledge through play was more engaging and therefore resulted in a more effective learning mechanism than simply reading the information. Specifically, our hypothesis was that *game playing allows for more engaged learning thus improving long-term knowledge retention (i.e. greater than a week after undergoing a learning method).*

8.2. Methodology

To test our hypothesis, we had two groups of participants that were randomly assigned to one of two learning methods: (1) playing the game (Player group) or (2) reading a web page with same content as found in the game (Reader group). Prior to the study, all participants were informed of the purpose and procedures, after which they gave informed consent.

During the experiment, all participants filled out a pre-test survey which contained questions pertaining to demographics and background information on their familiarity with the Mediterranean region (e.g. are they from the Mediterranean region or have they ever travelled there). After completing the pre-evaluation questionnaire, participants were randomly allocated to one of two groups: those who played the game "Player group" or those who read the web page about Seafaring practices "Reader group". The Reader group participants were asked to read the web page until they understood and were familiar with the material ("as if reading a Wikipage to learn about a topic") but did not have to study it in order to memorize the information. The game players were explained the premise of the game, specifically that "You are a trader during the Classical period in the Mediterranean. Your objective is to maximize wealth. Make sure you follow the narratives for clues on where to sail."

Immediately after completing the study, all participants (Gamers and Readers) performed a post-test questionnaire on their perception of how much they think they learned, how engaged they felt during the study, and whether they were more likely to go and learn more about Mediterranean seafaring and maritime practices in the Classical period than before participating in the study. At this stage we did not ask specific questions about what they learned as our goal was not to study short-term retention, but rather long-term retention.

Ten days to 2 weeks after participants had played the game or read the web page, a long-term post-test, which contained multiple choice questions on the information in the game about seafaring and trading practices in the Mediterranean during the Classical period, was given. In order to determine if the participants had learned a given objective during the study or had previous knowledge of it, for each question, the participants were asked if they had known the answer prior to the study. This gave us an indication of the subjects baseline knowledge.

Fig. 6 summarizes the experimental setting and procedure. At the end of the experiment the participants were compensated for their participation and time.

8.3. Pilot study

Prior to the large multi-site evaluation of "The Seafarers-2", we ran a pilot study at Concordia University (Montreal, Canada) with 34

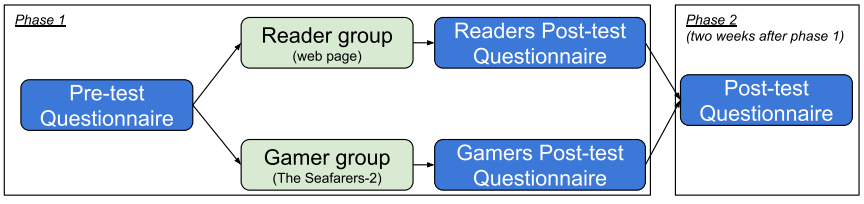


Fig. 6. Two-phase user-study. The first involved (1) filling out a pre-test questionnaire, (2) playing the game or reading the web page and (3) filling out a post-test questionnaire. In the second phase, done about 2 weeks later, a long-term post-test questionnaire was administered to study how well participants had retained the knowledge that was disseminated either through game playing or reading.

Column %	Gamer	Reader	NET
1	49%	36%	43%
2	28%	43%	35%
3	15%	16%	15%
4	8%	2%	5%
5	0%	2%	1%
NET	100%	100%	100%

(a)

Column %	Gamer	Reader	NET
1	43%	41%	42%
2	38%	30%	34%
3	11%	16%	13%
4	8%	11%	9%
5	0%	2%	1%
NET	100%	100%	100%

(b)

Fig. 7. (a) Knowledge on general topic in relation to the reader/gamer groups. (b) Knowledge on sailing practices in relation to the reader/gamer groups.

subjects (11 game players and 23 readers). The goal was to gather feedback to make any necessary changes in the game and adjust the experiment parameters in terms of game balance, learning content in the game, playing and reading times, and understanding of the questionnaires. Hence, for the pilot study, all three questionnaires (pre-test, post-test, and long-term post-test) were given. During the pilot study, we found that game players needed about 10–15 min to explore all of the functionality of the game and navigate through all the narratives. Therefore, for the main experiment the game players were given a maximum of 25 min to explore the game. In the pilot study all readers finished within 5 min. However, to account for English not being the first language at some sites we gave readers up to 10 min in the main experiment to read the material. The major feedback obtained during the pilot studies indicated that navigation of the ship was difficult and that travel time in the game was too long to reach ports.

Based on the feedback from the pilot-study we changed the game to provide sufficient hints for the player to know their relative location in the region, to know where particular ports were, and for the narratives to include island names and landmarks. Accordingly, the important changes made to the game include the following:

- Time of travel: Game timer recalibrated such that a trip from Delos to Chios takes 24 h which is a more realistic estimate.
- Landmarks: Icons are used on land and sea e.g. icons on the capes, multiple icons to indicate significance of ports etc.
- Narratives: There were no compasses at the time and exploration was performed with celestial navigation. Since celestial navigation cannot be accommodated given the style and gameplay of the game it was adjusted to include the landmarks instead of a compass.
- Navigation hints: The journey is divided into milestones. As the player gets closer to a milestone, there is a flashing arrow [for a few seconds] at the edge of the screen pointing towards the next milestone. Same thing happens until the player reaches the goal. An example with a flashing yellow arrow showing the right direction is shown in Fig. 5(a).
- Island names: Added and used in the narratives as clues.
- Player location: Camera zoomed-out just a bit to show a larger area.
- Global map [sketch]: Accessible to the player from the beginning.

Preliminary results also indicated that for each post-test questionnaire up to 90% of participants did not have prior knowledge of the seafaring information present in the narratives/on the web page for each question. This validated one of our initial premises that in general many visitors to the museum exhibits would be having little or no knowledge of this cultural information about the seas, seafaring and trading practices in the Mediterranean during the Classical era. Furthermore, we found that both readers and game players were able to learn the objectives and answer the post-test questionnaire correctly. This further supported our notion of focusing on long-term retention rather than immediate knowledge gain.

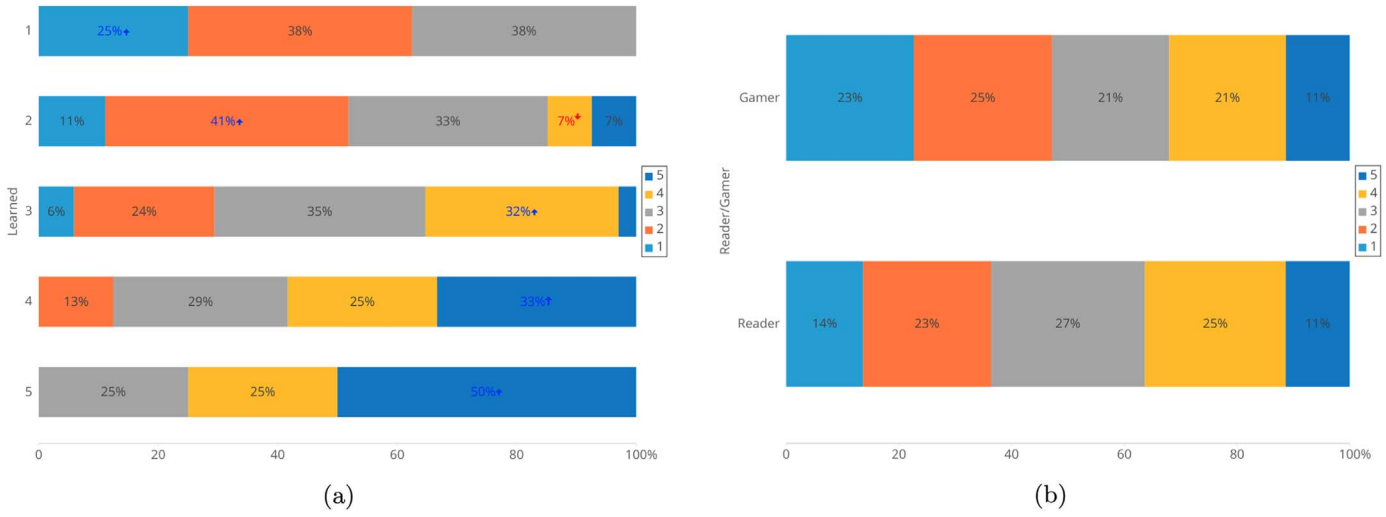


Fig. 8. (a) Engaged vs learned. (b) "More likely to visit a museum" in relation to the reader/gamer groups. There was no significant statistical difference in the participants' responses in (a) and (b). A close correlation between engagement and learning can be noted in (a).

Column %	1	2	3	4	5	NET
1	27%	14%	33%	0%	0%	19%
2	7% ▼	29%	42%	20%	100% ▲	29%
3	20%	29%	8%	30%	0%	19%
4	20%	14%	8%	20%	0%	15%
5	27%	14%	8%	30%	0%	19%
NET	100%	100%	100%	100%	100%	100%

Fig. 9. Video game frequency vs 'Did you like the game?'. Sample size = 48 (game players), 95% confidence level.

8.4. Multi-site study

8.4.1. Participant demographics

A sample size calculation assuming a standard effect size (E/S) of 0.500, showed that 63 participants per group were needed. We recruited 127 participants (64 game players and 63 readers) in total from the four sites [68.2% male and 28.7% female, 2.3% chose not to disclose their gender, and 0.8% identify as non-binary] which according to the demographic form ranged from 18 to 49 years old with the majority 60.5% within the age group 18–25 and second highest age group (33.3%) in the range of 26–33.

In the pre-test questionnaire 55.8% of participants indicated that they had never been in a museum/exhibit featuring artifacts from the Mediterranean region during the Classical period while a 79.1% of the participants selected 1 and 2 (45% and 34.1%, respectively) on a Likert scale of 5 [1 (not at all) to 5 (very much so)] when asked whether they were knowledgeable about nautical/maritime practices during the same era and sailing/maritime navigation in general. Thus, there was no significant differences between the categories of knowledge on topic and Reader/Gamer and knowledge on sailing and Reader/Gamer as shown in Fig. 7a and Fig. 7b, respectively.

8.4.2. Post-test questionnaire

After reading the web page on seafaring or playing the seafaring game, all participants answered four Likert scale questions from 1 (not at all) to 5 (very much so) on:

1. how much they felt they learned,
2. how engaged they felt,
3. whether they were more likely to go see an exhibit on the maritime practices during the classical and
4. whether they were more likely to go learn more about the topic.

For how much they learned readers scored that they learned slightly more ($M = 3.18$, $SD = 0.94$) than game players ($M = 2.41$, $SD = 1.02$), however, the scores were not significantly different ($p = 0.272$). In terms of how engaged participants were, surprisingly there was no significant difference ($p = 2.16$) between readers ($M = 3.10$, $SD = 1.11$) and gamer players ($M = 2.89$, $SD = 1.27$). When asked whether after reading the page on seafaring or playing the game, they would be more likely to go visit an exhibit on the topic of seafaring and maritime practices during the classical period again there were no differences ($p = 0.309$) between readers ($M = 2.84$, $SD = 1.27$) and game players ($M = 2.66$, $SD = 1.07$). Lastly, we found that readers ($M = 2.87$, $SD = 1.07$) were slightly more interested ($p = 0.002$) than game players ($M = 2.66$, $SD = 1.36$) to go learn more about the topic of seafaring in the classical period.

The game players answered an additional four questions specific to the game and were also asked to comment on the game in general. The first question asked the players on a Likert scale from 1 to 5 [1 (not at all) to 5 (very much so)] whether they liked the game. On average all players only somewhat liked the game ($M = 2.67$, $SD = 1.27$). In terms of the dialogues, 80% of participants said they understood the dialogues (11% said they didn't know if they understood). Further 52% of participants thought the amount of dialogues was appropriate, whereas 39% thought there were too many and 9% did not know. Given this last result it was surprising that 80% of participants would have liked to be able to click on specific topic words presented in the narratives (e.g. a port, a coin, a commodity etc.) and get more information on that topic, 9% did not know if they would like this feature and 11% did not want it. There was no significant difference in terms of engagement and learning however we noted a close correlation between the two as shown in Fig. 8a. Similarly, in terms of whether they were more likely to visit a museum the two groups have shown no significant difference in their responses as shown in Fig. 8b.

We also found that game players who play video games frequently were less likely to like the game as it is shown in Fig. 9. Those who liked, scored the game the highest [5 on the Likert scale] were those who did not play games frequently.

In terms of additional comments, many players felt that the game was compelling, e.g.: "the idea of the game is very nice", "Nice game! Very fun!", and "gameplay was cool, would have liked to do partial resource refills throughout different points on the coasts. Graphics were also appealing, and the gameplay was simple with a good bit of resource management and strategy". At the same time, other players commented that the graphics could be improved, for example, "Graphics were terrible, story line was decent." Navigation was also found to be difficult by most, e.g. "It would be nice to see the location of my ship on the map to know where to sail", "The way the ship navigates could be more fluid and perhaps have a map with a compass tied to it to find ourselves. Overall if a few components are modified, it would be a good learning game", "The map was not very helpful; many of the islands around where I started were not on the map and I didn't know in what direction I should start the journey.", "Was having a hard time figuring out the terrain with the map" and "It would be much better if we could see our current position on the map and if we could see names of every piece of land. The map should contain names of all islands that are shown." Yet others realized that to get understand the navigation, it was imperative to follow the dialogues, "The navigation advices were very helpful and let me understand in a better way the local geography."

Other interesting comments, suggested that there should be a way to re-read the information that was presented to the player, for example "Perhaps, there should be some kind of captains log or diary, containing all the dialogues of importance, so they are not permanently lost after reading through them."

8.4.3. Long-term post-test questionnaire

The participants were asked to return for the second phase i.e. long-term post-test questionnaire approximately two weeks after the first phase of the experiment. Of the 127 participants who took part in the

Column %	Gamer	Reader	NET
I don't know	26%	12%	18%
No	26% ▲	3% ▼	13%
Yes	48% ▼	85% ▲	68%
NET	100%	100%	100%

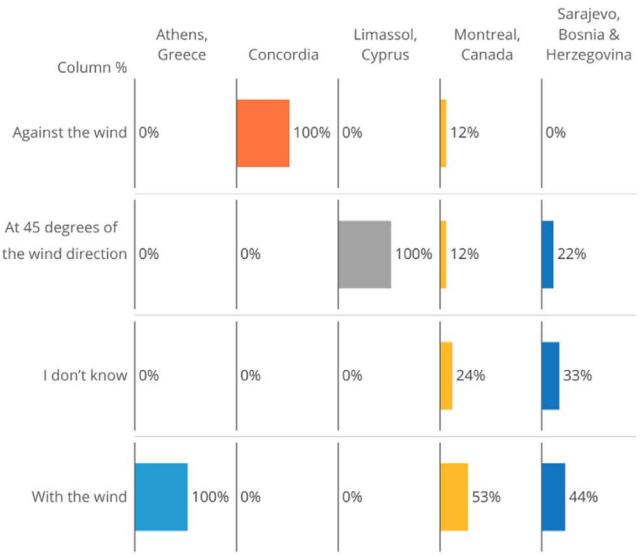
(a)

Column %	Gamer	Reader	NET
Against the wind	15%	6%	10%
At 45 degrees of the wind direction	0% ▼	31% ▲	17%
I don't know	31%	19%	24%
With the wind	54%	44%	48%
NET	100%	100%	100%

(b)

Column %	Gamer	Reader	NET
I don't know	47%	28%	36%
No	6%	7%	6%
Yes	47%	65%	58%
NET	100%	100%	100%

(c)



(d)

Fig. 10. (a) Were there pirates in the classical period sailing in the Mediterranean? vs Reader/Gamer. Sample size = 60, 95% confidence level. (b) "What is the fastest way to sail" vs Reader/Gamer. Sample size = 29, 95% confidence level. (c) Sailing during the classical period in the Mediterranean was done by cruising along the coast and then crossing the sea only when known landmarks became visible on the opposite shore e.g. caves vs Reader/Gamer. Sample size= 80, 95% confidence level. (d) Per-site analysis of the responses for "What is the fastest way of sailing?". Participants geographically located near the Mediterranean seem to be more familiar with sailing practices. Sample size= 29, 95% confidence level.

first phase of the experiment, 101 participants (53 readers and 48 gamer players) returned back who were asked to answer four knowledge questions and four follow-up Yes/No questions on whether they already had this knowledge prior to the study:

1. Were there pirates in the classical period sailing in the Mediterranean?
2. Did you know if there were pirates in the classical period sailing in the Mediterranean prior to the study?
3. For what reason did people most likely sail in the Mediterranean during the classical period?
4. Did you know for what reason did people were most likely sail in the Mediterranean during the classical period prior to the study?
5. What is the fastest way to sail?
6. Did you know what the fastest way to sail was prior to the study?
7. Sailing during the classical period in the Mediterranean was done by cruising along the coast and then crossing the sea only when known landmarks became visible on the opposite shore e.g. caves
8. Did you know about coastal cruising and landmark sailing prior to the study?

As previously stated, the objective of the study was to determine whether long-term retention was better in the case where the information was presented in the form of a game as opposed to traditional learning (in this case reading a web page). For this reason, for each aforementioned question participants who have indicated that they knew this information prior from the study were excluded from the analysis i.e. only participants who answered "No" in the "Did you know..." follow-up questions where considered.

In terms of retained knowledge on pirates during that era, the majority of the readers i.e. 85% have answered correctly whereas from the game players only 48% had the correct answer as shown in Fig. 10a. The results for knowledge retained on the purpose of seafaring show no significant difference between the two groups; in fact 100% of the participants chose the correct answer (Sample size=35, 95% confidence level). In terms of knowledge retained about the fastest way of sailing, although there was no significant difference in terms of correctness between the groups more game players answered correctly (54% vs 44%). Of the readers, 31% have answered incorrectly "At 45 degrees of the wind direction" which is higher than the average for "At 45 degrees of the wind direction" ($p = 0.03$). Finally, Fig. 10c shows that there was no significant differences in terms of retained knowledge on sailing using landmarks between the two groups.

8.4.4. *Discussion of results*

The analysis of the participants' responses has shown that there is indeed an advantage - albeit small - to learning through gameplay. Game players who were successful in performing multiple trades during the test seemed to grasp the knowledge better and retain it for longer as this is evident by the "What is the fastest way of sailing?" responses. We attribute this to the fact that game players had to navigate the ship and receive feedback based on their actions which has led them to absorb the fact that sailing with the wind allowed for faster travel among the ports. It is interesting to note that when performing a per-site analysis, participants located near the Mediterranean region seem to be more familiar with sailing practices as shown in Fig. 10d.

The two groups have shown no significant difference in retaining knowledge on the purpose of sailing during the era and sailing using landmarks. This can be attributed to the fact that the information was clearly conveyed in both media i.e. web-page and game.

In terms of knowledge on pirates during the era, the readers have significantly outperformed the game players. We attribute this to the fact that although the same information was provided to both groups, the readers had an advantage in that they were presented this information in the form of a web-page containing a short and concise passage as shown in the Appendix. This information was already extracted and made concise before being presented to them as opposed to reading a multi-page document and having to extract the important information. Thus, the readers were reading pre-filtered information and were able to learn and retain the knowledge in the long term better than the game players. In contrast, the game players had to play a game in which the same information was incorporated in the game-play. The player then had to deduce this from her/his actions during the game-play. For the specific question about pirates, game players had to realize that the story line which begins with the character's father being killed by pirates was a factual piece of information. Perhaps adding visual information that goes along with this story line would help game players better retain the knowledge. As, the knowledge in the game involved integrating information we believe the game players had to work harder than the readers in order to identify which information was important. This likely explains the game players' poor performance on the pirate question.

Given the comments from the game players, we believe that a number of changes should be made in order to make the game more engaging, less frustrating, and allowing for better knowledge retention. First, although the experts believed it was important to have realistic navigation for that time, game players felt frustrated that they did not know their location on a global map, did not have island names, could not travel more quickly between ports, etc. This led many to dislike navigating through the game. Therefore, it is likely that some realism must be compromised to allow for smoother game play. Navigation and seafaring information of that time could still be conveyed to the user through dialogues and story telling. Further, game players, particularly those that played video games felt that the graphics were not visually appealing – this is likely in comparison to commercial games that they are used to playing. Although the main objective of the developed game is learning, it will be important to have appealing graphics that may engage the users more and may in the long run allow for better retention of information, particularly for visual learners. We also saw some indication that those who played videos games less often were more likely to enjoy playing the game. Lastly, several participants noted that a mechanism for re-reading dialogues would have been helpful, for example a captain log book where you could go and reread information. This of course, would help users to reread both instructions and stories which would not only help them to navigate but also to encounter the content of the learning objectives more frequently. We believe this would be an important mechanism to improve learning.

9. Conclusion and future work

In this paper we presented the redesign of a serious game called "The Seafarers" whose main purpose is to engage the public in the general theme of maritime archaeology and to provide them knowledge and insight into ancient seafaring practices. Uniquely, the design and structure of the game are generic enough to support specialization to different situations simply by authoring and embedding new components like geospatial maps, ocean data, non-linear narratives, commodities, trade practices, etc. Specifically, the second prototype incorporates seafaring practices in the Mediterranean during the Classical period, embedded with actual authenticated data provided by archaeologists, topographers, and cultural heritage specialists. Furthermore, we have developed a GIS tool which allows us to embed route risks based on archaeological and geospatial data which to the best of our knowledge it has not been previously reported.

Secondly, we have presented the evaluation of the game with respect to the learning objectives of engagement in learning about maritime cultural heritage, seafaring and trading in particular. Specifically, the evaluation tested the hypothesis that game playing allows for more engaged learning thus improving longer-term knowledge retention. The evaluation was conducted in two phases and included a pilot study, followed by a multi-site, multi-continent user-study involving a large number of participants. Our results have shown that learning through gameplay does not necessarily increase long-term knowledge retention, however it has the potential to do so if the information is presented appropriately and the game is found to be engaging by the player. Short, concise information as presented to the readers also allows them to retain the information. Further it seems when knowledge is presented in an engaging way and not often (the character's father is killed by pirates at the beginning of the game), then it seems readers perform better. This might because the information presented to the readers was clear and concise or because game players took this not as factual knowledge but simply something with entertainment value.

The results from this evaluation will be used in the redesign of the next iteration of the game while lessons learned during the evaluation such as balancing the tasks of the two groups in terms of the effort required to extract the information will be taken into account in the follow-up evaluations.

Finally, "The Seafarers" is also a very good example of successful multi-continental, multi-institutional and multi-disciplinary cooperation - civil engineers and archaeologists from Cyprus, Human Computer Interaction (HCI) and Educationists from Bosnia and Herzegovina, cultural sociologists and computer scientists from Canada. This extended cooperation among various stakeholders from different backgrounds has been one of the primary contributors to various innovative elements in Seafarers.

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Appendix: Webpage

Fig. 11

Seafaring in the Mediterranean During the Classical Period

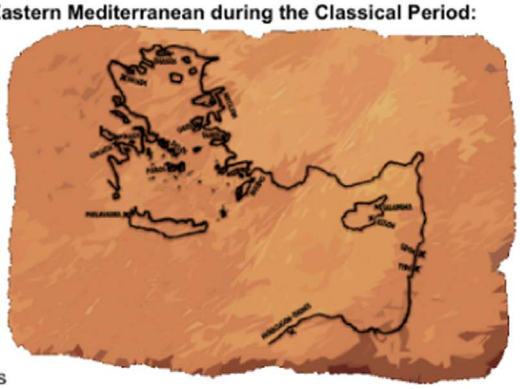
Sailing

Merchants from the Eastern Mediterranean in the Classical period sailed using small ships loaded with amphora (large ceramic jugs) filled with various commodities. They would stay close to shorelines, as it was very easy to get lost in open waters. When they needed to cross from one coast to another, they would do so at familiar locations, where landmarks or geographical features could be used as a point of reference.

Their sails were not as advanced as those used on ships in more recent historical periods, and as such they could only sail when the wind was blowing in the direction that they needed to go.

Seafarers would need to be wary, however, as pirates, rocky shallows, and windy seas could pose significant risk of sinking, theft, or death.

Ports in the Eastern Mediterranean during the Classical Period:



- Delos
- Paros
- Piraeus
- Phalasarna
- Thassos
- Heracleion-Thonis
- Kition
- Salamina
- Mytilene
- Mende
- Sidon
- Tyre

Trade

When trading, merchants would use drachmas, which came in several denominations, similar to coins used today. Many cities would cut their own versions of these coins, with the front/back of their coinage featuring important local such symbols as natural resources, political figures, or symbols with religious or historical significance.

Most cities had a small handful of commodities which were produced locally. Merchants would buy these commodities at a low price, and then bring them abroad to sell them for a higher price.

Example commodities:

- Timber
- Olives
- Olive Oil
- Wine
- Dyes
- Grains
- Metals (gold, silver, copper)

Fig. 11. The webpage presented to the readers which contains concise information about Seafaring in the Mediterranean During the Classical Period.

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