

# Renovating the Cultural Heritage of Traditional Shadow Theatre with eShadow

## Design, Implementation, Evaluation and Use in Formal and Informal Learning

Nektarios Moumoutzis<sup>1</sup>, Marios Christoulakis<sup>1</sup>,  
Stavros Christodoulakis<sup>1</sup>, Desislava Paneva-Marinova<sup>2</sup>

<sup>1</sup>Laboratory of Distributed Multimedia Information Systems and Applications,  
School of Electrical and Computer Engineering, Technical University of Crete, Greece

<sup>2</sup>Institute of Mathematics and Informatics, Bulgarian Academy of Sciences,  
1113 Sofia, Bulgaria

nektar@ced.tuc.gr, christoulakis@ced.tuc.gr,  
stavros@ced.tuc.gr, dessi@cc.bas.bg

**Abstract.** Digital storytelling is an engaging learning environment that gained worldwide popularity over the last years. It offers a rich cross-curricular learning environment within which children design, create and present their own stories and develop many skills including literacy, presentation and communication skills as well as inquiry-based learning and digital skills. In this paper we present a new way of digital storytelling, a form of dramatized storytelling inspired by the rich tradition of Shadow Theater. This form of storytelling showcases an engaging way of renovating cultural heritage with the use of digital technologies. It combines a number of digital tools for the production of the digital stories covering all five phases of film making: scenario development, pre-production, production, post-production and distribution. eShadow can be used (a) to create digital shadow puppets, and (b) to set up, perform and record the scenes of the digital story (production phase). This way, digital story creation is wrapped around engaging learning scenarios, playful improvisations and creative learning. eShadow has been extensively used to support cross-curricular learning mainly in Greek schools. It is extended to support marionette-like interactions to promote its use in countries with relevant storytelling cultures.

**Keywords:** digital storytelling, shadow theatre, cross-curricular learning, digital storytelling, digital marionettes.

## 1 Introduction

Shadow Theater is a storytelling tradition with deep roots in many countries. In Greece it used to play the role of cinema at the end of the 19th and beginning of 20th century with wide acceptance by people in both urban and rural areas. Although its popularity declined as cinema and TV invaded the Greek society, it still remains a favorite entertainment for many children and adults and a way for personal expression as a means of dramatized storytelling. It is a medium with significant educational value (Hatzigianni et al., 2016) especially for primary school children. This is linked to the ability of a

shadow theatre to activate children (and adults) and promote their creativity: During the preparation and the actual performance of a shadow theater play, children and adults find their own ways to act and imitate, create dialogues, get inspired and convey their own messages, direct, become stage designers, paint their own puppets and sceneries, sing, strengthen their self-confidence giving life to the puppets, and create their own stories. Thereby the participants practice theatrical speech in an entertaining way, cultivate their oral speech skills and develop in multiple modes their intelligence (multiple intelligences). In addition, they get familiar with the research process towards a creative exploitation aimed at learning (inquiry-based learning). Furthermore, they exercise their creative expression abilities through painting, designing, construction and other artistic creations. Finally, they are given the opportunity to discover the specific identity of peoples and regions through the musical, linguistic and cultural particularities of certain characters that are typical in traditional shadow theatre plays.

The digital version of shadow theatre enriches these particular features of its traditional form with elements relating to new technologies. It offers the possibility for students and educators to creatively practice, not only in traditional activities of shadow theatre storytelling but also in the production of digital multimedia content. Eventually, eShadow shapes a rich pedagogical framework for cross-curricular teaching, combining tradition and technology in a compelling manner. It ultimately promotes a new form of digital storytelling that combines the merits of traditional shadow theatre with digital storytelling. Indeed, digital storytelling is considered as an important educational tool providing an inclusive learning environment that promotes soft skills and opens up the opportunity for thematic learning interventions that promotes cross-curricular project-based learning. Thus, digital storytelling promotes children's learning, helps them organize their thoughts, extends their imagination and creativity, and reinforces their collaboration skills as well as their writing, presentation, and problem-solving skills (Lunce, 2011). Digital storytelling is also an important tool for teachers because it can make difficult topics easier to understand, it provides them with the means to integrate multimedia content in the curriculum and helps them trigger interesting discussion topics in the class (Lunce, 2011).

In the following sections, we present the main characteristics of traditional Greek shadow theatre and its modern digital version presented in this paper. Then, we present the implementation details of eShadow and the overall framework for creative learning which is supported by eShadow. The framework is based on the phases of the film-making process and constitutes a flexible learning environment that can be adapted to different educational needs by selecting the activities/phases that are significant in each specific situation. Next, we give examples (learning interventions) of specific cross-curricular activities that have utilized either the whole framework or its individual components and the experimental evaluation of eShadow to validate its usability and learning effectiveness. Finally, we present an extension of the software to support digital marionettes and the main conclusions drawn from the usage of eShadow. We also outline the main extensions planned for the future.

## **2 Shadow Theatre as Part of Storytelling Cultural Heritage and Its Modern Digital Version**

One storytelling tradition that is deeply rooted mainly in Eastern cultures is Shadow Theater. The diversity of possibilities provided by playing with shadows (for example when children play with hand-shadows) has impressed humans throughout history. This fact is what made traditional Shadow Theater so popular in many countries and over time (Lu et al., 2011). Traditional Shadow Theater remains very popular even after the invasion of cinema, television and, lately, the Internet in many countries around the world like Greece, China, Taiwan, France, India, Turkey, Malaysia and other. More specifically in Greece, Shadow Theater is a very popular form of entertainment. For older generations Shadow Theater was the only form of entertainment available to them. That was a time before cinema and television became available to the general public. Furthermore, traditional Shadow Theater is a common link across generations: Children in Greece still watch traditional shadow theater plays, learn about Shadow Theater in school and also play with shadow theater puppets.

Starting from these important facts, we have been exploring for the last eight years the development of digital tools inspired by the Greek shadow theater tradition with the aim to offer an infrastructure that will allow the set up of engaging learning spaces for both children and adults. The result of these investigations is eShadow (<http://www.eshadow.gr>), a digital storytelling tool that can be used from both adults and children in order to create, record, share and watch digital shadow theater plays. It provides alternative methods for controlling the digital puppets either through mouse or through a motion sensing controller and enables real-time collaboration over the Internet (e.g. between grandparents and grandchildren living in diverse geographical locations, or between students in collaborating schools that wish to develop their digital stories). With eShadow new possibilities emerge: The enactment of intra-family communication scenarios that promote intergenerational bonding and playful learning as well as collaborative learning scenarios between students of distant schools. Such kind of new opportunities for intergeneration bonding that overcomes the physical separation of children and their grandparents is important for children's development and contributes to the well being of the elderly as well (Vutborg et al., 2010). In a similar way, the opportunity of collaborating with children from other schools, opens up new learning opportunities and could also help in cases of remote schools with few students that wish to create links with other students in distant schools and collaborate with them.

The important impact Shadow Theater has on children justifies its use as a learning tool. Especially in primary education it is used as an alternative way of playing and learning. One basic criterion for selecting it as a learning tool is that children relate to its main character (Karagiozis) in many ways. Karagiozis has the ability to motivate children and expand their creativity. Children find their own ways of mimicking plays, create their own improvised dialogues, express their emotions and create their own stories with unique characters. Additionally children get familiar with the research process and with collecting and using information about different shadow theater plays. Tradi-

tional plays were written in difficult times for Greece. They all contain historical information about life and many sarcastic elements about the conquerors/authorities of those times.

Another aspect of traditional shadow theatre is music. Every play has a musical theme that is, in many cases, unique. Each shadow theater performer used local traditional musical themes for his plays. By examining the music from different plays, children can learn about musical tradition across the whole country.

When creating their own plays, children work in groups. Each group is assigned to a different task of the play creation process. The most common assets of a play are: scenario of the play, dialogues, music, characters and sceneries. Children cooperate in order to create the scenario and dialogues, find the appropriate music for each part of the play and draw the puppets or sceneries. With the active participation in the above process, children are engaged in a collaborative fun process that allows them to express their creativity.

Except from the creation of a play, watching one is another activity that offers collaborative learning experiences for both children and adults. Many traditional plays have educational characteristics. The most common topics that they address are: equality (gender and social equality), environmental protection, people with special needs and many other social issues that are common to every society.

### 3 Implementation of eShadow

eShadow offers an intuitive way of setting up scenes and enacting them. The user can select the desired scenery objects (Fig. 1) and digital puppets (Fig. 2) and then move them with mouse drag operations (Fig. 3). All movements can be easily recorded along with the voice of the user. These recordings can be exported in appropriate file formats to be further edited with external video processing tools.

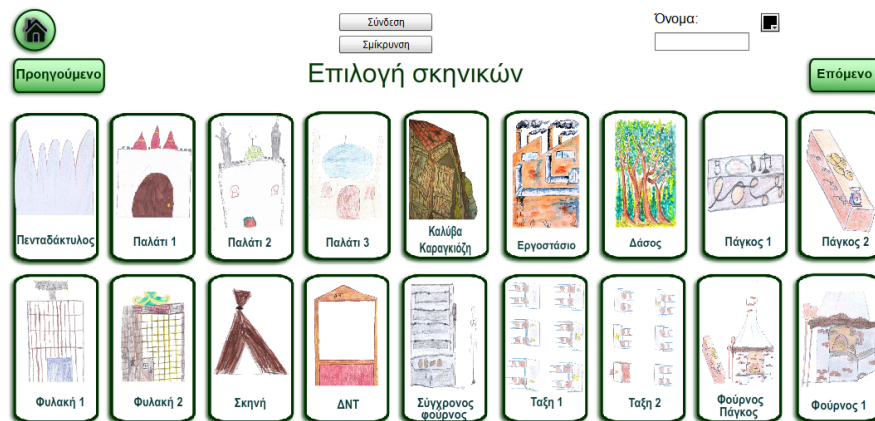


Fig. 1. Selecting scenery objects in eShadow.



Fig. 2. Selecting digital puppets in eShadow.

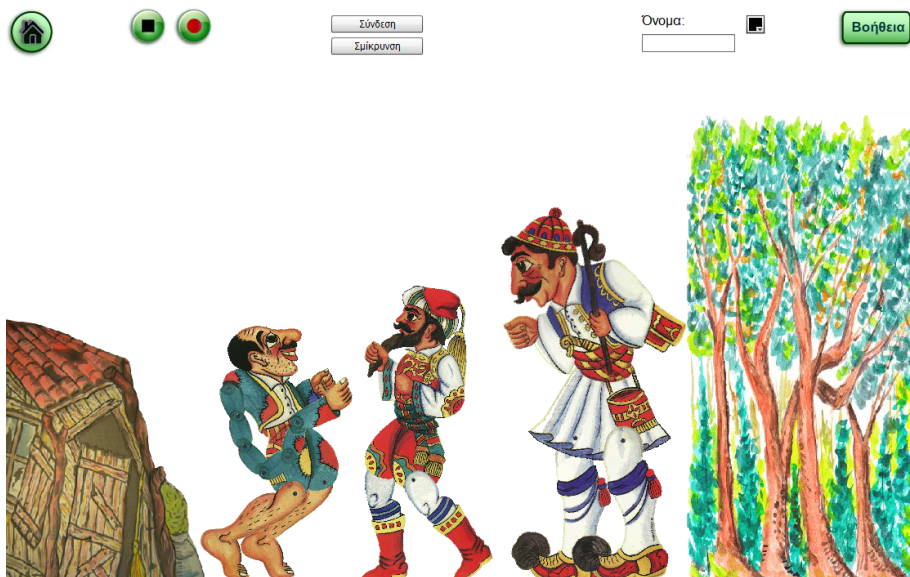


Fig. 3. Enacting a scene with three puppets and two scenery objects in eShadow.

eShadow gives emphasis in the realistic motion simulation of shadow theatre's puppets (Fig. 3) that is based on a physics engine. Realistic movement provides an explanation for the popularity of our platform among Greek teachers and students as revealed during the field trials as well as during testing with actual professional performers (Moraiti et al., 2016). Furthermore, realistic movement of digital puppets creates an atmosphere of playful interaction where the users are very easily engaged in theatrical improvisations that can be very important to develop communication skills related to oral expression and interpretation of body language.

Moreover, eShadow extends traditional shadow theatre by enabling collaboration not only locally but also from distance. Thus, learners from different physical locations can engage in role-playing game-like activities when preparing their stories or just for

the fun of improvisation. This kind of role-playing interaction can be interesting in various communication settings including the remote collaboration between children and adults as well: Adults can impersonate favorite heroes to engage children in playful creative interactions. This resembles traditional Greek shadow theatre dialogues between Karagiozis and other characters before the main part of a shadow theatre performance.

eShadow offers both a desktop and a web application. Several input devices can be used to control the digital puppets including the computer mouse, a motion recognition controller such as Nintendo's Wii Remote or any device supporting the Open Sound Control standard. Collaborative performance online is supported to record individual scenes, store and combine them in playlists. Each remote client communicates with the eShadow server (Fig. 4) that handles coordination between clients so that all clients see the same scene with the movement of digital puppets synchronized.

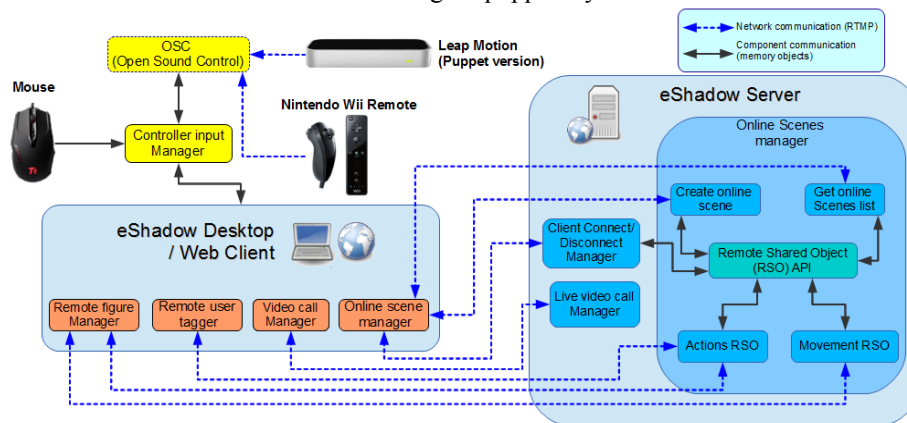


Fig. 4. eShadow client-server architecture and input devices.

Significant importance has been given to eShadow's usability as it targets users ranging from young children to teenagers, parents and teachers. Throughout the system development usability tests were conducted with real users. The results derived were then analyzed in order to extract requirements for the continuous improvement of eShadow's usability and functionality. Widely accepted methodologies were used for the evaluation of the whole system (Moraiti et al., 2016).

A special desktop application, namely eShadow editor, enables creation of digital puppets. Significant emphasis has been given on the usability of this application as well by using similar software development methodologies (Moraiti et al., 2016) as in the case of eShadow. eShadow editor provides a playful environment (Fig. 3) where children can remix digital puppets in many ways: by painting, changing the appearance of their faces, combine different body parts and use various accessories such as hats and hand-held objects. Digital puppets can be stored for further editing or exported to eShadow to be used in actual scenes and improvisations.

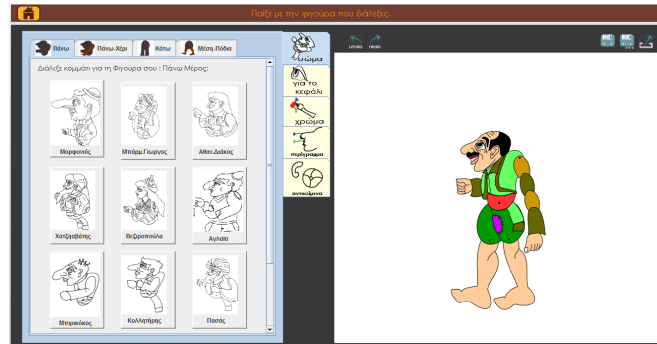


Fig. 5. Remixing a digital puppet in eShadow editor.

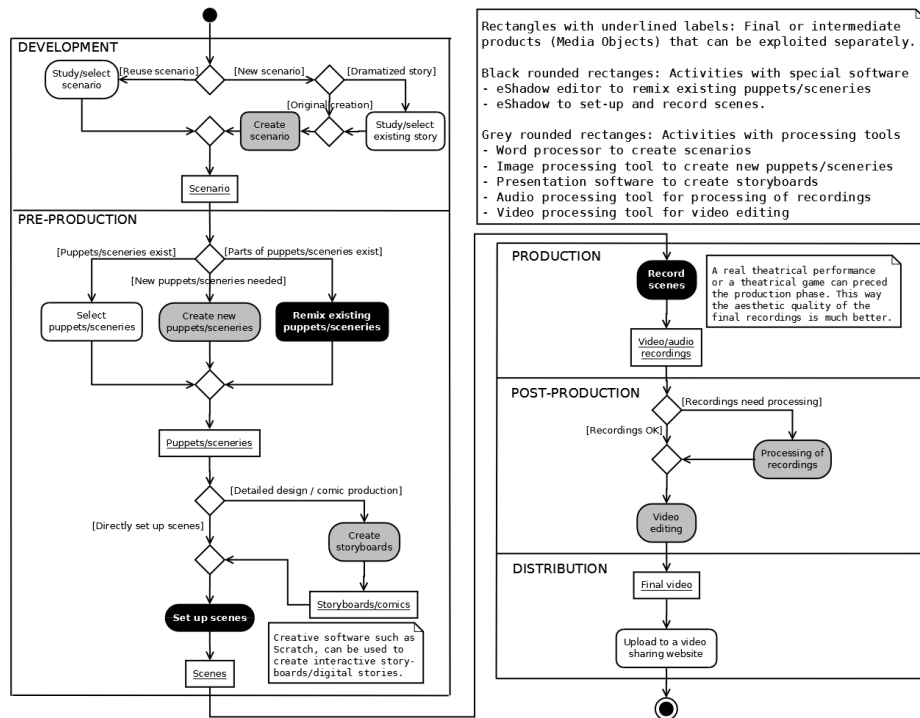
#### 4 A Project-based Pedagogical Framework to Use eShadow in Learning Interventions

eShadow is used in many schools to promote project-based learning combining arts with a wide range of school topics ranging from language learning, history and humanities to mathematics, physical sciences and computer science (Moraiti et al., 2016). The creation of such artworks with eShadow corresponds to a project-based process with three distinct stages that is generic and refers to any media artwork such as movies, digital games, interactive animations etc. In particular, these stages are the following: Preparatory actions (pre-production), subsequent development (production) of the main materials of the artwork, and final assembly (post-production). In some cases two more stages are distinguished: (a) One is distinguished from pre-production and is related to the development of the general concept or idea that will guide the development of the media artwork. For example, in film making, this initial stage could refer to scriptwriting. (b) One more is distinguished from post-production and refers to the distribution or sharing of the media artwork. For example, a digital story (as a digital video), could be distributed via YouTube or any other appropriate video sharing web portal.

Pre-production includes some form of storyboarding and/or sketching, design, planning and research to identify the important properties of all elements that will be used in the synthesis of the artwork. The production stage employs capturing devices and techniques (audio recording, video recording) as well as coding the interactive behavior of the media artwork as in case of digital games or animations. Post-production may include editing and mixing as well as testing in case of complex interactive media artworks such as games.

The adaptation of the above project-based workflow in the case of digital stories created with eShadow is depicted in Fig. 6 as an activity diagram that highlights tasks and external tools employed. The process begins with script writing or selection of an existing script. Playful interventions are also possible: The teacher could offer a (possibly partial) story or a set of story elements and ask students to dramatize it. This may be combined with inquiries to research actual historical events or other facts and link them to persons that will become the main characters of the story. Second is the pre-

production phase that includes selection or creation of digital puppets and sceneries, articulation of story scenes and detailed design via storyboards (optional). Third is the actual production (scenes recording). The post-production phase includes audio processing (optional) and video editing to produce the final digital story. The fifth is the distribution of the digital story.



**Fig. 6.** The process of creating a digital story with eShadow. The five phases are adopted from the filmmaking process.

The process is modular allowing the selection of activities/tasks that will be carried out by the students of a specific class and enables alternative implementation options. For example, script writing could be skipped if an existing script is used. Existing digital puppets and sceneries can also be used instead of creating new ones. Post-production can be skipped in lower grades, where pupils lack skills to work with the corresponding tools or when classroom time is limited. In such cases audio processing and video editing can be done by the teacher or external partners.

It is worth pointing out that the whole process can be enriched with additional activities depending on teacher's goals, students' interests and time available. These additional activities could further enhance the creative, game-like and personalized nature of the approach by introducing the use of creativity platforms beyond eShadow or address issues on how stories can be adapted to students' prior knowledge and/or ways of learning (i.e. learning styles). Indicative enrichment activities include: (a) utilization of



a creative programming platform for the development of interactive storyboards or an alternative form of the digital story in interactive form; and (b) preparation of a theatrical performance or theatrical games that enable students to practice spoken word articulation and kinesiology of the performance.

## 5 Indicative Learning Interventions with eShadow

### 5.1 Initial Learning Interventions During “The Triumph of Shadows” Exhibition

The initial learning interventions that used eShadow were held in Athens, Greece, in the context of the exhibition titled “The Triumph of Shadows”. In the first intervention the participants were members of the EcoFans Club. The EcoFans Club is a program designed to raise and promote environmental awareness and consciousness through an educational process combining ecology and English language learning. The EcoFans Club main group consists of students attending the Hellenic America Union English Language program, their parents, friends and other people that wish to participate in the EcoFans activities. As a result of this intervention, one shadow theater play was produced in digital form by the children with the support of their teachers. The play is available at: [http://www.youtube.com/watch?v=VB\\_jn0WkG1Y](http://www.youtube.com/watch?v=VB_jn0WkG1Y).

Two more interventions were implemented for people with special needs. In the first of these two interventions the participants were children with physical disabilities and their accompanying teachers (**Fig. 7**). Six children and six teachers participated in this intervention. In the second one, the participants were adults with mental disabilities (**Fig. 8**): Six adults and six trainers (each adult had his/her own trainer).



**Fig. 7.** Children with special needs during a learning intervention with eShadow.

The workflow of activities implemented in each intervention followed a fixed pattern:

- The participants were initially welcomed and a brief introduction was made to the software and its capabilities.
- The participants watched a play that has been created in cooperation with a professional shadow theatre performer as an example of the possibilities offered by the software.
- The participants were instructed on the use of eShadow and created their own shadow theatre play based on an existing scenario or improvised with their peers or created their own scenario.



**Fig. 8.** Adults with special needs during a learning intervention with eShadow.

Within the context of the exhibition, a panel discussion was organized on December 1st, 2012. The panel brought together artists, performers, and academics to discuss about the history and the art of Greek shadow theater and its modern versions. During this event, eShadow was presented along with information about its use in formal and informal learning settings (Christoulakis et al., 2014).

## **5.2 Learning interventions during local events in Chania, Crete**

Further use of eShadow was pursued within the context of local events in Chania, Crete, Greece. These events targeted teachers, parents and children. eShadow was presented and participating visitors were invited to use it for creating digital stories. One of these events took place in a primary school and the aim was to enhance the co-operation among children and between children and adults. Furthermore it aimed to familiarize children with Greek traditional shadow theater through eShadow as well as to trigger their imagination. The importance of this aim, for the people engaged, was to have better understanding with each other and then realize that co-operation between generations can have surprisingly better learning results.



**Fig. 9.** Students watching a play created with eShadow during the sessions in Chania.

The final output of this learning intervention was an actual Greek traditional shadow theater play which was created with eShadow and is entitled “Karagiozis and the IMF”. This play is addressing social issues that have arisen as a result of the economic crisis that hit Greece from 2009 onwards and it is available at: <http://www.youtube.com/watch?v=JXP-3ruCrv> This shadow play was used as an indicative example showcasing the capabilities of the software during another local event that was part of the annual Student Digital Creativity Festival that takes place in more than 15 cities all over Greece from 2010. **Fig. 9** depicts a group of visiting students with their teachers during this event.

### **5.3 Using eShadow in a Live Online Educational Event**

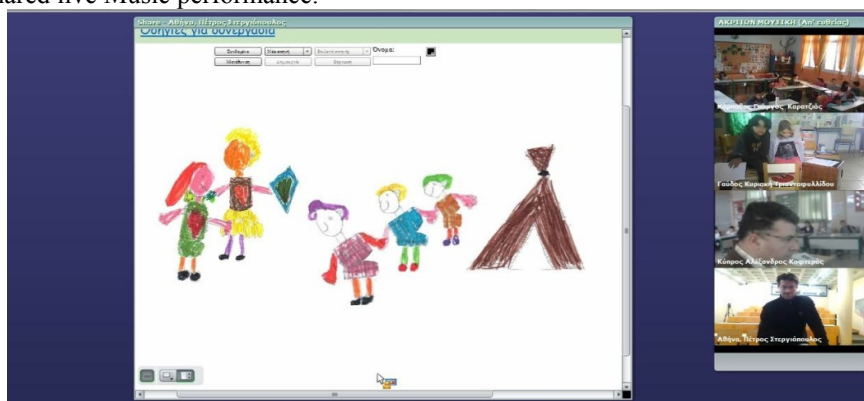
eShadow was used in "AKPITΩN MOYΣIKH (Akriton Mousiki)" which was a live interactive performance audiovisual event combining Music and eShadow and took place on April 2013. Akriton Mousiki was part of **D**istance learning **M**usic **A**goge (DMA - <http://dma.ea.gr>) and it was its fifth implementation.

Akriton Mousiki was a more ambitious implementation of DMA in two ways:

1. It was the first time in the program that 5 Greek remote areas were connected at the same time.
2. It was the first time that real time music visualization was used and it was achieved through eShadow.

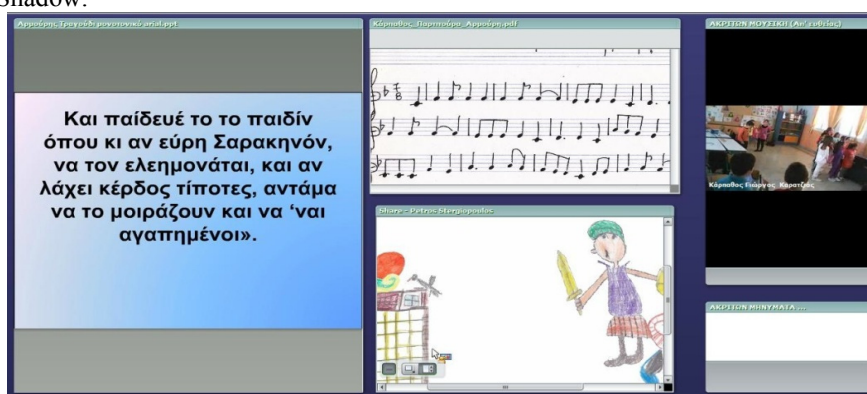
The performance was inspired by Greek Acritan heritage and included the collaborative preparation, co-creation and realization of an online event between multiple distant schools linked together via videoconference. During the linkcast (webcasted vide-

conference) pupils from four remote schools presented a virtual-stage role-playing educational activity by moving digital puppets (e-shadow platform) accompanied with shared live Music performance.



**Fig. 10.** Schools for Cyprus and Gavdos perform a scene of an Actitic song visualized using eShadow. The pupils from the Schools of Karpathos and Athens (coordinator) are watching.

The blueprint of the linkcast scenario was derived from the “Let Us Share The Music” activity recognized as a good practice from the Pedagogical Institute Good-Practices Database. The scenario involved pupils from Gavdos, Karpathos, Kastelorizo and Cyprus. An early version of the scenario was initially decided in which each participating school undertook the responsibility of preparing the musical presentation of a certain Acritic song while another school was responsible for visualizing the scenes from the selected song using eShadow. 4 songs were selected in total and each school had the responsibility of presenting one of them with music and one of them visually using eShadow.



**Fig. 11.** Karpathos school during a rehearsal.

The final scenario was based upon the educational needs of every site that took part on the event following the phases of the good practice. This final scenario included advanced interaction between five remote sites through live physical-instrument music

performance and digital images movement. Part of the dialogues performed by the students were arranged and prepared specifically for the event and they were based upon the Byzantine epos of Digenis Akritas.

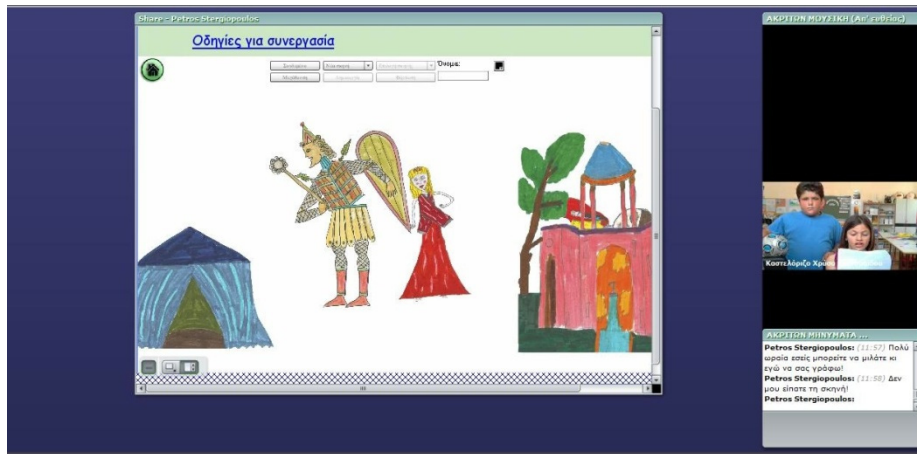


Fig. 12. Kastelorizo school during a rehearsal.

The planning of this event involved, trials, studying - finalization of the final scenario and rehearsals with teachers and students emulating as much as possible the duration of the final event.

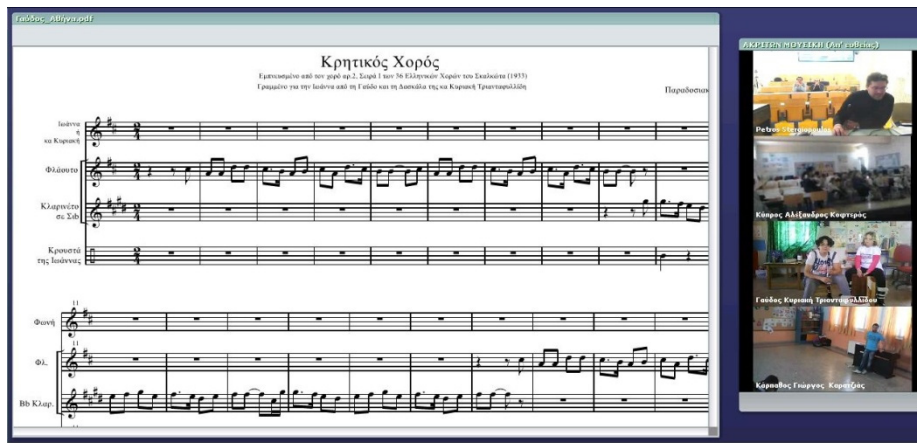


Fig. 13. Gavdos and Athens performing a sequence of music themes live. Karpathos turns the pages of the sheet music.

For the part of the event supported by eShadow (visualization of performed songs), children were asked to draw their own acritan puppets. Children's drawings were sub-

sequently scanned and processed with an image editing program in order to be converted into digital puppets and then imported to eShadow. When children saw their drawings moving like actual puppets, they were very excited, as their teachers stated. All the training of the teachers was accomplished through video-conference since physical presence was not possible. The participation of many remote users who are able to co-create a cultural event fulfills the basic and primordial characteristic of music creation that is the “Sympraxis” (=cooperation) of different people and cultures in order to co-create Music. Therefore, this approach showcases the new capabilities for creative expression brought about by digital technologies and emphasizes the use of eShadow as a tool to support the visual aspects of such complex collaborative workflows to prepare and implement rich multimedia performances.

## 6 Experimental Evaluation of eShadow

Apart from its extensive use in schools, continuing the learning interventions described in the previous section, eShadow has been thoroughly tested within the context of two field trials in order to evaluate its usability, user acceptance and educational added value. The first trial addressed school students of grades K-3 and above. The second addressed kindergarten and lower primary school grades (K-1 & K-2).

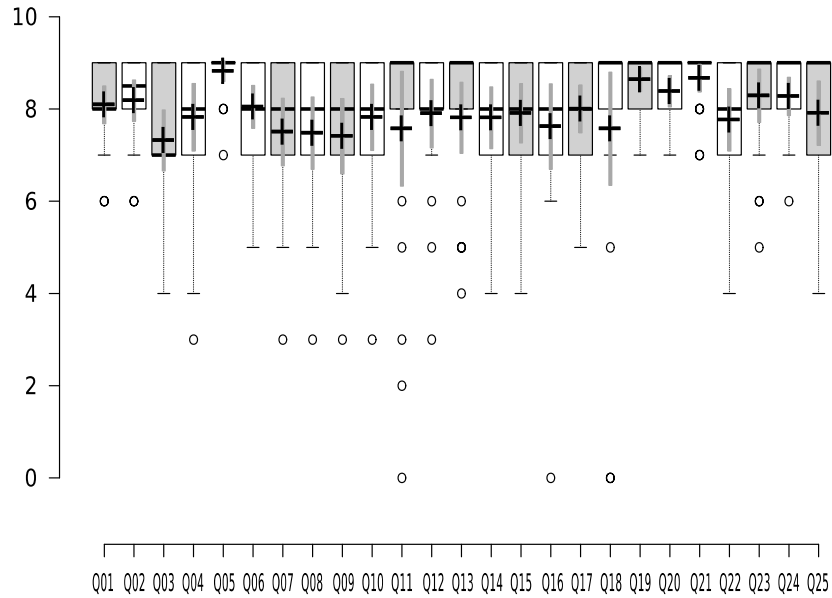
Both trials were organized the same way with different feedback questionnaires: During the trials, students first watched a digital story prepared with eShadow. After that they got the text script divided in nine scenes and formed groups with 2-4 members each. Every group used eShadow to perform and record a certain scene without any help beyond a short demonstration on the use of input devices to control the digital puppets. Every group had the option to improvise instead of recreating one of the nine story scenes. Finally, the students filled a questionnaire:

1. For the first trial the questionnaire used was an adapted version of QUIS, which is a standard user satisfaction measurement tool (Chin et al., 1988). It contained 25 rating questions to evaluate the creativity features and usability aspects of eShadow. 47 students filled this questionnaire.
2. For the second trial emoticon cards (Agarwal & Meyer, 2009) were used taking into account that most children up to grade K-2 cannot read fluently and, thus, the QUIS-based questionnaire would be inadequate. In total 61 filled questionnaires were collected.

The results of the first trial are shown in **Table 1**. It is clear that in all questions concerning the added value and educational potential of eShadow as a creative platform as well as its usability aspects, the students responded with high ratings. All mean values are above 7 with only one exception for question Q03 (Mean=6.76). More than one third of the mean values (9 out of 25) are greater or equal to 8.

**Table 1.** First trial results with 95% t-confidence interval.

Q	Question	Mean	Stand. Error	95% C.I.
01	I would create a story for personal expression 0-9	7,09	0,33	±0,67
02	I would create a story to share with friends 0-9	7,55	0,30	±0,60
03	I would create a story to transmit a message 0-9	6,76	0,40	±0,81
04	I would create a story to share what I learned 0-9	7,38	0,32	±0,63
05	I would watch stories created with eShadow 0-9	8,36	0,19	±0,37
06	eShadow can be used for learning 0-9	8,02	0,20	±0,40
07	Interacting with eShadow: difficult (0) – easy (9)	7,72	0,25	±0,51
08	Help messages: unhelpful (0) – helpful (9)	7,48	0,29	±0,58
09	Becoming an expert user: disagree (0) – agree (9)	7,43	0,32	±0,65
10	Easy to use: disagree (0) – agree (9)	7,91	0,24	±0,49
11	Reading the screen: difficult (0) – easy (9)	7,83	0,37	±0,75
12	Screen organization: confusing (0)–very clear (9)	8,33	0,19	±0,37
13	Screens sequencing: confusing (0) – very clear(9)	8,26	0,19	±0,38
14	Adequate terminology: never (0) – always (9)	7,98	0,20	±0,40
15	Messages' placement: confusing(0)–very clear(9)	7,91	0,19	±0,37
16	System state notifications: Never (0) – always (9)	7,69	0,28	±0,56
17	System speed: slow (0) – fast (9)	8,04	0,18	±0,37
18	Problems encountered: many (0) – none (9)	8,00	0,33	±0,67
Overall reactions to the system:				
19	Terrible (0) – wonderful (9)	8,62	0,08	±0,17
20	Frustrating (0) – satisfying (9)	7,89	0,30	±0,61
21	Dull (0) – stimulating (9)	8,17	0,28	±0,56
22	Difficult (0) – easy (9)	7,41	0,32	±0,65
23	Rigid (0) – flexible (9)	7,76	0,30	±0,60
24	Learning the system: difficult (0) – easy (9)	8,04	0,24	±0,48
25	Doing desired task:difficult (0) – easy (9)	7,93	0,24	±0,49



**Fig. 14.** Box plot of questionnaire responses. Mean values shown with crosses, media values with horizontal lines, outliers with “o” symbols.

**Fig. 14** provides a box plot of the ratings. It is evident that most ratings are very close or above the mean values already shown in Table I and depicted as crosses in the plot. There are few exceptional very low ratings that could be considered as outliers (small circles in the plot). It is worth noting that the majority of ratings are above or equal to seven (7) for all questions. Consequently, we could safely infer that the trial results clearly show high user acceptance, thus demonstrating the potential of eShadow. Furthermore, eShadow successfully communicates to students its educational value as a creative platform (questions Q01-Q06) and provokes positive reactions (Q19-Q25) especially regarding its stimulating nature (Q19).



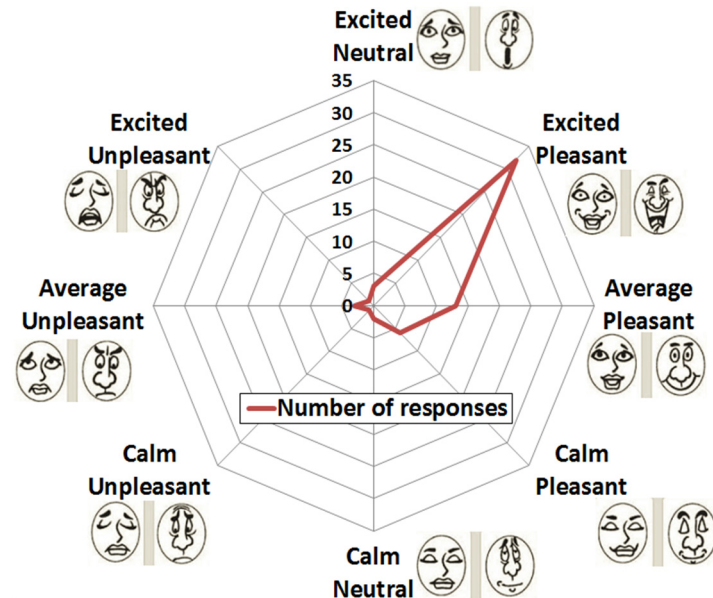
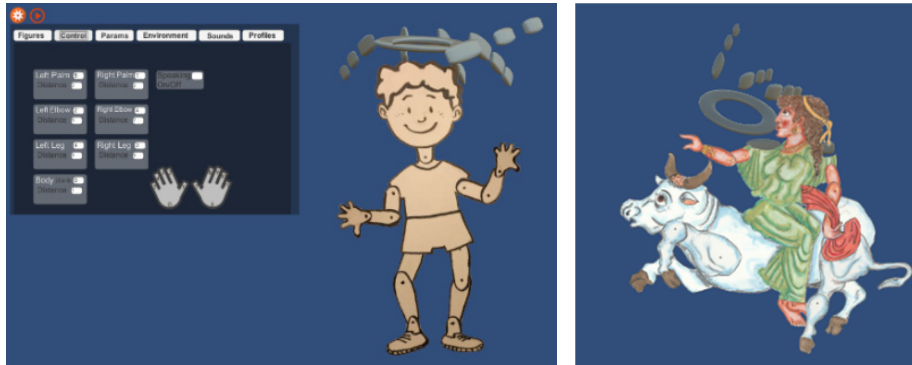


Fig. 15. Evaluation of emotional response using emoticons.

Fig. 15 depicts the results of the second trial evaluating the emotional response of younger children. These results are very positive as well showing that the vast majority of the children responded with excitement and pleasure to eShadow.

## 7 Extending eShadow to Support Digital Marionettes

Shadow theatre is a special form of theatre. Consequently, eShadow promotes the renovation of drama-based artistic forms by combining them with digital technologies and facilitating their effective use in formal education to promote learner engagement and creativity. To exploit this potential within a context that would link the initial positive use of eShadow to Western European traditions of storytelling (in particular marionettes) an extension of eShadow was implemented interfacing it with a LEAP motion device (“Leap motion”, n.d.) to enable control of digital puppets with fingers, thus simulating traditional marionettes (Fig. 16). The aim was to enable drama improvisations in real-time by interacting with digital puppets in cultural events organized by the Caravan Next project as well as to engage local schools in specially designed activities that take place before scheduled cultural events. During these activities students are invited to develop their own digital stories inspired by the theme of the forthcoming events.



**Fig. 16.** Special eShadow extension to support marionette-like interactions. Digital puppets are controlled with users' fingers via a Leap motion device. Controlling fingers are configurable through the panel shown in the screenshot on the left.

The software was evaluated during a pilot school project in the 5<sup>th</sup> Grade of the 19<sup>th</sup> Primary School of Chania in Crete, Greece, to create a digital story (available at: <https://youtu.be/GqiOaCejFxs>) using a digital marionette inspired by the myth of Europe. This was directly related to the theme of the Caravan Next micro event organized in Heraklion, Crete, Greece, in September 2016. The students were invited to research on the myths of EU countries and prepare a scenario showing mythical Europe traveling in these countries and learning about their corresponding myths. After finalizing their scenarios, the students were asked to prepare drawings on the myths they have selected. The drawings were subsequently scanned and used with the digital marionette software as background images. Finally, the students used the software to animate their story. After finishing their project, the students were asked to fill System Usability Scale (SUS) questionnaires (Brooke, 1996).

The analysis of the questionnaires revealed that the average rating by the participants was high (78.55%). However, in terms of learnability, the score was rather moderate. In particular, this refers to the results recorded in SUS questionnaire questions that directly address the learnability of the system. To further investigate the learnability issue, a second experiment was designed and conducted to investigate the source of this lower performance in terms of learnability. The hypothesis was that the poor performance was related to the inherent difficulty in controlling the specific digital marionette (depicted on the right side of **Fig. 16**). During this second experiment students were invited to use a different digital marionette (the one depicted on the left side of **Fig. 16**) that is easier to control. The results of this second experimental round confirmed the overall high score with respect to the usability of the software (total score 78.62%) showing an improvement of learnability score by 11.48% (from a sum of 4.53 to a sum of 5.05 for the two questionnaire questions measuring learnability).

## 8 Conclusions and Future Work

eShadow is an on-going project about an electronic shadow theater application inspired by Greek traditional shadow theater aiming at adapting traditional shadow theater in modern times, preserving traditional art as much as possible and make traditional shadow theater more popular as a learning tool for both children and adults. With eShadow users can create, record, share and watch digital shadow theater plays. It can accommodate virtual puppets inspired by fairy tales or children narratives, legends or historical figures as well. It supports intra-family communication scenarios that promote intergenerational bonding and playful learning. It also facilitates the implementation of learning scenarios in formal education following a project-based pedagogical framework adopting the five phases of the film making process: scenario development, pre-production, production, post-production and distribution.

The major conclusion of this work is that digital technologies renovate theatrical storytelling tradition by promoting active engagement in cultural events and creative learning in formal learning settings. It enables people to engage deeper with their cultural traditions and raise awareness about other cultures in a way that combines ICT in a creative and educationally significant framework. The use of digital technologies in school inspired by traditional shadow theatre, as it was observed, motivates students and promotes important social skills. The usability evaluation of the software demonstrated high usability scores. Further investigations are being done within the context of Erasmus+ projects e-ARTinED (<http://www.e-artined.eu/>) and MultiLib (<http://www.multilibproject.eu/>) to validate the potential of digital arts in formal and informal learning settings (Moumoutzis et al., 2017). Beyond schools, it should be noted that the new learning opportunities are created within informal learning settings as well in the case of exhibitions and cultural events also have a great potential and future plans include the use of eShadow in such events in a way that revitalizes cultural heritage assets such as myths, fairy tales and traditional stories. Finally, future plans include the development of a mobile app for facilitating the development of digital sceneries and digital puppets from photographs of paintings, icons and similar cultural assets so that it would be possible to animate stories inspired by representations found in such cultural assets.

## Acknowledgments

Parts of this work have been implemented within the context of OpenDiscoverySpace (FP7-ICT-PSP: 297229), ALICE (518106-LLP-1-2011-1-IT-GRUNDTVIG-GMP), e-ARTinED (2015-1-SE01-KA201-012267), CaravanNext (Creative Europe 559286) and the MultiLib (Erasmus+ ID 2016-1-SE01-KA201-022101) projects.

The authors thank Nikos Blazakis for supporting this work by allowing the use of his traditional shadow theatre puppet in digital format and also developing the original version of the marionette depicting the myth of Europe. They also thank Mrs. Aliki Vitoriou, teacher in the 19<sup>th</sup> Primary School of Chania, Crete, Greece and her students for participating in the evaluation of the digital marionette software.

## References

- Agarwal, A., & Meyer, A. (2009). Beyond usability: evaluating emotional response as an integral part of the user experience. In proceedings of the CHI EA '09 conference, 2009.
- Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability evaluation in industry* 189 (194), pp. 4-7.
- Chin, J., Diehl, V., Norman, K. (1988). Development of an instrument measuring user satisfaction of the human-computer interface. In proceedings of the CHI '88 conference: Human Factors in Computing Systems, 1988.
- Christoulakis, M., Pitsiladis, A., Stergiopoulos, P., Moumoutzis, N., Maragoudakis, G., & Christodoulakis, S. (2014). Creative collaborative experiences with interactive shadow theater. *Formazione & Insegnamento XII – 2 – 2014*, ISSN 1973-4778 print – 2279-7505 on line doi: 107346/-fei-XII-02-14\_17 Available online at: <http://ojs.pensamultimedia.it/index.php/siref/article/viewFile/876/848>
- Hatzigianni, M., Miller, M., & Quiñones, G. (2016). Karagiozis in Australia: Exploring principles of social justice in the arts for young children. In *International Journal of Education & the Arts*, 17(25), 2016.
- Leap Motion (n.d.). In Wikipedia. [https://en.wikipedia.org/wiki/Leap\\_Motion](https://en.wikipedia.org/wiki/Leap_Motion)
- Lu, F., Tian, F., Jiang, Y., Cao, X., Luo, W., Li, G., Zhang, X., Dai, G. and Wang, H. (2011). ShadowStory: creative and collaborative digital storytelling inspired by cultural heritage. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1919-1928). ACM.
- Lunce, C. (2011). Digital storytelling as an educational tool. *Indiana Libraries*, 30(1), 77-80.
- Moraiti A., Moumoutzis N., Christoulakis M., Pitsiladis A., Stylianakis G., Sifakis Y., Maragoudakis I., Christodoulakis S. (2016). Playful creation of digital stories with eShadow. 11th International Workshop on Semantic and Social Media Adaptation and Personalization (SMAP), Thessaloniki, 2016, pp. 139-144.
- Moumoutzis, N., Christoulakis, M., Pitsiladis, A., Maragoudakis, I., Christodoulakis, S., Menioudakis, M., Koutsabesi, J., Tzoganidis, M. (2017). Using new media arts to enable project-based learning in technological education. *Global Engineering Education Conference (EDUCON) 2017 IEEE*, pp. 287-296, ISSN 2165-9567.
- Vutborg, R., Kjeldskov, J., Pedell, S., & Vetere, F. (2010). Family storytelling for grandparents and grandchildren living apart. In *Proceedings of the 6th Nordic conference on human-computer interaction: Extending boundaries* (pp. 531-540). ACM.

Received: June 14, 2018

Reviewed: June 30, 2018

Finally Accepted: July 10, 2018