

eShadow LCE: Evolution of a Digital Shadow Theatre Platform to Support Analog Puppet Digitization and Collaboration

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Abstract. Shadow theatre is a culturally significant storytelling tradition that has evolved across centuries, with Greek “Karagiozis” standing out as a prominent example that blends humor, social commentary, and historical reflection. Despite its cultural value, the art form faces decline in the digital age. This is in sharp contrast to its educational potential to foster creativity, collaboration, and cultural awareness. Modern digital technologies offer promising solutions to help revitalize shadow theatre and make it accessible across schools to enable rich learning experiences. This paper presents eShadow LCE, an enhanced digital shadow theatre platform that supports real-time collaboration, simplified puppet creation through mobile-based computer vision and AI, and an inclusive methodology for classroom use. Used within the Stories4All Erasmus+ project, eShadow LCE was evaluated during a three-day teacher training event focused on digital storytelling, empathy, and inclusion. Findings from participant feedback and a standard user experience questionnaire demonstrate the platform’s strong usability and educational value.

Keywords: Digital Storytelling, Shadow Theatre, Digital Shadow Theatre, eShadow, Creative Learning, Inclusion.

1 Introduction

Shadow theatre is an ancient form of storytelling that utilizes flat, articulated figures to cast shadows on a translucent screen, creating dynamic narratives through the interplay of light and shadow. This art form has deep-rooted traditions in several countries, spanning from Greece to the Far East. The puppets are usually made from leather and are intricately carved and painted (Wayang kulit, 2026).

Greek shadow theatre, known as “Karagiozis”, became prominent during the Ottoman occupation of Greece. The central character, Karagiozis, is depicted as a cunning and impoverished Greek who frequently outwits authority figures. Karagiozis performances fulfilled several important roles in society. By dramatizing historical events and

folklore, this art form provided audiences with valuable insights into Greek history and cultural heritage. At the same time, the stories' humorous and satirical nature provided entertainment, making them widely enjoyed by both children and adults. Additionally, the narratives often served as a form of social commentary, critiquing societal norms and political situations, which encouraged reflection and discussion among viewers.

The evolution of Karagiozis in Greece reflects the country's socio-political changes. Initially influenced by Turkish shadow theatre, it gradually incorporated Greek elements, especially after the country's independence in the first half of the 19th century. The character of Karagiozis became a symbol of the Greek spirit, embodying resilience and wit (Karagiozis, 2026). In contemporary Greece, with the wide adoption of TV's and the rise of the internet, traditional shadow theatre has seen a steep decline. One of the last large-scale efforts to push shadow theatre into the mainstream was with the Karagiozis TV show by Evgenios Spatharis, which ran from 1966 up to 1992 to overwhelming public acclaim. However, it was inevitably taken over by more modern shows catering better to the interests of newer generations. Nowadays, Greek shadow theatre is limited to sporadic performances by local artists. Traditional figures and sceneries are in prominent display in institutions like the Spathario Museum of Shadow Theatre in Athens (<https://www.thisisathens.org/museums/spathario-museum-shadow-theatre>), ensuring that this cultural heritage remains accessible to future generations.

Shadow theatre can have a huge contribution potential in education (Hatzigianni et al., 2016). An ordinary theatrical play can be educative and thought-provocative. However, the form with the biggest education potential is the participatory form. Through the development of a shadow theatre play, students can develop their creativity, improve their speaking skills, and learn to interact with others in a constructive way. Shadow theatre can introduce forms and objects using the human body and voice. Additionally, in cases where the students derive from a country with a rich tradition in shadow theatre, giving shadow theatre a place in the classroom can help preserve this currently disappearing art and cultivate a sense of appreciation for the contributions of shadow theatre in modern multicultural classrooms.

One of the biggest obstacles in introducing traditional shadow theatre in classrooms is probably the installation and operation overhead of the shadow theatre stage, puppets, and scenery. It can prove to be quite a costly endeavor, requiring, in many cases, artistic and technical expertise that most schools simply cannot afford. However, the recent rise and democratization of modern technology have led to new, cheaper, and easier ways to replicate shadow theatre in classrooms, while preserving the core educational benefits it offers. Therefore, there have been a handful of notable endeavors at the international level of taking advantage of those digital technologies to create experiences that can benefit education and popularize shadow theatre once again.

This paper discusses such an approach that is based on previous solid work by the authors to offer a digital version of the traditional shadow theatre, namely, eShadow. The work reported in the paper builds on the previous work and adds new features that make the software highly usable, while at the same time offering effective collaboration in controlling the puppets in a scene. The new version of the software has been part of

the offer of the Stories4All Erasmus+ project, building a methodology for the educational use of digital storytelling, and has been evaluated during a 3-day training event reported here.

The rest of the paper is organized as follows: Section 2 presents the previous work based on which this paper further elaborates. Section 3 presents implementation details of eShadow LCE, the new version of eShadow. Section 4 presents how eShadow LCE has been used in the above-mentioned teacher training event that ended with an evaluation of the software and its educational potential. Section 5 presents the evaluation results. Section 6 concludes and presents plans for future work.

2 Previous Work and Current Contributions

2.1 eShadow and Its Evolution Towards eShadow LCE

eShadow is a digital storytelling platform inspired by traditional Greek shadow theatre, designed to blend cultural heritage with modern technology. It allows users to create, record, and share interactive digital performances using customizable digital puppets, sceneries, and scripts (Moumoutzis et al., 2022). The platform emphasizes creativity and engagement, providing an accessible way to experiment with storytelling techniques while preserving the artistic traditions of shadow theatre. eShadow has been used in educational settings to enhance learning, foster collaboration, and inspire creativity, making it a versatile tool for both formal and informal environments. Its adaptability and user-friendly interface make it suitable for a wide range of audiences, from students to cultural enthusiasts (Moumoutzis et al., 2022).

Despite its innovative features, eShadow has limitations that constrain its usability in collaborative and dynamic settings. One major limitation is the lack of real-time collaborative functionality, which prevents multiple users from simultaneously controlling puppets or contributing to a shared scene over a network. This absence of collaborative tools makes the platform less effective in group environments, particularly in educational or creative workshops where teamwork and interaction are key components.

Another significant challenge lies in the complexity of creating and adding new puppets and scenery objects. The process requires technical skills, such as isolating, cropping, and assembling puppet parts, as well as generating detailed JSON files to configure their structure. This technical barrier can discourage non-expert users, such as educators or students, from fully utilizing the platform’s potential, limiting its accessibility and hindering the creation of personalized content.

The eShadow LCE (Live Collaboration Edition) system that is presented in this paper aims to improve upon the original eShadow in two main aspects: puppet creation and puppet manipulation in a local collaborative setting, while keeping the functionality as tightly integrated, responsive, and user-friendly as possible.

The main idea consists of taking advantage of readily available smartphone capabilities, such as a high-resolution camera, as well as various input and communication interfaces integrated into the devices to expand upon the capabilities of the platform. The puppet creation part is to be able to work with both drawn parts as well as real-life

objects, such as trees, statues, and even be able to transform a person into a puppet in a fast but effective way, with minimal to no limitations as to what the source is. This goal is to be achieved by using powerful machine learning and computer vision algorithms running locally on the host device, as well as a small pinch of diffusion-based generative AI that will be able to give a more artistic feel to objects or people captured. The collaborative puppet manipulation aspect aims to allow multiple users to move their puppets simultaneously in real time using their smartphone’s touch screen as input.

2.2 Developing a Digital Storytelling Methodology for Inclusive Education

Based on the eShadow software, an early effort to put it in action within the framework of an elaborate pedagogical methodology was initiated within a project targeting four kindergartens in Thessaloniki, Greece (Hatzigianni et al., 2021). Following this initial successful learning intervention, Stories4All (2026), an Erasmus+ project, was initiated. This project aims at providing methodological and software tools for the educational use of digital storytelling, while, at the same time, promoting inclusion and cultural awareness in European classrooms. eShadow was selected as the main digital storytelling tool of the project.

In September 2025, following the developments of the Stories4All project regarding the development of its methodology, a 3-day training event was organized in Chania, Greece, to showcase the use of eShadow LCE, exploiting its new capabilities. Teachers and student teachers from the project countries had the opportunity to collaborate in inventing stories, creating the corresponding puppets and scenery objects, digitizing them via the eShadow LCE mobile app, and animating their stories using the software. At the end of the training, participants were asked to reflect on their experience and evaluate the software. The results are presented in this paper. They clearly demonstrate the usability of the software and its strong educational potential that is further explored in the last phase of the project when the project partners develop and put online a complete digital storytelling for education training program for educators.

3 eShadow LCE Implementation

eShadow LCE comprises multiple components interacting over a local network, spanning various devices and designed with modularity and ease of deployment in mind. Below, a diagram presents the system’s primary components, their interactions, and other relevant details.

The architecture distinguishes between four main components. The first is eShadow Companion (Mobile Application). Many users can be connected via their mobile devices. The corresponding mobile app has been built with Flutter (Google, 2026), aiming to maximize compatibility with the various mobile devices, the app serves as the main interface for users and provides access to all system core functionality. It acts in many ways similar to a frontend client application; however, it stands out by leveraging the

mobile device’s hardware (Hi-Res camera, touchscreen) as well as performing a great deal of processing tasks directly on the device.

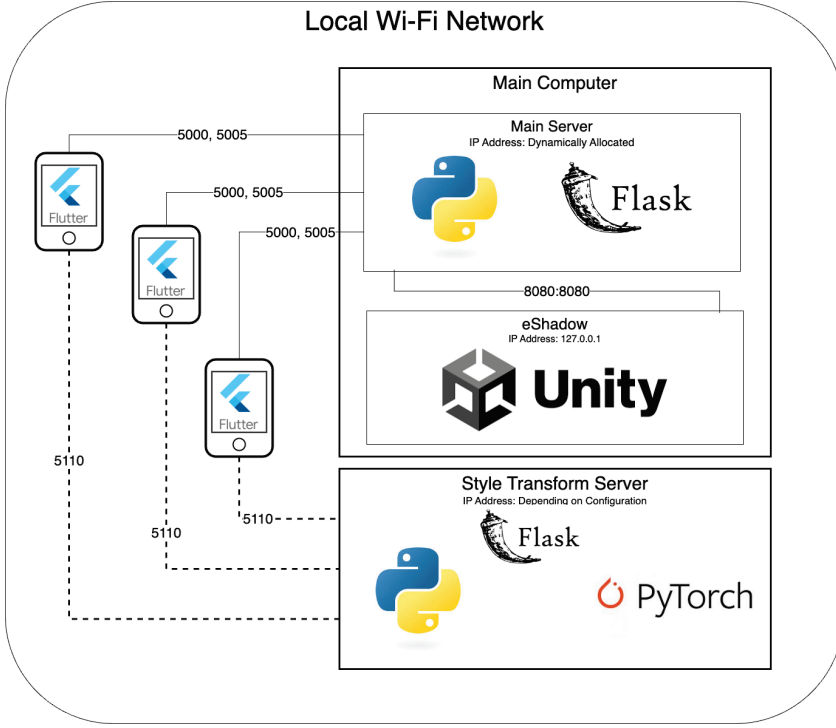


Fig. 1. eShadow LCE architecture.

The other major component is the Main Server. It runs on a desktop computer and it has been developed in the Python programming language using the Flask library (Pallets Projects, 2026) to facilitate communication. The main server acts as the primary gateway to the system’s functionality, while also facilitating interaction between the mobile application and the enhanced eShadow platform. This server leverages Python’s robust ecosystem of libraries to perform advanced image processing tasks as well as hosting an AI model for background removal.

The style Transform Server, developed also in the Python programming language with the Flask library (Pallets Projects, 2026) is used to facilitate communication. This server integrates the advanced PyTorch framework (Meta AI, 2026) to deliver machine learning capabilities, incorporating a combination of the Stable Diffusion model (Rombach et al., 2022), ControlNet (Zhang et al., 2023), and a custom LoRA (Hu et al., 2021) model trained on traditional Greek shadow theatre figures. The server provides a straightforward REST API, with a primary endpoint that accepts an input image, applies a style transformation, and returns the transformed image as output. Due to its resource-intensive nature, the system is designed to run efficiently on mid-to-upper tier computers equipped with CUDA-supported (NVIDIA Corporation, 2026) GPUs. Built

with modularity in mind, the server ensures that even in its absence, the system remains fully functional, albeit with one less feature.

Finally, the eShadow LCE (Unity Platform) serves as a virtual stage for real-time puppet manipulation and rendering. While preserving all the original eShadow functionality, it has been upgraded to integrate seamlessly with other components of the application. Additionally, it incorporates several quality-of-life enhancements designed to enhance the platform’s versatility and improve the overall user experience.

Communication between the above components is facilitated through RESTful APIs and UDP for some low-latency operations. In particular, the communication between components occurs within a local network where the corresponding IP addresses are shared using QR codes. To address functionality, the message is sent as the specific component’s IP address at the function’s pre-designated port number, utilizing HTTP or UDP protocols, depending on the operation. Below, we offer a detailed explanation of each port’s roles, functions, and the communication protocol it employs within each component.

The Main Server uses port 5000 (HTTP) to handle REST API requests from the Mobile Application for operations like background removal, segmentation, and puppet/scenery uploads. It also uses port 5005 (UDP) to receive low-latency control messages from the Mobile Application, which are relayed to the Unity platform. Finally, it uses port 8080 (HTTP) to communicate REST API requests as well as UDP messages to the Unity platform. The AI Server uses port 5110 (HTTP) to process AI-based style transformation requests from the Mobile Application. Finally, the Unity Platform uses port 8080 (UDP, HTTP) to handle how the Main Server sends low-latency commands for puppet and scenery control to the Puppet Server, as well as figure/scenery-related data.

For aspects regarding the user interface operations, the interested reader can see a complete video tutorial along with a link to download and install the software at eShadow LCE (2026). A selection of stories created with the software is also available there.

4 eShadow LCE Training Setup

The experimental evaluation of the eShadow LCE within the context of the digital storytelling methodology of the Stories4All project was done during a 3-day teachers’ training event with international and blended participation titled “STORIES4ALL – Exploring the Power of Digital Storytelling with eShadow: STEM, Empathy and Inclusion”.

The training was implemented from September 17th to 19th, 2025, in the city of Chania, Crete, Greece. The event brought together educators, artists, technologists, and students to explore how digital storytelling can promote empathy, inclusion, and social awareness through the creative use of technology. The workshop was organized by the Technical University of Crete and combined hands-on learning, artistic exploration, and social reflection. Participants were introduced to eShadow LCE and learned how to integrate it with design thinking methodology to create meaningful digital narratives.

The event opened with an inspiring introduction to shadow theatre, followed by sessions on the pedagogical framework and design thinking delivered by experts from the University of West Attica. Participants then formed hybrid working groups - mixing on-site and remote members - and began developing their own digital stories using both eShadow LCE and the Stories4All Community Platform. At the end of the first day, a social dinner was organized, featuring a live shadow theatre performance and an open discussion with the artists, offering participants a deeper understanding of the cultural roots and expressive power of traditional shadow theatre.

On the second day, participants visited the Municipal Art Gallery of Chania, where they were guided through the exhibition “Journeys in Art: Works from the Collection of the Bank of Greece.” Through the educational program “Odd and Even: Talking about Values through Art”, attendees explored how visual art can inspire dialogue about respect, freedom, justice, and empathy themes closely aligned with the training event goals.

The final day focused on the production of digital stories by each group and the presentation of results. Participants completed their digital storytelling projects, synthesizing multimedia materials collected during the workshop and producing short digital narratives that reflected both personal creativity and collaboration. Each group presented its final work, followed by a reflective evaluation session offering valuable feedback on the methodology and tools used. A questionnaire was also used to assess eShadow LCE. The results are presented in the next section.

All materials used during the training can be found on the dedicated activity space of the training event that is hosted in the project's Community Platform: https://stories4all.coursevo.com/course_page?course_id=792.

5 Experimental Results

19 participants registered for the training event. Their profiles are reflected in the pie chart below. Most of them were teachers or student teachers (36.8% in each category). 11 of the participants downloaded and used eShadow LCE during the training event. All of them filled out the special questionnaire for user experience evaluation. The results are reported next.

The User Experience Questionnaire – UEQ (Laugwitz et al., 2008) consists of 26 scales organized in 6 evaluation axes (Fig. 3) about **attractiveness** (overall impression), **perspicuity** (how easy is to get familiar with the software), **efficiency** (how easily the users can solve their tasks without unnecessary effort), **dependability** (evaluates if the users feel in control of the interaction), **stimulation** (how exciting and motivating is it to use the product), **novelty** (addresses the innovative and creative aspects). 11 questionnaires were collected from the participants as already stated. Filling out the questionnaire was a voluntary activity after the experience during the training event, as already presented.

I am (please select):
19 responses

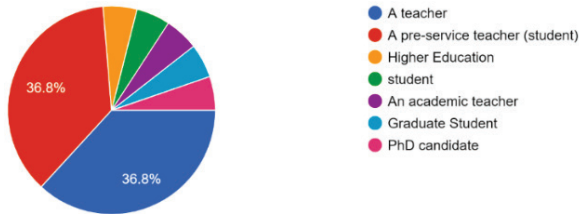


Fig. 2. Profiles of participants in the training event.

	1	2	3	4	5	6	7		
annoying	☐	☐	☐	☐	☐	☐	☐	enjoyable	1
not understandable	☐	☐	☐	☐	☐	☐	☐	understandable	2
creative	☐	☐	☐	☐	☐	☐	☐	dull	3
easy to learn	☐	☐	☐	☐	☐	☐	☐	difficult to learn	4
valuable	☐	☐	☐	☐	☐	☐	☐	inferior	5
boring	☐	☐	☐	☐	☐	☐	☐	exciting	6
not interesting	☐	☐	☐	☐	☐	☐	☐	interesting	7
unpredictable	☐	☐	☐	☐	☐	☐	☐	predictable	8
fast	☐	☐	☐	☐	☐	☐	☐	slow	9
inventive	☐	☐	☐	☐	☐	☐	☐	conventional	10
obstructive	☐	☐	☐	☐	☐	☐	☐	supportive	11
good	☐	☐	☐	☐	☐	☐	☐	bad	12
complicated	☐	☐	☐	☐	☐	☐	☐	easy	13
unlikable	☐	☐	☐	☐	☐	☐	☐	pleasing	14
usual	☐	☐	☐	☐	☐	☐	☐	leading edge	15
unpleasant	☐	☐	☐	☐	☐	☐	☐	pleasant	16
secure	☐	☐	☐	☐	☐	☐	☐	not secure	17
motivating	☐	☐	☐	☐	☐	☐	☐	demotivating	18
meets expectations	☐	☐	☐	☐	☐	☐	☐	does not meet expectations	19
inefficient	☐	☐	☐	☐	☐	☐	☐	efficient	20
clear	☐	☐	☐	☐	☐	☐	☐	confusing	21
impractical	☐	☐	☐	☐	☐	☐	☐	practical	22
organized	☐	☐	☐	☐	☐	☐	☐	cluttered	23
attractive	☐	☐	☐	☐	☐	☐	☐	unattractive	24
friendly	☐	☐	☐	☐	☐	☐	☐	unfriendly	25
conservative	☐	☐	☐	☐	☐	☐	☐	innovative	26

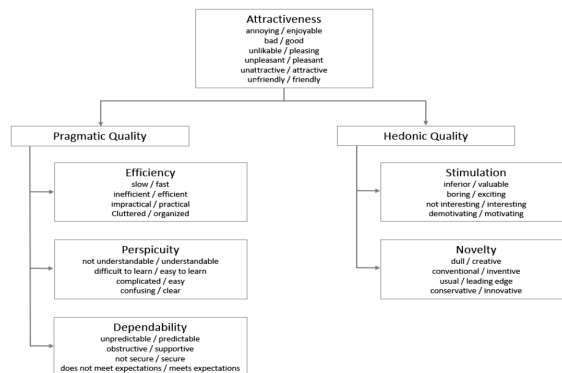


Fig. 3. User Experience Questionnaire scales and sections.

The results of the questionnaires are shown in Figure 4 below, on top of a benchmark graph that is provided by the UEQ questionnaire. The benchmark is designed to provide a meaningful context for interpreting evaluation scores by comparing the results to a large dataset of other evaluated artifacts. This is important because, on its own, a UEQ score does not indicate whether a the user experience is good or poor. Following this benchmark, as depicted in Figure 4, eShadow LCE scores **Excellent** in four out of the six evaluation axes, namely attractiveness, dependability, stimulation, and novelty. In the remaining two, namely perspicuity and efficiency, it scores **Above Average**. The detailed numbers are shown in Table 1.

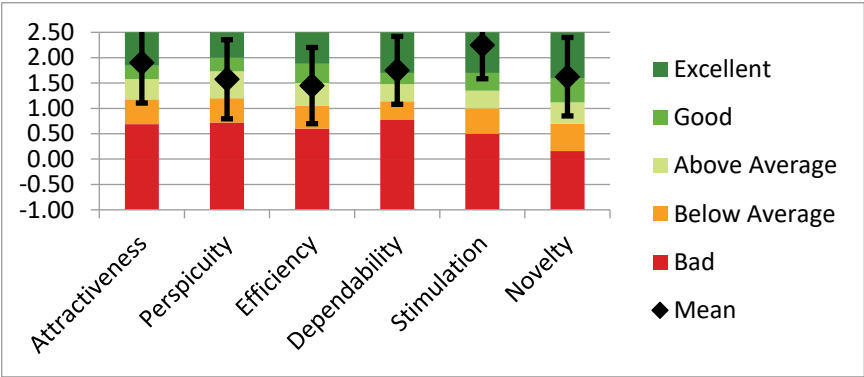


Fig. 4. UEQ results along with the questionnaire benchmark.

Table 1. Arithmetic results of the UEQ.

Scale	Mean	Comparison to benchmark	Interpretation
Attractiveness	1.90	Excellent	In the range of the 10% best results
Perspicuity	1.58	Above Average	25% of results better, 50% of results worse
Efficiency	1.45	Above Average	25% of results better, 50% of results worse
Dependability	1.75	Excellent	In the range of the 10% best results
Stimulation	2.25	Excellent	In the range of the 10% best results
Novelty	1.63	Excellent	In the range of the 10% best results

Apart from the UEQ scales, the questionnaire for the participants contained a number of questions regarding the evaluation of their training experience and their view regarding the potential of eShadow LCE. All participants who downloaded eShadow LCE reported that they were able to create a story with it. The free text comments they offered demonstrate their engagement and excitement when using the software. Some technical problems were experienced due to the blended nature of the training, but they have been overcome with the help of the technical team from the Technical University of Crete. Some indicative comments follow: “Thank you for this valuable experience”, “I’m truly Appreciate”, “Everything was very good organised!”, “The mobile app is

really user friendly”, “I think it would be interesting to have a teacher who regularly uses the software in their practice with children, speak about the challenges of the software, tricks and potential projects”, “This workshop was really enlightening and everyone was really helpful. I gained a lot of knowledge from this few days and i hope to develop a complete story in the future.”, “I am so grateful for this opportunity to learn and reflect this in my own teaching practices.”, “thanks for such a great workshop!”.

Regarding the usefulness of eShadow LCE for education, the free text responses of the participants to the question “Do you consider eShadow useful for education?” were the following: “Students can use it to practice, review, or shadow tasks step by step.”, “Absolutely yes”, “Yes very very much”, “Sure! It’s a more entertaining way of learning especially when it comes to children.”, “Very much”, “Absolutely”, “Yes, but with some restrictions - not every student has a mobile device, school doesn’t provide devices for students”, “Yes, but I am not sure if children can use it independently”, “Yes”, “Yes you can use it in various ways. While you teach History, art, other language. When you want your pupils be more emphatetic.”.

Furthermore, the participants were asked to identify the most favorable feature of eShadow LCE. Their answers were the following: “It turns theory into action by letting students learn through guided practice”, “I like it most that the drawings come to life with narration by this way”, “To mix different uploads drawings, photos”, All of them were good. I really couldn’t decide one!”, “Putting ourselves in it. It’s even more inclusive and can be more playful”, “The possibility of using it as a tool in lots of topics”, “Being able to make a puppet out of your photo”, “That it is quite easy when it works”, “The Mobile app”, “Everything looks nice but you cannot load more things from other apps. Sometimes it doesn’t work very fast”, “That you can add your own figures and sceneries so the possibilities are endless”.

Finally, the participants were asked to identify any missing features that could help using eShadow LCE in schools. They mainly identified voice recordings within the platform (currently, the recordings rely on Windows software) and its availability for Apple devices (currently, the mobile app is available only on Android devices and the server in MS Windows).

6 Conclusions and Future Plans

This paper presented eShadow LCE, an enhanced digital storytelling platform that revitalizes the tradition of shadow theatre by integrating modern technologies and supporting inclusive educational practices. Building on previous iterations of eShadow, the new system addresses major usability and collaboration limitations through advanced mobile-based puppet creation, AI-driven style transformation, and real-time multi-user manipulation. Its integration within the Stories4All Erasmus+ project demonstrates its pedagogical value, offering educators a powerful tool to promote creativity, cultural awareness, and collaboration in the classroom.

The results of the three-day international training event confirm the system’s strong usability and positive user reception, with UEQ scores ranking between Above Average and Excellent across all scales. Participants highlighted both its technical strengths and

educational potential, while also identifying areas for further improvement, such as integrated voice recording and broader device compatibility. Overall, eShadow LCE shows significant promise as an innovative digital medium for preserving cultural heritage and enriching contemporary educational environments.

eShadow LCE is currently integrated with a project of the Municipality of Chania addressing road safety issues and sustainable mobility. Within this project, several classes of local schools have the opportunity to develop their own stories, draw the corresponding characters and scenes, digitize, and animate them.

Future plans include the use of eShadow in major local events to enable rich learning experiences and the use of high-quality artworks, such as paintings, to develop digital stories, thus offering an experiential approach to the relationship between students and fine arts.

Acknowledgements

Parts of this work have been implemented within the context of the Erasmus+ project Stories4All - Developing Innovative Pedagogies and Tools to enable the Establishment and Sustenance of Communities of Educators Promoting Empathy and Social Inclusion via Digital Stories for All (reference number: 2023-1-DE01-KA220-HED-000164993). Details about the project and its results can be found at: <https://www.stories4all.tuc.gr/>.

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Received: March 15, 2026

Reviewed: April 20, 2026

Finally Accepted: May 15, 2026