Creativity and inclusiveness in elementary schools with Augmented Reality

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Creativity And Inclusiveness in Elementary Schools With Augmented Reality

Anna Osello, Carlotta Bin, Margherita Cassis, Nicola Rimella, Elisa Stradiotto, Guillaume Tarantola

Abstract

Augmented Reality in theatrical performances allows for the transcendence of stage limitations by exploring a space where the imaginary becomes a reality, enhancing educational offerings, creativity, inclusivity and accessibility. This technology was applied in the show "Il Piccolo Principe", staged in May 2023, and promoted by the primary schools of the Italian municipalities of Almese, Avigliana, and Villar Dora. The objective was to educate and include children and spectators using five different communicative modes: alphabetic, augmentative and alternative communication, audio, body expression, and Augmented Reality.

Parole chiave

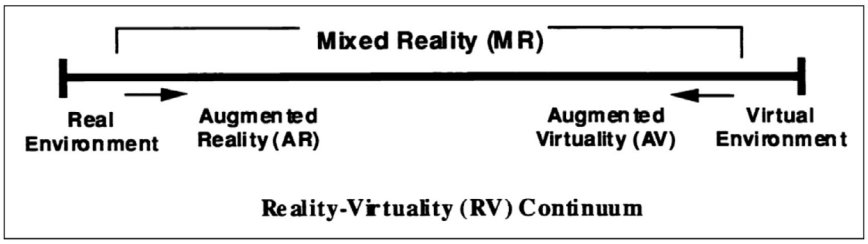
Augmented Reality; Disability; Inclusivity; Theatrical Performances; Accessibility

Introduction

The project, entitled "Il Piccolo Principe Inclusivo…Aumentato e Aumentativo", originated from a collaborative effort between Rotaract, Rotary Club Susa and Val Susa, the Municipality of Villar Dora, Polytechnic University of Turin, State High School "Oscar Romero" in Rivoli, Comprehensive Institute of Avigliana, and Primary Schools in Villar Dora and Almese. UNICEF provided its endorsement for this initiative. The project has achieved significant milestones, including the coordination Pathways for Transversal Skills and Orientation (PCTO), the development of an Augmented Reality (AR) application and the staging of the theatrical production "Il Piccolo Principe". It aimed to create a theatrical experience integrating traditional narrative techniques like physical expression, alphabetic and audio language with support tools for individuals with communication difficulties, like Alternative Augmentative Communication (AAC) and Augmented Reality (AR) technologies. The first part of the article presents an overview of the current landscape, examining the use of Augmented Reality in theatre, performances as a tool for social inclusion, and diverse communication methods to enhance the understanding of neurodivergent audiences. It then delves into the methodology used to structure and 'augment' the theatrical performance, which is organised into three main phases: research, development, and simulation. Finally, the article presents the results and concludes by discussing potential avenues for future developments based on the methodology presented.

State of the art

The integration of real and virtual dimensions represents a significant innovation in the field of performing arts and theatre, particularly when applied to experimental experiences to promote inclusivity and explore their potential in medical contexts. Theatre has long been engaged in interdisciplinary and multifaceted collaborations, combining technology and art forms to produce works that enrich and engage the full spectrum of human creativity. As a result, new technologies are a natural fit within theatrical experimentation. It can be argued that the core of theatre lies in the shared, immediate experience that connects actors with the audience (Pike, 2020). Consequently, it can be proposed that Virtual Reality technologies work best when they support rather than replace real performances (Jernigan, Fernandez, Pensyl, Shangping, 2009). Therefore, Augmented Reality (AR) practices are generally more suitable for theatre than Virtual Reality (VR). VR and AR occupy opposite ends of the Reality-Virtuality Continuum (fig. 1), a concept that illustrates the nuances of Mixed Reality (MR) between the real and virtual. Thus, AR serves to enhance the user's natural feedback with simulated cues through see-through devices where virtual images are superimposed upon the real environment (Milgram, Takemura, Utsumit, Kishino, 1994). When employed to enhance and enrich performances, AR enables the integration of innovative theatrical practices while maintaining traditional elements (Jernigan, Fernandez, Pensyl, Shangping, 2009). Projection-based AR technologies, for instance, facilitate the enhancement and support of actors in their artistry without replacing them (Pike, 2019). These technologies can be employed, through various methodologies, to enhance dynamic elements such as actors or their costumes (Lee, Kim, Heo, Kim, Shin, 2005), or static elements like props or set designs,



1/ Simplified representation of RV Continuum (Milgram, Takemura, Utsumit, Kishino, 1994)

creating a hybrid and flexible space on stage resulting from the intersection of real and virtual. These technologies have been found to be interesting to individuals with Autism Spectrum Disorder (ASD) and have the potential to significantly improve their performance in symbolic play (Weisberg, 2015), helping them grasp abstract social concepts (Bai, Blackwell, Coulouris, 2015).

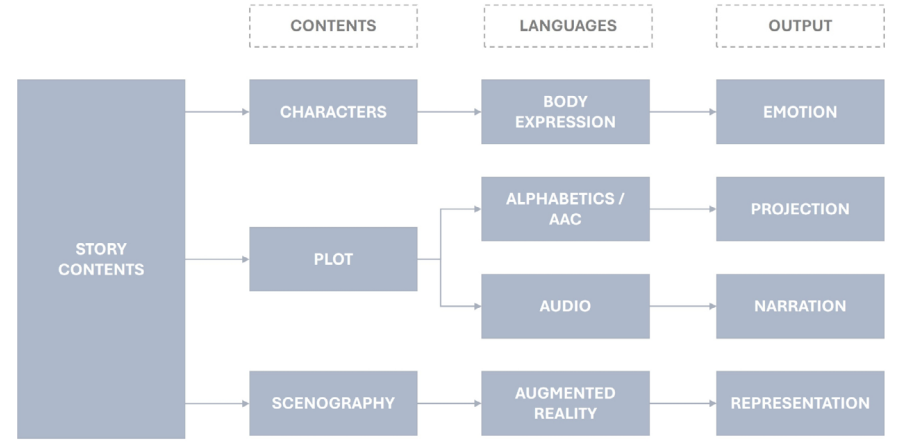
Individuals with ASD encounter a range of social challenges, including a lack of interpersonal interactions, verbal and non-verbal communication, and imagination (American Psychiatric Association, 2013). Theatre can be employed as a strategy to address the primary deficits related to the social sphere and interpersonal interactions of youth with ASD (Kim, et al., 2015). Indeed, as a form of social and interpersonal art, the theatre has the capacity, analogous to symbolic play, to create spaces where everyday norms and hierarchies are suspended and, on occasion, inverted, thereby creating opportunities for personal and collective change (Kim, et al., 2015). It has been demonstrated that young people transfer the skills acquired during theatrical activities into other aspects of their daily lives (Hughes, Wilson, 2004). The application of AR in theatrical activities is particularly relevant given that youth on the autism spectrum display a high level of interest in interactive media. Furthermore, research has shown that AR has a positive impact on social training and learning processes (Wang, Lee, 2020). The integration of words and images in the presentation of concepts facilitates the retention of information in both neurotypical and neurodivergent individuals. This phenomenon can be attributed to the fact that the human information processing system comprises two distinct channels: visual/pictorial and auditory/verbal. The concurrent use of both channels facilitates the acquisition of more comprehensive and enduring information (Meyer, 2002). Universal Design for Learning (UDL) extends and deepens the idea of using multiple communication channels simultaneously for knowledge transfer. This approach considers the characteristics and vulnerabilities of individuals, viewing the use of multiple and simultaneous ways of representation and expression as a means of making knowledge universally accessible, transcending individual limitations such as dyslexia or physical disabilities (Rose, 2000). AAC is a language that combines gestures, graphic symbols, verbal communication, and other resources to improve communication skills in individuals with ASD (Nunes, Barbosa, Nunes, 2021). In this instance as well, the utilisation of multiple languages serves to enhance the process of learning.

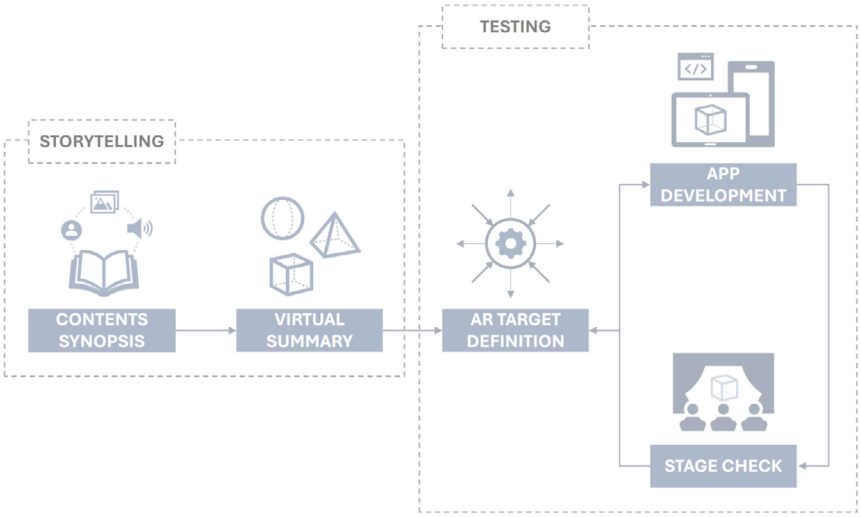
Methodology

The initial phase of work focused on defining the contents of the theatrical experience and planning activities within the PCTO program, which is managed by the "Oscar Romero" State Secondary School in Rivoli, with coordination from the primary school teachers involved and the Polytechnic of Turin. Fig. 2 presents the methodology adopted for selecting the main narrative elements from Antoine de Saint-Exupéry's story (Saint-Exupéry, 1943). The process began with studying the book "Il Piccolo Principe", published by Erickson in the "I Classici con la CAA" series (Scataglini, Bonanni, 2015). This integrated and multidisciplinary process involved several pivotal stages: extracting and selecting the main plot elements, determining the languages through which to convey them and the outputs used for their presentation. An initial analysis of the text was conducted to identify and extract key storyline elements. This phase required a comprehensive reading and understanding of the main themes, pivotal moments, and significant characters that form the backbone of the narrative. Special attention was given to the settings and protagonists of the story, aiming to integrate Augmented Reality elements into the stage space to enrich the visual representation of the scenery and create an immersive, interactive environment for the audience. Subsequently, the most appropriate languages used to convey these

contents were determined. Selecting these languages was crucial to ensuring effective, inclusive, and accessible transmission of the themes. This process involved choosing different expressive modalities such as verbal, visual, and multimedia languages, each selected to enhance and represent the narrative and scenic elements effectively. Finally, a series of tools were researched to improve the sharing and representation of themes and contents, thereby amplifying their impact. In particular, in defining the protagonists of the theatrical experience, the primary emotions and values expressed in various chapters of the story (e.g., courage, fear, imagination...) were identified and conveyed through physical expression, adding depth to the performance and guiding the style of the supporting scenery. The transmission of the main plot elements was represented using both video projections containing alphabetical and AAC languages and through the involvement of a narrator. Both approaches involved selecting and acquiring texts, adopting multi-language communication techniques to enhance accessibility and inclusion. The most significant part of the preliminary content definition work was dedicated to studying the scenery and stage objects.

Augmented Reality was the chosen communicative language, tested for flexibility and accessibility purposes, used to characterize characters and enrich the environment. Fig. 3 outlines the strategy adopted in the subsequent phase of theme development, structured by researchers from the Polytechnic of Turin, which enabled the development of a methodology to enhance its contents, utilizing AR capabilities. The next step involved translating the elements gathered in the first phase of research (Contents Synopsis) into multimedia material, with particular attention to identifying and defining three-dimensional models (Virtual Summary)





2/ Methodological framework for defining content, adopted languages, and desired outputs.

3/ Methodological framework for AR application development

that could be implemented in the theatrical representation. Graphic elements for scenery, props, and key characters of the story were identified. The realization of these models in the theatre space was made possible through an iterative approach of research, development, and simulation. Initially, the most effective and sustainable technological and practical solutions for defining AR targets capable of enhancing the theatrical experience were researched. For the development of the mobile application, Unity3d Game Engine software (Unity Technologies, 2024) and the Vuforia library (Vuforia Engine, 2024), an OpenSource tool that allows the association of three-dimensional models with virtual replicas of physical targets, were used. Both "Single-Image Target" and "Multi-Image Target" supports were adopted. The former consisted of individual 2D images (Vuforia Engine, 2024), displayed on vertical support panels and associated with static and animated 3D models to enrich the scenery and bring the performance settings to life. For proper camera recognition of the target on mobile devices, the images constituting the target needed to be highly detailed to provide an appropriate number of references. The latter (Vuforia Engine, 2024), made up of three-dimensional supports (fig. 4), enabled the virtualization of props and key characters of the story, allowing for easy fitting and ensuring freedom of movement within the theatre space. These targets could be recognized from all sides, ensuring recognition of references on every side of the support. The adoption of these targets helped minimize the use of bulky costumes, which could have created sensory difficulties for autistic individuals (American Psychiatric Association, 2013). Subsequently, a phase of development and programming of an application for Android mobile devices followed, along with testing to verify its effectiveness and stability in real environments. The decision to allow the use of the AR application by the audience attending the theatrical performance also necessitated programming a user guide on the application's usage to make users aware of its limitations and potentials. Development simulations (fig. 5) allowed for the calibration of supports concerning three different factors: the distance between the observation point and the AR target (fig. 6), actor movement, and varying intensities of lighting on the stage.

Results

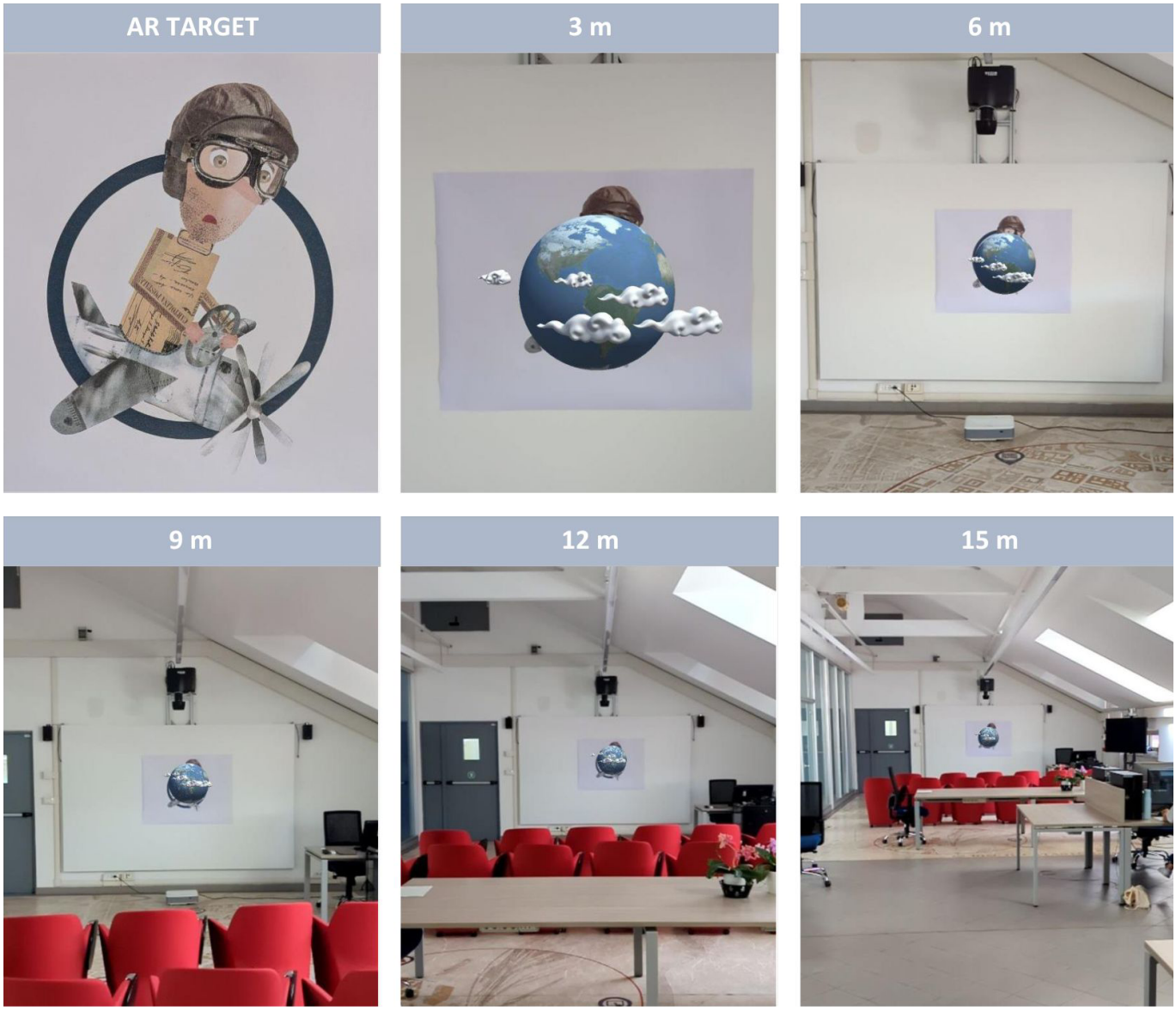
The performance, presented on May 12, 2023, marked the culmination of the project and collaboration among all initiative participants. Children and teachers contributed to designing the stage and props used during the show and played an active role in narrating the story through five communication modes. This transformed storytelling into an experience that stimulates creativity, curiosity, and engagement across audiences of all ages. The project successfully integrated the book "The Little

4/ "Multi-Image Target" definition.

5/ Simulations of the AR application during development on "Multi-Image Targets".

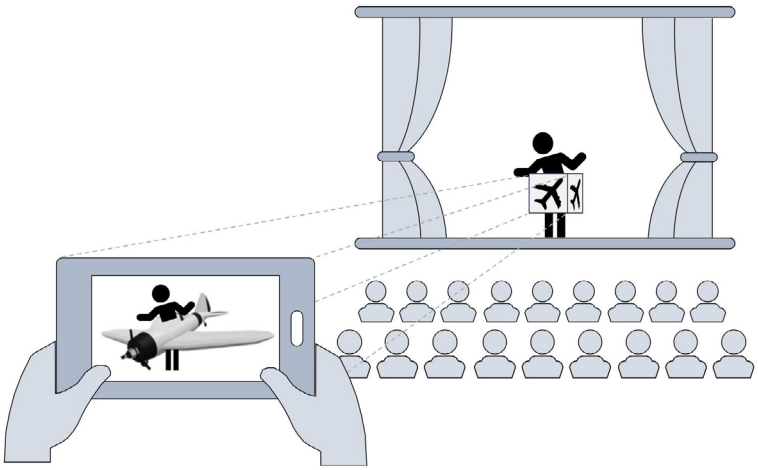
Prince" (Scataglini, Bonanni, 2015). Approximately 200 attendees downloaded the application developed by the Politecnico research team via a QR code before the show, enabling them to view visual and interactive elements that enhanced interaction and learning opportunities (fig. 7). Positive user feedback confirmed the application's ease of use and accessibility, making it suitable for a wide audience. AR targets were positioned on vertical panels to enhance the stage settings and on actors' costumes, transforming traditional storytelling into an interactive experience. During the performance, main actors wore costumes with targets, allowing the audience to interact with virtual AR content. This strategy enabled actors, including children and youths with disabilities and neurodivergent conditions, to actively participate in the experience, aiding communication and overcoming expressive difficulties (Tang, Xu, Winoto, 2019). Additionally, the application actively transported viewers to new visual environments, enriching the theatrical experience (Jernigan, Fernandez, Pensyl, Shangping, 2009). Such activities demonstrated that integrating augmented reality with theatre significantly enhances emotional and social skills among disabled children, facilitating understanding and expression of emotions and promoting more effective social interactions (Wang, Lee, 2020).

As a memento and outreach tool, themed bookmarks with AR targets were distributed to the audience following the event. The project received high praise from



6/ AR Target distance-dependent testing on 'Single-Image Target'.

the UNICEF/MIM 2023/2023 School Friend Project Examination Committee. The committee lauded the project as «commendable, excellent, complex, well-structured, and documented, addressing issues related to autism and the rights that must be ensured for persons with disabilities [...]».
The project highlighted how integrating real and virtual dimensions can offer flexible design elements, defining a new paradigm for space and service provision. AR technology made the theatre space versatile in terms of costs and time, establishing new staging strategies characterized by rapid and adaptable construction. This approach reduced production costs for stage designs, offering creative and dynamic solutions tailored to the specific needs of each performance (fig. 8). Overall, implementing AR technologies in theatrical contexts revealed significant educational and audience engagement benefits. However, there were areas identified for application improvement, such as AR target placement on the stage. Actor movement and audience distance from the stage posed challenges for content visualization in AR. Addressing these technical challenges will be crucial for enhancing application effectiveness and ensuring seamless interaction between the audience and virtual content. Moreover, distributing bookmarks with AR targets showcased how digital technologies can extend the educational experience and engage the audience even after the show ends. These findings suggest potential for integrating technology into contemporary theatre, enhancing accessibility and overall experience for all spectators. The implementation of diverse languages and communication strategies was essential to actively include not only actors with disabilities and neurodivergence but also the audience, thus transcending conventional stage limitations.



7/ Example of the use of methodology in performance.

8/ Simulations and tests with the children involved in the performance.

Conclusion

The methodology and execution of the theatrical experience showcased how the integration of Augmented Reality (AR) technologies can render the stage environment flexible and interactive. Virtual elements can be swiftly added, removed, or adapted without physical alterations to the sets and costumes. This not only saves time and resources in terms of sustainability but also opens up exciting creative possibilities. The ability to transport the audience virtually into fantastical worlds, without modifying the stage space, enhances the immersive experience and enables the enrichment of environments with scenery and effects that would be impractical or prohibitively expensive to create in reality. The adoption of diverse communication methods enhances inclusivity among the audience and enhances the learning experience, particularly for neurodivergent individuals. The achieved results have demonstrated how the methodology presented can be replicated and easily tailored to different contexts, making it a scalable strategy for both AR targets (characters, scenery, props, etc.) and the adaptable nature of spaces where it can be integrated. Future developments may include making the developed app more accessible for widespread use by the audience. Moreover, exploring and implementing alternative AR technologies, such as video projection mapping techniques with various applications for set backgrounds and character enhancements (Grundhöfer, Iwai, 2018), along with holograms noted in (Pi, Liu, Wang, 2022) as «one of the most promising 3D display technologies capable of reconstructing all depth cues of a 3D scene» could further advance these capabilities.

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