# STREEN – Designing Smart Environments for Story Reading with Children

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**Abstract.** Augmented e-books employ digital media to enhance the reading experience, and although they have the potential to promote the reader's engagement, so far the possibilities afforded by these technologies have been underexplored. In this article, we study the potential of literally transforming the space where reading takes place, in order to create superior reading experiences and foster the emergence of an immersive story universe, placing the reader in an imagined time and space. We present ongoing work on STREEN (Story Reading Environmental Enrichment), a smart environment for story reading. STREEN is able to trigger digital media enrichment depending on the reading performance and the narrative. We explain our innovation methodology that is based on an analysis of the design space to create a framework for a design thinking process. Additionally, we describe the first steps of using this methodology to explore and design STREEN solutions for primary school children.

**Keywords:** Augmented reading, Digital Media, Reading, Story, E-books, Smart Environments, Innovation Methods.

## 1 Introduction

The culture of reading is fundamental to the fabric of our society. The reading of stories in books is one of the cornerstones of almost any culture. By reading stories we enter new universes, discover new things, and nurture the development of the mind and the imagination. Acquiring reading skills plays a fundamental role in intellectual development [1]. Early childhood reading has significant cognitive benefits, as it strongly influences the development of vocabulary, promoting logical thinking and even facilitating the learning of mathematics [2]. Sullivan and Brown also report that reading for pleasure has more influence on the development of cognitive structures during adolescence than parental education [2].

Language develops naturally, however, the acquisition of new vocabulary, that is the learning of new words and concepts, is a social and interactive process [3] that depends largely on shared experience and development of common concepts [4]. The years up to the age of seven are critical for the development of grammar and vocabulary [5].

The learning of vocabulary plays a crucial role in learning to read [6] and paves the way for a good academic performance. Children and adults with a rich vocabulary can more easily create semantic networks and inferences between the words they read. This, in turn, produces more complete mental representations [7] and a better comprehension of the texts [6, 8–10]. Furthermore, the learning of vocabulary by inferring it from the context is more effective than direct vocabulary instruction [11–14].

A lack of vocabulary can have a significantly negative effect on people's reading abilities, which sometimes cannot be remedied, thus compromising their overall academic success [15, 16]. Indeed, such issues could have consequences throughout a life.

Story reading and enacting are an integrant part of a child's universe [17], providing the ideal context for stimulating language learning and reading comprehension skills. Moreover, stories promote cognitive, social and affective development [18–20], simultaneously nurturing the development of creativity and imagination [21]. Furthermore, stories help children to organize their thinking, to create sequences organized in time and in logical terms of cause and effect, while assisting in the development of a sense of the story structure [22]. Stories nurture the development of complex language structures, promoting the development of grammar, vocabulary, and sentence formation [19]. In addition to this, stories act as a "memory framework" that helps to understand [23] and facilitate the construction of meaning and the creation of new stories [24]. In this sense stories underpin a holistic development of the self.

## 2 From Paper to Digital

In the recent years, the main technological evolution of the book so far has been focused on transforming paper pages into digital pages [25]. As a result there has been a shift in the materiality of the book, and most importantly in the way we read [26]. A challenging implication is that e-reading typically involves distractive multifunctional devices, in which readers may find it difficult to engage in "Deep Reading". Wolf and Barzillai [27] have emphasized that e-reading is endangering the processes that propel reading comprehension, hampering inferential and deductive reasoning, analogical skills, critical analysis, reflection, and insight. Consequently, using flexible multitasking devices to read may contribute to the contemporary decline of reading skills. The question is whether it is possible to mitigate this situation in a society in which the use of e-reading devices is rapidly increasing. The conservative, cautious solution is certainly to limit the use of e-readers, tablets and smartphones, e.g. by denying children access to them and going back to paper books. Although we fully acknowledge the value of traditional reading experiences, we still envision alternative

approaches to reading, providing not only disadvantages and risks, but also opportunities, potentials, and new experiences. Specifically, we are investigating ways to employ digital media to improve, deepen and intensify, instead of diminishing the reading experience. This can be achieved by stimulating involvement, enjoyment, immersion, and ultimately triggering intrinsic motivation. Readers who are intrinsically motivated are more likely to benefit from and achieve a deeper learning [28]. Nowadays, computing devices are widespread and invisibly embedded in everyday ambient items, sensing and reacting to the presence and activity of human beings. Such devices provide a unique opportunity to leverage the reading activity to a new level, where reading is no longer limited to the physicality of the book, whether it is screen or paper, and where the motivation to read prevents readers from getting distracted by the other functionalities of their mobile devices.

In this context Kuzmičová [29] suggested that reading skills could be enhanced through artificial environmental propping, suggesting for example that early readers could be exposed to sensory stimuli corresponding to the settings of a narrative they read. He proposes that such artificial environmental stimuli can serve as a prop for triggering mental imagery and/or more generally a locus of pleasure, defending that these functionalities are especially relevant while reading complex narratives, because they make the story more salient and vivid in the reader's mind, preventing him/her from losing interest.

In *A History of Readings*, Manguel denotes that a space can be transformed by reading in it [30]. We envision that different aspects of intrinsic motivation such as involvement or social interaction [31] can be promoted by transforming the space where reading takes place. In this article, we present ongoing work on STREEN (Story Reading Environmental Enrichment), a smart environment for story reading. STREEN represents an artificial environment where digital media infrastructures are able to proactively and reactively trigger digital media enrichments, depending on the reading performance and the narrative itself [32]. For instance, with STREEN, a mobile device is able to display the text of a story, and at the same time identify the reading position and control an artificial environment composed by digital media infrastructures such as light or speakers.

Besides promoting “Deep Reading”, another important aspect of STREEN, is to explore new contexts and forms of social interaction. The scale of the display of a smartphone or tablet where users can read stories has a restrictive impact on the scale of the social interaction [33], merely allowing two or three users to read simultaneously. Conversely, our concept allows several persons or groups (e.g. classroom, museums or a library) to simultaneously interact with a narrative, therefore supporting additional forms of social interaction. For example, a narrator should be able to control digital media enrichments through gestures or voice intonation [32]. Such functionalities can be used for promoting social activities such as reading aloud for an audience.

# 3 Related Work

In *Suggestions d'avenir: La fin des livres*, Octave Uzanne and Albert Robida [34] envisioned the replacement of written content with pocket-sized audio players. This publication was probably the first invocation of a technological metamorphose of the book, and a vision of its multimodal and multisensorial future.

## 3.1 Augmentation of the Book

A significant number of studies have investigated how to digitally augment the book. One century after *Suggestions d'avenir: La fin des livres* the MagicBook project[35] explored the potential of augmented reality to enrich the reading experience. With the MagicBook, a reader can visualize 2D and 3D graphics and animations emerging from the paper pages.

The SequenceBook [36] is an interactive book with blank pages that serves as a medium for a dynamic projection that depends on the current page. The FingerLink [37], developed by Fujitsu Technologies, extends this concept by allowing the position of the fingers to control the projection. Another interesting concept that aims at complementing the book is the Marginalia prototype [38]; it expands on the experience of a textbook with a margin extension on a fold-out screen. The margin space allows readers to add digital notes to the physical object. Bridging Book [39] is conceptually similar to Marginalia and consists of a printed book and a tablet, placed side by side with synchronized digital and physical content. The page selection triggers the device to display corresponding digital content. "Wuxia the fox" [40] is a commercial example of a paper book that can be paired with an app running on a tablet, which explores audio-visual content that reacts to the voice telling the story.

Another interesting trend is the physical augmentation of the book itself. The Electronic Popables [41] are basically pop-up books that extend the traditional pop-up book experience with the control of lights, sounds and mechanical movements. Blink [42] integrates the digital content into physical books via circuits printed in conductive ink on the same page as the text. These printed buttons (links) communicate with nearby digital devices, providing access to any kind of digital content, like a web page, a video, or music.

## 3.2 Smart Environments to Support the Reading Activity

Notably, only a small number of studies have been conducted in the area of ubiquitous environments which include digital media enrichments that react to the reading activity. The SIT book [43] is a prototype that uses the speed of the reader's hands as a control parameter for a narrative soundscape (music and sound effects). The Listen Reader System [44] builds on the SIT Book project and uses sound as a foreground element, conveying information about what is currently being read. The Listen Reader System has a multilayered interactive soundtrack with music and sound effects that are triggered by the user's actions.

Bahna and Jacob [45] presented an interesting concept of peripheral augmentation, consisting of an interactive technique for computer-based reading, in which extra information is peripherally conveyed through a video projection. More recently, Alam et al. [46] proposed the Haptic e-book, a system capable of augmenting an e-book reading experience by controlling haptic interfaces and an audio-visual system installed in a living room. Schafer et al. [47], developed the cyber-physical LIT KIT, a system that augments a printed children's picture book. LIT KIT transforms read-aloud into a multimedia, mixed-reality experience projected in a room. The system contextualizes the language and provides feedback supporting children's enjoyment and meaning-making. "Disney Table lamp" [48] is able to automatically change the light colour whenever a reader turns a page in the e-book. In addition, another interesting approach is the usage of robots and embodied virtual agents, which are able to react to the reading activity [49].

Although the work described above successfully explored the sensorial dimension of environmental reading enrichments (with a special focus on visual or auditory feedback), the concepts used in these studies did not fully explore the potential of a smart environment that enriches the reading experience itself in relation to the reading performance and the narrative content. Indeed, aspects such as synchronizing narrative elements with digital media enrichments, or mapping the characteristics of the reading performance to environmental effects remain underexplored. We aim to uncover these aspects by exploring two different synchronization approaches: accessing the reading position via speech recognition for reading-aloud scenarios, and eye tracking for scenarios where someone reads alone and silently. When it comes to reading aloud, we are exploring how to use the expressiveness of the reader's body and voice in order to trigger, synchronize and modulate the appropriate digital media enrichment, e.g. isolating features of the speech (e.g. speed, intonation, emotion), as well as analysing body gestures and facial expressions.

## 4 Design Process

Our research aims at discovering innovative and useful ways of synchronizing the reading performance and the narrative with one or more digital media experiences, thus enriching the story reading experience. For this, we have built on Design Based Research and Design Space Exploration, as well as on Participatory and Co-design methods. The methods were chosen in order to meet our overall research goal, namely, to discover the most innovative, promising, useful and enjoyable solutions within a vast space of opportunities. Thus, the delimitation and organization of the space of possibilities is a crucial factor within our research; hence the importance of a continuous development of an organized representation of the design space. Innovative methods such as Design Thinking [50] respond to the innovation quest, while a particular weight on Design Based Research (cf. below) is related to our current focus on primary school scenarios.

Design Based Research (DBR) is increasingly being used in educational contexts, especially in connection with technological interventions [51]. By definition a crucial part of DBR is the design of pedagogical materials/tools (e.g. learning activities, or

technological tools). One of the characteristics of DBR is that it takes place in real educational settings where a significant technological intervention is designed and tested in a partnership between researchers and practitioners. The design process starts by analysing the design goal (typically driven by a problem or improvement), assessing the local context, and collecting information about relevant literature. Design Based Research is practice driven, flexible and iterative and typically evolves through prototypes in a cyclical process of designing, testing and redesigning. The design process evolves from practical design principles, patterns, and/or grounded theories and leads to new knowledge and theoretical and empirically founded products. As a result, the DBR methodology is intended to result in newly adopted educational practices [51] with the goal of producing design principles that can support upcoming projects [52].

A central activity in our design process is the incremental construction and analysis of the design space. This activity implies the encoding of the full range of formal solutions to the innovative quest of developing novel augmented reading systems. In practice, the process of designing a specific STREEN demonstrator will be guided by the exploration and definition of a parametric model that aims at encompassing all possible solutions to the problem. Thus, every possible augmented reading system defined with this parametric model exists somewhere within the design space. Considering a simplified design with two dimensions—input modality and output modality—we could easily conceive different artefacts, for example a touch based input modality could detect the progression of the narrative and an auditory output modality could reproduce music that would intensify the reading experience. Simply by inserting different parameters in these two dimensions we can quickly envision a new augmented reading system artefact, e.g. speech based input/vision based output.

Our method combines the exploration of the design space dimensions with a human-centred approach. We use the multidimensional spectrum of the design space as a framework to support ideation and the exploration of various possibilities. We start with an analysis of the design space, i.e. the manifold dimensions that determine the space of potential augmented reading systems. The design space analysis functions as a framework that helps system designers to decide on where to look at in order to explore a potentially innovative solution. This design space based approach also fosters a fundamental aspect of Design Thinking, namely that of thinking concretely, example based, and visually. This approach facilitates the visualization of ideas, as well as their categorization, organization, and the discovery of their relationships.

Thus, the multidimensional spectrum of the augmented reading design space offers a tool for exploration and ideation, while the user-centred design process is guided by design thinking principles. These include users' participation that actively contributes to the design of new solutions. Such an approach implies establishing a core co-design team of potential users that participate in design activities and a core team of professional digital system designers. As part of the co-design process various techniques and tools are used, such as brainstorming, storytelling, design workshops, and continuous low-fi prototyping.

We based our methodology on DBR logic by adding the goal of an incremental construction of the design space and an incremental construction of a STREEN technological platform (Fig. 1).

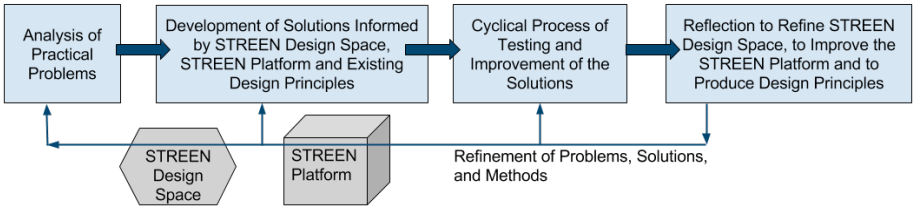


**Fig. 1.** Adapted Design-based research in four phases[52].

### 4.1 Designing STREEN Solutions for Primary School Children

Based on the design process mentioned above we are currently exploring and designing STREEN solutions for primary school children. Our goal is to create a joyful reading environment that encourages children to read and stimulating their reading skills. The design process encompasses researchers, teachers and children will collaborate and contribute to the design process. The older children enrolled in the third and fourth grade have a special co-designer role, whereby they take various roles helping in different parts of the analysis-design-evaluation cycle, e.g., carrying out fieldwork (following instructions from the design team) interviewing their mates, documenting the design process (by taking photos, etc.), discovering concepts, developing and testing prototypes.

As part of the analysis/exploration phase of the design process, we have conducted a workshop with two focus groups of teachers from a local primary school targeting the following objectives: a) present and discuss the concept of STREEN with teachers and b) identify/characterize the reading activities typically carried out at school that can potentially be complemented by an augmented reading concept. Each focus group was composed of four teachers, in total seven females and one male, with ages ranging from 33 to 51 years of age. The workshop lasted for three hours and took place after school in the classroom of a primary school. After presenting and discussing the STREEN concept we asked the teachers to identify and characterize the various reading activities that take place at school. The two groups worked independently and each described 19 different reading activities. We then asked each group to select three reading modalities that could potentially be enriched. “Lesekiste”, “Lies mal! - Hefte”, and “Ganzschrift/Lesemütter/Schmökerei” were recommended by the teachers as reading activities that could be improved by digital media. Briefly explained, “Lesekiste” means choosing a book to read and identifying objects that are related to the story. After reading the book, the child prepares a shoebox by placing objects related with the story inside, and then writes the title and author of the book on the outside of the box. After that the child writes a sentence about each object. “Lies mal! - Hefte”[1] are booklets mainly with pictures that are

[1] See commercial examples of Lies-mal-Hefte at: https://jandorfverlag.de/lesen/

associated with words or simple short sentences that intend to motivate beginners in reading. “Ganzschrift/Lesemütter/Schmökerei” takes place at the school library or at home, and a family member, e.g. grandparents, parents, reads for/with the children.

After choosing the reading modalities, each group selected the most suitable types of enrichments for each of the three modalities based on its appropriateness. Afterwards, we asked each group to choose from the three referred reading modalities the one they considered could benefit the most when enriched by digital media. At the end of this activity each group presented its conclusions to the other workshop participants describing the activity, the type of enrichment that could be used and explaining how such enrichments would enrich the reading experience.

Group one chose the reading modality “Lesekiste”, supporting their choice on the characteristics of this modality. Namely, “Lesekiste” is an individually designed activity that takes place in the classroom, in which a student presents the plot and reads aloud to an audience (colleagues and teacher), followed by an exchange of ideas and discussion about the text between the reader/performer and the audience. Group one considered that the reading performance would be visually and auditory enhanced through digital media, bringing images to life, therefore creating a high degree of motivation and involvement. Further, they mentioned that the digital media enrichments would better engage the listeners, increasing not only the listener’s motivation but also their motivation to discuss the story. Interestingly, the teachers saw a great opportunity to motivate boys to read, seeing the use of the technology as a way to counter poor interest in reading. In fact, the teachers reported that from their own experience boys are often less motivated readers, and more motivated by technology.

The second group chose the reading modality “Lies mal! - Hefte”, a tool that helps beginners start to read their first words and small sentences alone, and then paint what they have understood. The teachers see the potential of the digital media enrichment in highlighting the letters as they are being read, namely, while the child is reading a word the next/following letter is highlighted, e.g. with the word U-F-O, first the U is highlighted, then the F and then the O, in synchronization with children’s reading. As soon as the child reads the complete word, then the corresponding picture appears. Subsequently, the word should be read in a sentence, e.g. the UFO comes from space.

Furthermore, they felt that immediate feedback (through digital media enrichment) would promote interest and success, at the same time it would accommodate individual reading and support individual reading speed. On a whole, they considered that such a system would promote vocabulary enrichment, provide word and sentence guidance as well as be appropriate for learning German as a second language.

## 5 Scenarios

Based on the results obtained from the first interactions with teachers, we developed two exploratory scenarios that are related to the reading activities rationale and the envisioned STREEN capabilities. These scenarios served as input to identify the design space dimensions and consequently establish our base design space model. This model will be then incrementally adapted through the cyclical process of

designing, testing and re-designing until it becomes a fully functioning tool supporting future developmental efforts. The ultimate goal is to allow designers to cross new scenarios with the multidimensional spectrum of the design space in the interest of discovering innovative designs for augmented reading systems that enhance the traditional reading experience or that even offer completely novel kinds of reading activities.

### 5.1 Reading Alone: The "Deep Reading" Scenario

Individuals reading with flexible multitasking devices such as a smartphone may have difficulties reading in depth. Reading in digital format promotes the usage of speed-reading techniques such as skimming [26]. The ability humans have to produce stimulus-independent thoughts (mind wandering) allied with the usage of devices that provide a plethora of functionalities certainly contribute to an increasingly "distracted" society [53]. This "distraction" may endanger readers' capacities to engage in "Deep Reading" [27, 53]. "Deep Reading" is a contemplative-reading technique that requires the reader to go inside himself/herself, to find meaning, and to reflect upon what he has read. This implies slowing down the reading activity in order to really capture the message. "Deep Reading" is a way of reflecting on the world and about ourselves, while improving skills that are becoming more and more scarce in our society: the ability to pay attention and to focus [53].

It can be very challenging to encourage people to practice "Deep Reading", and we believe that augmented reading systems come in handy for such focused reading experiences, when they employ neurofeedback to provide appropriate control loops. Since reading is a high attentional activity, demanding constant or very frequent foreground visual attention, STREEN focuses on stimulating the peripheral awareness. This peripheral interaction aims to subtly augment the surrounding space with cues that depend on the reader's current brain activity; for example using ambient lights or a soundscape. Indeed, the peripheral stimulation is controlled depending on the current attentional capacity of the reader, e.g. depending on the reader's brain activity the stimulation is reduced or another stimulation medium is selected.

Imagine the following situation: A young girl goes to the library to read in a reading carrel. After sitting down, she says out loud, "I want to read in a forest," and the walls immediately turn green, the images of trees appear displayed on the walls and the sound of birds chirping begins to be heard. She picks up the e-reader and searches for a book to read. She begins to read a rather complex narrative, which takes place in a region and culture that she does not know. As the complexity of the narrative increases she progressively loses focus. Thanks to an eye tracking system [54] (optionally a headband that monitors brain activity [55, 56]) the system detects the loss of focus and progressively begins to synchronize reading with artificial environmental props. As the reader goes over a passage where the main character comes to a wild island, the sounds of the forest are progressively replaced by the sounds of seagulls, waves, etc. The walls of the reading carrel take on a bluish tonality, mysterious music intensifies the narrative and the diffusion of a maritime scent stimulates the reader's olfactory sense. This artificial and automatic enrichment

of the narrative calmly stimulates the reader's imagination making the story more salient in her mind, preventing her from losing interest, and instead triggering her curiosity and attention. Furthermore, the reading carrel also allows readers to share their interpretations, thus creating a feeling of reading together while alone [57].

In this imaginary scenario, we have exemplified how an augmented reading system can be used to prevent the reader from losing focus. The approach here is to provide digital media enrichments contextualized with the narrative whenever the reader starts to lose focus, having therefore an assistive function. Certainly, other approaches are possible; in fact, enrichments could be used as a gamification element that motivates readers to stay focused on the narrative. In this regard, the digital enrichment can act as a reward element when the reader is focused on the narrative, or in opposition, the digital enrichment fades away whenever the reader is losing concentration. Although there is an obvious need for validation of these approaches, we consider that this scenario clearly highlights the potential of STREEN.

### 5.2 Reading in Social Context: The "Reader's Theatre" Scenario

Enacting stories is a powerful way of involving children in literacy activities [17]. Like in a theatre play [58, 59], children can perform the narrative by acting out different roles and embodying the characters. Narrative performance [60, 61], such as the dramatic play of narratives, is essentially an act of embodied communication [62, 63], which is created and negotiated with others [64], acting as social mediator while helping to structure the self and understand the world [65–67]. As if in a theatre performance [58], children act upon a stage, participating in social interactions [59]. In fact, when enacting stories children's interaction can be divided into three distinct levels: in level one children act as the directors of the play, orchestrating the action [65, 68], choosing the settings, the characters, and all the other elements; in level two children embody the characters and become actors in their own play; in level three children become observers of their own creations. Children's enactment of these "Stage-Narratives" [69], in which they use props for dramatic play [70], offer a way for children to develop not only their language skills and thoughts, but also their social skills [17, 71]. According to Wright "Such open-ended, personal forms of knowing, expressing and communicating unleash and reveal children's deep meaning, multiple perspective-taking and fluidity of thought." [68].

Similar to the "Stage-Narratives", the "Reader's Theatre" is an instructional activity, in which students have to select parts of a script, rehearse and perform it for an audience. This activity is different from traditional theatre in that students focus on reading rather than memorizing their lines [72]. This method requires that performers express their role using oral interpretative reading and nonverbal communication. An important component of this method is the rehearsal, in which students are motivated to repeatedly read their parts of the script until they can read it with a high level of fluency for an audience. "Reader's Theatre" is an effective motivational strategy to foster fluency that ultimately increases reading comprehension and promotes a positive impact on reading development [73]; it is also a flexible instructional activity that can be performed for example with a story, joke, poem or even texts with a thematic focus. In fact, the only rule of "Reader's Theatre" is that the participants

need a script from which to read [72]. Glenberg considers that reading comprehension has an embodied nature, being related to the actions we do with our body. Moreover, he refers that developing reading fluency when there is a lack of text comprehension may lead to a reader's frustration, and consequently loss of interest in reading. To counteract this, he developed a technique called "Moved by Reading", in which children physically and cognitively interact with the text resulting in an "embodied, action-based understanding of the text" [74]. The method uses physical objects or images on the computer screen that correspond to the objects and characters in the text that children are reading. Children read the sentences aloud and then move the physical elements or the images to simulate what they are reading.

In the context of the "Reader's Theatre", STREEN empowers the participants to assume different roles, as they became directors, actors and observers of the performance [69]. In addition to this, it supports the "Moved by Reading" technique by allowing participants to creatively define the digital media enrichments for a narrative. Furthermore, STREEN can provide assistance for activities such as rehearsal and performance. Last but not least, it will allow the participants to explore the digital media enrichments as a means of extending their reading performance by influencing the enrichments depending on body gestures, facial expressions and speech characteristics (speed, intonation, emotion) of the reader.

Keeping the "Reader's Theatre" sub-activities in mind (understanding the text as a whole; planning the performance; practicing/rehearsing; performing) consider the following scenario: during class a teacher reads the story of "Jack and the Beanstalk" to his early readers by performing "Reader's Theatre" with them. The artificial environment acts as a theatre in which the wall behind the teacher becomes a big screen, synchronizing images, animations and subtitles with the oral performance of the teacher. Additionally, lamps, and the surrounding sound system intensify the immersive reading experience by delivering contextualized ambient light, soundscape and music, thus stimulating the student's peripheral attention. Such media enrichment potentially intensifies, clarifies and fosters the contextual analysis while facilitating vocabulary acquisition and meaning making.

The day after, the students build groups to plan their own original performances. In the first phase, each student plays a role that suits his/her reading level. Each student has his own space in front of a wall, which we named "magical wall", where s/he can both plan (define how the artificial environment will enrich the reading performance), and rehearse the own performance. The students navigate through their scripts via gestures and synchronize digital media enrichments with specific language elements (word, clauses or phrases), e.g. a boy who is playing the narrator is enriching the sentences: "During the night, beans had sprouted. They had grown into a beanstalk so tall that it was in the clouds." For that he picks images, animations, sounds, music and lights from a gallery presented on the "magical wall" that he synchronizes with the text. He chooses a weak light that results in a dark background, a full moon, clouds and a cricket singing as a soundscape. Next he picks the animation of a beanstalk growing and drags it to the word "grown". The result of this drag and drop operation is that he synchronizes the animation with the moment when he reads the word "grown". Additionally, he synchronizes a magical sound effect with the word "grown".

The “magical wall” also acts as a rehearsal space, where students can navigate through their scripts and practice their performance with the help of a virtual character, who acts as a director guiding the students throughout their performances.

On the day of the performance while reading students trigger the digital media enrichments as previously planned. Therefore, the wall behind them turns into a farm, a cow is grazing, and a light wind is blowing. As the sun rises the light in the room intensifies, the sounds of birds chirping start to be heard and a rooster begins to sing. Moreover, the wall in front of the performing students (which is also the wall behind the audience) serves as a smart teleprompter displaying the text to be read while simultaneously showing information coordinating the stage, such as identifying the next performer, e.g. by displaying his photo, and the instructions he has to follow (showing the direction where they have to look, e.g. audience, digital media elements or the other students).

Finally, students are able to become observers of their own performance by playing the recorded actuation. While using this functionality, all students are passive and observe their own creation. Students can watch a video of their performance on the “magical wall” and experience all the other environmental enrichments such as soundscape and light effects. This is a third-person experience, which is delivered by the digital media infrastructures and follows the metaphor of playing a DVD movie on a TV screen.

# 6 Design Space

Considering the scenarios described before and the smart environment systems mentioned in the related work (see Section 3.2), we next discuss the dimensions of the respective design space and establish our base design space model.

## 6.1 Agency

The concept behind STREEN is to provide readers an experience of agency; this means that the reader’s actions influence the artificial environment where reading takes place. Agency [75] denotes the aesthetic pleasure that is derived from making something happen in a dynamic digital environment. As such, it is connected to a first-person experience [76], as opposed to a third-person experience, which is delivered by passive media, such as movies or literature. In fact, agency results from the provision of adequate affordances to take action, provided by selected input devices, and the well-formed exploitation of the procedural and participatory properties of the digital medium. The level of agency is directly related with the type, quantity and quality of the provided interaction. Regarding STREEN, we foresee three possible manifestations: no interaction, indirect interaction and direct interaction. With no interaction, a Digital Media Enrichment is strictly used as output. The indirect interaction occurs based on implicit input, e.g. whenever the reader is focused on reading, an implicit enrichment is triggered (e.g., melody, and lights intensifying the drama). The direct interaction occurs when a Digital Media

Enrichment is used both as input and output, e.g. when a reader explicitly uses enrichment to complement his/her performances, for instance by making gestures that set all lights off. Agency will be leveraged by different input modalities, such as speech recognition (intonation of the voice, emotion or reading speed), touch, eye tracking, gesture recognition, body position, facial recognition, biosensing (e.g., EEG, heart rate monitor, etc.)

### 6.2 Sensory Dimension

In her seminal work Computers as Theatre [76], Brenda Laurel has denoted that one of the qualitative elements of structure in human-computer activity is the Spectacle (enactment), the possible modes of interaction that the interface presents to the user, focusing on the sensory dimension. A Story Reading Environmental Enrichment integrates sensory stimulus, which trigger different types of bodily sensations on the reader such as visual, auditory, kinesthetic, tactile or even olfactory. The Spectacle, the sensory dimension of the action can be promoted by different types of digital media such as images, animations, video, sound, music, voice, light, text, or a combination of them, as in multimedia presentations, up to a level of highly augmented reality.

### 6.3 Intensity

One important property of a Story Reading Environmental Enrichment is the intensity [32]. Like the previous dimensions it has to be considered in a reader-centred perspective. As such, the enrichment's intensity will be perceived differently by the different readers. One of the functions of enrichment is to intensify the reading experience, e.g. a sad music starts to play when reading a dramatic event. In our perspective, the intensity of the enrichment is directly related with the *quality*, *heterogeneity*, *contextualization*, and *concreteness* of the enrichment. The enrichment intensity is influenced by the *quality* level of a specific enrichment. Furthermore, it can also be influenced by the *heterogeneity*, ranging from a single enrichment channel to an orchestration of different enrichment channels, which trigger different types of sensations in the reader. To intensify a reading experience, it is essential to contextualize the enrichment with the narrative, e.g. in order to intensify a dramatic event, dramatic music must be played instead of cheerfully music. Finally, the *concreteness* of the enrichment also influences the intensity, in the sense that a definite and vivid enrichment will create a better and more effective intensification than a vague and abstract enrichment.

### 6.4 Temporal Dimension

Synchronizing the reading activity with a specific enrichment plays a fundamental role in the reading experience [32]. Actually, the response to the reading performance and narrative itself can be more or less granular. Depending on the precision provided

by the sensing module, a specific enrichment can be activated per chapter, per page, per sentence or per word. *Granularity* can be achieved through sensors targeting the different modalities such as touch, speech recognition, eye tracking, gesture recognition, emotion recognition or by checking the text displayed on the e-reader.

Synchronizing reading with enrichments introduces another temporal aspect—the *transition*. The passage of time and transitions between changing scenes within the story requires a juxtaposing of different enrichments, e.g. some versions of the story "Jack and the Beanstalk" do not describe the climbing of the beanstalk and therefore this climbing requires a transition between the enrichments associated with Jack's house and the enrichments associated with the castle in the clouds. The *transition* itself is a form of enrichment; it suggests the passage of time and provides a sense of motion from one scene to another, giving the reader a feeling of traveling in time and space within the narrative temporal structure.

Another temporal aspect of enrichment is the *duration*. Depending on the narrative's pace, specific enrichment can take more or less time, for instance the description of a character/object/scene delays the progress of the story allowing prolonged enrichment, e.g. suspenseful music can be heard while reading the description of a mysterious forest. On the other hand, narratives with a fast pace describe different scenarios and different events in a short period of time also impacting the *duration* of the enrichment. Naturally, the narrative pace is not the only aspect impacting the *duration* of the enrichment, for instance the reading speed must also be taken into account. This dynamicity demands therefore a real-time flexible mutability of the enrichments.

### 6.5 Location

The location of the enrichment is not necessarily defined by the spatial location of the enrichment, but instead refers to the user's perception [77]. Reading is a highly attentional activity, demanding constant foreground visual attention. Therefore, enrichment should be able to target both the peripheral attention and the foreground attention. Peripheral interaction aims to subtly enrich the environment within the narrative's context, e.g. a lamp producing blue light effects combined with a submarine soundscape to reflect an underwater environment. Alternatively, the interaction can obviously encompass a more concrete and "eye-catching" stimulation (e.g. displaying in a surrounding wall underwater photography of an ancient Portuguese shipwreck), inviting the reader to shift his foreground attention or providing the listeners of a read-aloud with a concrete and eventually interactive context.

### 6.6 Presence

One major objective of enriching written stories with multimedia experiences is to increase presence [78], or the perception of being physically present in the non-physical story world. Presence may be correlated with the intensity of enrichment

provided, but not necessarily since it may be leveraged by immersive technologies and thereby be related to the sensory dimension and agency provided by the media.

### 6.7 Social Dynamics

In the scenarios described above we explored two reading modalities, reading alone and reading in social context. The social dimension of a reading activity influences greatly the design of an environment able to provide Story Reading Environmental Enrichments. Depending on the reading situation, the sensing module, responsible for assessing the reading position will have different requirements, e.g. a social read-aloud enrichment may be based on speech recognition; in opposition, reading alone silently can obviously not use the same technique, instead requiring a different sensing module, such as eye tracking. Another aspect that has to be considered is that the scale of the social interaction influences the morphology of the digital media infrastructure, e.g. the scale of the device responsible to display the text of a story may vary depending on the scale of the social interaction [33]. In case the designer wants to create a social reading experience where each participant will benefit from both collective and personalized enrichments, then a possibility worth considering is the usage of personal devices (e.g. tablet or smartphone) that are able to communicate between each other.

## 7 Design Space Discussion

In the previous section we established our base design space model. This model will be used as a framework to support ideation and the exploration of potential augmented reading systems. Furthermore, this model will incrementally evolve through the user-centred design process. The impact of the different dimensions is highlighted in the design decisions described in the two scenarios. For instance, in order to experience agency in the “Deep Reading” scenario (user reads silently) we suggest the usage of an eye tracking module to determine the reading position, and the usage of a wearable brain sensing headband (electroencephalogram) to measure the attention level of the reader. The “Reader’s Theatre” scenario agency is enabled through speech recognition and optionally via gestures and face recognition. The high degree of agency created by our model has the potential to create a new reading experience, where the social dimension of the reading activity can be explored, empowering the user to take different roles. Indeed, users can be merely readers, or depending on the reading situation, they can become performers, directors (they choose and control the digital media enrichment, e.g. defining the scenario), or just take the role of a spectator. Regarding the sensory dimension the scenarios that we have presented, target mainly the stimulation of visual and auditory sensations, while the “Deep Reading” scenario also suggests the use of olfactory sensations. The two scenarios clearly differ in the design of the intensity; in fact the “Reader’s Theatre” scenario employs a constant intensity while the “Deep Reading” scenario varies the intensity (namely the heterogeneity and contextualization of the enrichments)

depending on the attention level of the reader. The different aspects of the temporal dimension are considered in the scenarios, especially the *granularity* which allows the automatic synchronization of enrichments with the temporal structure of the narrative at the level of sentences and words. Finally, the scenarios also demonstrate that enrichments can vary depending on the location dimension, by providing enrichments that target both the peripheral attention and the foreground attention. For example, in the "Reader's Theatre" students practice their reading performances with the help of a virtual character, which is clearly directed to the reader's foreground attention. On the other hand, in the "Deep Reading" scenario the system tries to prevent the reader from losing the focus by providing digital media enrichments directed to the reader's peripheral attention. This strategy ultimately aims to increase the reader's perception of being physically present in the non-physical story world.

## 8 A Prototyping Tool for Participatory Design

The participatory design approach that we are pursuing gives us fundamental information about how story reading enrichments can promote involvement, social interaction and enjoyment while stimulating reading skills. Following the establishment of our base design space model, one of the next steps is to use low/medium fidelity prototypes that allow us to explore and test different design concepts with the users. Presently, we are focusing on the development of a prototyping tool to be used in participatory design settings, which allows real-time manipulation of digital media enrichment. The concept behind the development of such a tool is to provide designers with the means to allow them to easily and quickly sketch an enriched reading experience. The prototyping tool both encompasses the text of a story and interfaces to trigger enrichments, allowing the understanding, perception, and measurement of the effect of digital media enrichments on the reading experience and the exploration of the design space parameters of STREEN.

Presently, the STREEN prototyping tool is a mobile application that is able to control a technical infrastructure composed by speakers, a smart TV, a Philips Hue LED bulb and a Philips Hue LED strip (see Fig. 2). The tool displays a set of buttons that interact with specific parts of the narrative, this way allowing the designer to trigger synchronized digital media enrichments.

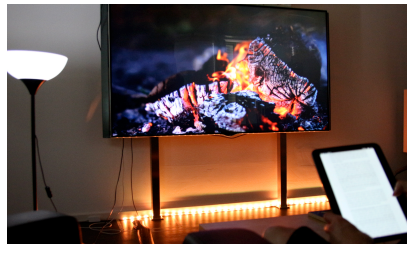

**Fig. 2.** Technical infrastructure of the prototyping environment

To exemplify how the tool works, imagine the following situation: During a participatory design session a boy reads the story "Jack and the Beanstalk", and while the boy is reading, a designer uses the prototyping tool to trigger contextualized enrichments. However, the boy is not happy with the enrichment of the sentence "During the night, beans had sprouted"; he suggests triggering the sound effect of an earthquake. The designer then registers this information, which enables him to redesign the reading experience following an iterative design cycle.

## 9 Conclusion

In this article, we have presented STREEN, a concept for augmented reading, in which we use environmental digital media enrichments to promote reader's engagement, involvement, enjoyment and social interaction. We have described a design method that combines the exploration of a design space dimensions with a human-centred approach. We then reported a participatory design session and described two divergent user scenarios, in which we discussed different reading situations, namely reading alone and reading in social context. Further, we presented and discussed the various dimensions of the design space. Finally, we presented a prototyping tool that enables designers to simulate digital media enrichments during participatory design sessions.

Presently we are focusing on the educational domain, therefore we are collaborating with a group of teachers and students in order to understand which reading scenarios are appropriate for such educational settings. As reading is one of the core activities at primary school, which can be carried in various ways, we want to potentiate such activities by developing scenarios that can enrich and expand the reading experience, both for the students as well as for the teachers. By creating a meaningful tool that could well engage students, the aim is not only to promote reading proficiency but the acquisition of various skills.

## References

1. Ritchie, S.J. |Bates: Does Learning to Read Improve Intelligence? A Longitudinal Multivariate Analysis in Identical Twins from Age 7 to 16. Child Dev. 86, 23–36 (2015).
2. Sullivan, A., Brown, M.: Reading for pleasure and progress in vocabulary and mathematics. Br. Educ. Res. J. 41, 971–991 (2015).
3. Snowling, M.J., Hulme, C.: The Science of Reading: A Handbook. John Wiley & Sons (2008).
4. Vygotsky, L.S.: Mind in Society: The Development of Higher Psychological Processes. Harvard University Press (1980).
5. Moulton, W.G.: Review of Biological Foundations of Language. Am. Sci. 55, 525A–527A (1967).
6. McGregor, K.K.: Developmental dependencies between lexical semantics and reading. Handb. Lang. Lit. Dev. Disord. 302–317 (2004).
7. Kintsch, W., van Dijk, T.A.: Toward a model of text comprehension and production. Psychol. Rev. 85, 363–394 (1978).

8. Lonigan, C.J.: Vocabulary development and the development of phonological awareness skills in preschool children. Vocab. Acquis. Implic. Read. Comprehension. 15–31 (2007).
9. Nagy, W.: Metalinguistic awareness and the vocabulary-comprehension connection. In: Wagner, R.K., Muse, A.E., and Tannenbaum, K.R. (eds.) Vocabulary acquisition: Implications for reading comprehension. pp. 52–77. Guilford Press, New York, NY, US (2007).
10. Perfetti, C.A., Landi, N., Oakhill, J.: The Acquisition of Reading Comprehension Skill. In: Snowling, M.J. and Hulme, C. (eds.) The science of reading: A handbook. pp. 227–247. Blackwell Publishing, Malden (2005).
11. Nagy, W.E., Anderson, R.C.: How Many Words Are There in Printed School English? Read. Res. Q. 19, 304–330 (1984).
12. Nagy, W.E., Herman, P.A., Anderson, R.C.: Learning Words from Context. Read. Res. Q. 20, 233–253 (1985).
13. Coady, J., Huckin, T.: Second Language Vocabulary Acquisition: A Rationale for Pedagogy. Cambridge University Press (1997).
14. Krashen, S.D.: The power of reading: insights from the research. Libraries Unlimited, Englewood, Colo. (1993).
15. Hart, B., Risley, T.R.: Meaningful Differences in the Everyday Experience of Young American Children. P.H. Brookes (1995).
16. Hart, B.: The Early Catastrophe. The 30 Million Word Gap. Am. Educ. 27, 4–9 (2003).
17. Paley, V.G.: A Child's Work: The Importance of Fantasy Play. University of Chicago Press (2009).
18. Bruner, J.S., Haste, H.: Making Sense (Routledge Revivals): The Child's Construction of the World. Routledge (2010).
19. Speaker, K.M.: Storytelling: Enhancing Language Acquisition in Young Children. Education. 125, 3 (2004).
20. Eagle, S.: Learning in the early years: Social interactions around picturebooks, puzzles and digital technologies. Comput. Educ. 59, 38–49 (2012).
21. Harris, P.L.: The work of the imagination. Blackwell Publishing, Malden (2000).
22. Morrow, L.M.: Retelling Stories: A Strategy for Improving Young Children's Comprehension, Concept of Story Structure, and Oral Language Complexity. Elem. Sch. J. 85, 647–661 (1985).
23. Miller, J.: Eccentric Propositions: Essays on Literature and the Curriculum. Routledge & Kegan (1984).
24. Morrow, L.M.: Literacy Development in the Early Years: Helping Children Read and Write. Pearson/Allyn and Bacon (2005).
25. Park, A., Lee, K.J., Casalegno, F.: The Three Dimensions of Book Evolution in Ubiquitous Computing Age: Digitalization, Augmentation, and Hypermediation. In: 2010 IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing. pp. 374–378 (2010).
26. Durant, D.M., Horava, T.: The Future of Reading and Academic Libraries. Portal Libr. Acad. 15, 5–27 (2015).
27. Wolf, M., Barzillai, M.: The Importance of Deep Reading. ResearchGate. 66, 32–37 (2009).
28. Clark, C., Rumbold, K.: Reading for Pleasure: A Research Overview. National Literacy Trust (2006).
29. Kuzmičová, A.: Does it Matter Where You Read? Situating Narrative in Physical Environment. Commun. Theory. 26, 290–308 (2016).
30. Manguel, A.: A history of reading. Viking (1996).
31. Guthrie, J.T., Hoa, A.L.W., Wigfield, A., Tonks, S.M., Humenick, N.M., Littles, E.: Reading motivation and reading comprehension growth in the later elementary years. Contemp. Educ. Psychol. 32, 282–313 (2007).

32. Ribeiro, P., Iurgel, I., Müller, W., Ressel, C.: Enrichment of Story Reading with Digital Media. In: Entertainment Computing - ICEC 2016. pp. 281–285. Springer, Cham (2016).
33. Terrenghi, L., Quigley, A., Dix, A.: A taxonomy for and analysis of multi-person-display ecosystems. Pers. Ubiquitous Comput. 13, 583 (2009).
34. Uzanne, O.: The End of Books. Octave Uzanne (2016).
35. Billinghurst, M., Kato, H., Poupyrev, I.: The MagicBook: a transitional AR interface. Comput. Graph. 25, 745–753 (2001).
36. Yamada, H.: SequenceBook: Interactive Paper Book Capable of Changing the Storylines by Shuffling Pages. In: CHI '10 Extended Abstracts on Human Factors in Computing Systems. pp. 4375–4380. ACM, New York, NY, USA (2010).
37. Fujitsu Develops Next-Generation User Interface for Intuitive Touch-Based Operations - Fujitsu Global, http://www.fujitsu.com/global/about/resources/news/press-releases/2013/0403-01.html.
38. Chris R Becker » MFA Thesis: Marginalia, http://www.chrisrbecker.com/marginalia.
39. Figueiredo, A.C., Pinto, A.L., Branco, P., Zagalo, N., Coquet, E.: Bridging Book: A Not-so-electronic Children's Picturebook. In: Proceedings of the 12th International Conference on Interaction Design and Children. pp. 569–572. ACM, New York, NY, USA (2013).
40. Wuxia le renard, http://www.wuxiathefox.com/.
41. Qi, J., Buechley, L.: Electronic Popables: Exploring Paper-based Computing Through an Interactive Pop-up Book. In: Proceedings of the Fourth International Conference on Tangible, Embedded, and Embodied Interaction. pp. 121–128. ACM, New York, NY, USA (2010).
42. Manolis Kelaidis | Blink, http://manokel.com/blink/.
43. Back, M., Gold, R., Kirsch, D.: The SIT Book: Audio As Affective Imagery for Interactive Storybooks. In: CHI '99 Extended Abstracts on Human Factors in Computing Systems. pp. 202–203. ACM, New York, NY, USA (1999).
44. Back, M., Cohen, J., Gold, R., Harrison, S., Minneman, S.: Listen Reader: An Electronically Augmented Paper-based Book. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 23–29. ACM, New York, NY, USA (2001).
45. Bahna, E., Jacob, R.J.K.: Augmented Reading: Presenting Additional Information Without Penalty. In: CHI '05 Extended Abstracts on Human Factors in Computing Systems. pp. 1909–1912. ACM, New York, NY, USA (2005).
46. Alam, K.M., Rahman, A.S.M.M., Saddik, A.E.: Mobile Haptic e-Book System to Support 3D Immersive Reading in Ubiquitous Environments. ACM Trans Multimed. Comput Commun Appl. 9, 27:1–27:20 (2013).
47. Schafer, G., Green, K., Walker, I., King Fullerton, S., Lewis, E.: An Interactive, Cyber-physical Read-aloud Environment: Results and Lessons from an Evaluation Activity with Children and Their Teachers. In: Proceedings of the 2014 Conference on Designing Interactive Systems. pp. 865–874. ACM, New York, NY, USA (2014).
48. Buy Disney LED StoryLight Interactive Lamp | Philips Lighting, http://www.usa.philips.com/c-p/719945548/disney-table-lamp.
49. TROBO the Storytelling Robot, http://mytrobo.com/.
50. Designerly Ways of Knowing. In: Designerly Ways of Knowing. pp. 1–13. Springer London (2006).
51. Anderson, T., Shattuck, J.: Design-Based Research A Decade of Progress in Education Research? Educ. Res. 41, 16–25 (2012).
52. Amiel, T., Reeves, T.C.: Design-Based Research and Educational Technology: Rethinking Technology and the Research Agenda. J. Educ. Technol. Soc. 11, 29–40 (2008).
53. Hall, M.P., O'Hare, A., Santavicca, N., Jones, L.F.: The power of deep reading and mindful literacy: An innovative approach in contemporary education. Innov. Educ. 15, 49–60 (2015).

54. Miller, B.W.: Using Reading Times and Eye-Movements to Measure Cognitive Engagement. Educ. Psychol. 50, 31–42 (2015).
55. Eid, M., Fernandez, A.: ReadGoGo!: Towards real-time notification on readers' state of attention. In: 2013 XXIV International Conference on Information, Communication and Automation Technologies (ICAT). pp. 1–6 (2013).
56. Huang, J., Yu, C., Wang, Y., Zhao, Y., Liu, S., Mo, C., Liu, J., Zhang, L., Shi, Y.: FOCUS: Enhancing Children's Engagement in Reading by Using Contextual BCI Training Sessions. In: Proceedings of the 32Nd Annual ACM Conference on Human Factors in Computing Systems. pp. 1905–1908. ACM, New York, NY, USA (2014).
57. Kaplan, N., Chisik, Y.: Reading Alone Together: Creating Sociable Digital Library Books. In: Proceedings of the 2005 Conference on Interaction Design and Children. pp. 88–94. ACM, New York, NY, USA (2005).
58. Burke, K.: A Grammar of Motives. University of California Press (1969).
59. Goffman, E.: The Presentation of Self in Everyday Life. Doubleday (1959).
60. Langellier, K.M., Peterson, E.E.: Storytelling In Daily Life: Performing Narrative. Temple University Press (2004).
61. Todorov, T.: The poetics of prose. Cornell University Press (1977).
62. Madison, D.S., Hamera, J.: The SAGE Handbook of Performance Studies. SAGE (2006).
63. Peterson, E.E.: Performance and Storytelling. In: 21st Century Communication: A Reference Handbook 21st century communication: A reference handbook. pp. 147–155. SAGE Publications, Inc., 2455 Teller Road, Thousand Oaks California 91320 United States (2009).
64. Hühn, P., Meister, J.C., Pier, J., Schmid, W.: Handbook of Narratology. Walter de Gruyter GmbH & Co KG (2014).
65. Bamberg, M.G.W.: Narrative Development: Six Approaches. Psychology Press (1997).
66. Bruner, J.S.: Toward a Theory of Instruction. Harvard University Press (1966).
67. Collins, F.: The Use of Traditional Storytelling in Education to the Learning of Literacy Skills. Early Child Dev. Care. 152, 77–108 (1999).
68. Wright, S.: Graphic-Narrative Play: Young Children's Authoring through Drawing and Telling. Int. J. Educ. Arts. 8, 1–28 (2007).
69. Sylla, C., Coutinho, C., Branco, P.: A digital manipulative for embodied "stage-narrative" creation. Entertain. Comput. 5, 495–507 (2014).
70. Scoter, J.V.: The Potential of IT to Foster Literacy Development in Kindergarten. In: Voogt, J. and Knezek, G. (eds.) International Handbook of Information Technology in Primary and Secondary Education. pp. 149–161. Springer US (2008).
71. PALEY, V.G.: THE BOY WHO WOULD BE A HELICOPTER. Harvard University Press (1990).
72. Garrett, T.D. lO'Connor: Readers' Theater: "Hold on, Let's Read It Again." Teach. Except. Child. 43, 6–13 (2010).
73. Mraz, M., Nichols, W., Caldwell, S., Beisley, R., Sargent, S., Rupley, W.: Improving Oral Reading Fluency through Readers Theatre. Read. Horiz. 52, (2013).
74. Glenberg, A.M., Goldberg, A.B., Zhu, X.: Improving early reading comprehension using embodied CAI. Instr. Sci. 39, 27–39 (2011).
75. Murray, J.H.: Hamlet on the Holodeck: The Future of Narrative in Cyberspace. Simon and Schuster (1997).
76. Laurel, B.: Computers as Theatre. Addison-Wesley Publishing Company (1993).
77. García-Herranz, M., Olivera, F., Haya, P., Alamán, X.: Harnessing the Interaction Continuum for Subtle Assisted Living. Sensors. 12, 9829–9846 (2012).
78. Kuzmičová, A.: Presence in the reading of literary narrative: A case for motor enactment. semi. 2012, 23–48 (2012).