DIGITAL MULTISENSORY STORYTELLING AS EDUCATIONAL-DIDACTIC METHODOLOGY

IL DIGITAL MULTISENSORY STORYTELLING COME METODOLOGIA EDUCATIVO-DIDATTICA

Claudia Chierichetti[1]
Niccolò Cusano University
claudia.chierichetti@unicusano.it

Elisabetta Tombolini[2]
Niccolò Cusano University
elisabetta.tombolini@unicusano.it

Double Blind Peer Review

Citazione

Chierichetti C., Tombolini E., (2023) Digital multisensory storytelling as educational-didactic methodology, Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva - Italian Journal of Health Education, Sports and Inclusive Didactics. Anno 7, V 2. Edizioni Universitarie Romane

Doi:
https://doi.org/10.32043/gsd.v7i2.890

gsdjournal.it
ISSN: 2532-3296
ISBN: 978-88-6022-470-5

ABSTRACT

The learning process can benefit from the support of digital and multisensory components. This research investigates the effect produced by two different narration methodologies on a sample of 40 5-year-old children. The control group participated in storytelling, while the experimental group took part in digital multisensory storytelling. The results have shown that the second methodology is linked to a higher ability to recall the story orally and to the implication of greater emotions in children in retelling phase.

Il processo di apprendimento può beneficiare del supporto delle componenti digitali e multisensoriali. Questa ricerca indaga l'effetto prodotto da due differenti metodologie narrative su un campione di 40 bambini di 5 anni. Il gruppo di controllo ha partecipato allo storytelling, mentre quello sperimentale ha preso parte al digital multisensory storytelling. I risultati hanno mostrato come la seconda metodologia sia legata ad una superiore capacità di rievocare oralmente la storia e all'implicazione di maggiori emozioni nella fase di retelling.

KEYWORDS
Narration, emotions, learning, childhood, technology
Narrazione, emozioni, apprendimento, infanzia, tecnologia

Received 18/05/2023
Accepted 18/05/2023
Published 20/05/2023

[1] Author of introduction and paragraphs n. 2, 3, 4
[2] Author of paragraphs n. 1, 4, 5 and conclusion

Introduction

The learning environment must consider a multitude of factors that, complementing and enriching each other, give rise to the complex process of information acquisition. Therefore, it is important to consider tools and methods that answer to emerging needs related to continuous and pressing development, including technology.

It is agreed how classic educational-didactic methodologies should integrate aspects of various natures in support of a quality learning process.

Storytelling is a narrative methodology based on shared reading. It is commonly used by means of which information of various kinds are conveyed throughout the different levels of school education.

The learning context must be thought as an environment in which students have an active role in the construction of their own knowledge. Thanks to technological development, even within the educational landscape, digital tools have been introduced in order to support an acquisition process that it is liked to changing needs (Tisza & Markopoulos, 2021). So, this is allowed through combination the technological component with classical modalities of learning, this kind of agreement was able to give rise to digital storytelling. In addition, educational environment has to take into account the multiplicity of stimuli of a different sensory nature. In fact, students have to daily decode, even unconsciously, this multiplicity that bring an additional value to learning processes (Li & Deng, 2022).

1. The evolution of Storytelling

Storytelling is a methodology that uses narrative to give meaning and significance to reality. Storytelling represents a ubiquitous activity in human culture and has always had relevant application in educational settings. Telling children stories helps them understand the world and learn about the culture they belong to (Catalano & Catalano, 2022).

Shared reading experiences produce significant improvements in children in various developmental areas, enabling them to acquire language skills and to develop emotional literacy. Stories provide opportunities to capture children's attention, helping them to learn more actively. They provide a means to bring facts to life, to explain and illustrate abstract ideas and concepts in a way that makes them more concrete and accessible (Isbell et al., 2004).

Young children build knowledge about their world through the stories they hear and participate with. When we read or listen to stories, different parts of the brain actively follow the story as if the subject is experiencing them and the child

becomes an active participant, contributing to the reconstruction of the narrative (O'Byrne et al., 2018). Neurocognitive studies show that storytelling activates areas of the brain related to cognitive control (Lehne et al., 2015), emotions (Hsu et al., 2015) and empathy (Brink et al., 2011). Therefore, it offers the opportunity to simultaneously stimulate the cognitive and emotional dimensions, that are crucial in the early years of life.

The nature of storytelling is changing by virtue of emerging digital methods: in fact, the increase in technological' tools is encouraging the adoption of innovative approaches even in educational and didactic childhood contexts. So, digital tools, in recent years, have been included in the storytelling process to give rise to digital storytelling (Di Fuccio et al., 2016).

The use of technological tools, in fact, makes it possible to create dynamic learning contexts that support the maintenance of attention and encourage student's engagement and interest (Henriksen et al., 2023; Shin, 2017). In this way, the introduction of digital contributes to make the cognitive process enjoyable and inviting, leading to improved learning outcomes (Tisza & Markopoulos, 2021). It also fosters the presence of the embodied component within the learning process (Romero-Ayuso et al., 2021; Fuhrman et al., 2020; Monacis & Colella, 2019).

Digital storytelling represents a narrative that originates from the combination of textes, recorded voices, musics, sounds, images and videos. It represents a valuable tool that supports teachers in engaging students in the learning process, having a positive impact on internal motivation to learn and concentration level (Catalano & Catalano, 2022).

It also constitutes a teaching strategy, adaptable to any developmental level, that has a strong impact in the learning context, making it more fun, engaging, communication and theatricality (Shemy, 2021). It stimulates discussions and supports understanding of concepts, registering a positive effect on learning of disciplinary content (Merjovaara et al., 2020). It has been shown as a tool for improving learning autonomy in children's early years, who had the opportunity to perceive storytelling more vividly (Indriani & Suteja, 2023).

Therefore, telling digital stories constitutes a pioneering pedagogical strategy that combines educational messages with meaningful learning experiences in order to create more engaging and exciting learning environments (Rahiem, 2021).

2. The multisensory processing

The perceptual process is related to the analyses of the nature of different information in the surrounding environment. Multisensory processing is present from the earliest phases of stimulus encoding. It is configured as a process that allows the analysis and the integration of information from the various sensory domains. In addiction this process consists of considering the nature of specific and different properties. In fact, the global and integrated consideration of reality information is linked to the human being's ability to simultaneously process its characteristics in order to the implement a flexible and adaptive behaviors that respond to the demands present in the surrounding environment. So, such complex analysis enables the individual to learn and subsequently respond functionally to the stimulations present in the surrounding environment. Toward the end of the first month of life, the neuronal activity of the unborn child exhibits an initial multisensory character. As the nervous system grows and matures, the individual can simultaneously and functionally integrate information from different sensory systems (Sarko et al., 2012). Sensory signals convey, in addition to information of a descriptive nature of the surrounding environment, important features related to the emotional aspect of stimuli, completing and enriching the process of perception. In fact, features of an emotional nature related to stimuli, attribute a purely subjective view that allow the individual to create his or her own analysis of reality. It emerges how the perceptual process is directly influenced by the emotional analysis, sometimes unconscious, of the individual. Among the various areas involved in the processing and elaboration of sensory information, the amygdala plays a major role. It is activated in response to the analysis of salient information and, consequently, to the recognition of the emotional nature of stimuli, projecting feedback to sensory pathways in order to generate an activation that takes into account the valence of such information (Pourtois et al., 2013). The activity of this hub allows the integration of multisensory information related to the physical characteristics whit the of the one linked to a purely emotional nature (Domínguez-Borràs et. al, 2019). Specifically, it has emerged how stimuli with emotional valence do not have to reach a level of conscious awareness (Domínguez-Borrà & Vuilleumier, 2022) for the amygdala process of information, emphasizing how the processing of emotionally salient stimuli turns out to be linked to a particular mode of processing (Domínguez-Borrà et al., 2020). Emotional attention, in which the amygdala plays an initial and causal role, is a fundamental component belonging to the more complex attentional process, which influences its sensory processing (Pourtois et al., 2013). In addition, functional neuroimaging data show how this hub plays a potential role in the multimodal integration of

emotional signals. Moreover, it has been demonstrated how the activity of this hub is increased in the case of congruence of sensory stimuli with emotional value (Domínguez-Borrà et al., 2019). It follows how the learning process must consider the importance acted by multisensory contexts. It has emerged that compared to a unisensory presentation, a multisensory context with the presence of congruence of stimuli improves performance (Li & Deng, 2022).

2.1 The integration of auditory and visual information

The functional integration of information from the different sense allows an analysis of reality that is responsive to the multitude of stimulations in it. In fact, the synergy between the nature of sensory information enables the individual to correctly process its meaning. It has emerged how the integration of emotional signals from both visual and auditory modes of perception (Dong et al., 2022; Gao et al., 2019) enriches the perceptual process. Indeed, it has been shown that stimulus processing, which associates the nature of visual and auditory modalities, makes the integration of information in process of acquisition. Specifically, the increased processing strength of audio-visual stimuli can be linked to the association of naturally occurring. For example, there is a highly correlation of features such as the shape of an animal and its characteristic sound (Beauchamp et al., 2004).

Furthermore, it has been shown that the amygdala response is amplified in correspondence with the presence of audio-visual information, as opposed to the presence of auditory or visual stimuli alone. Finally, the simultaneous combination of visual and auditory stimulation is potentially linked to the presence of more neuronal spikes as compared to the sum of responses to specific stimuli (Montes-Lourido et al., 2015; Domínguez-Borrà et al., 2019).

2.2 The olfactory perception

The sense of smell plays a crucial role in nutritive processes, but also in those related to information learning that allow, from the earliest stages of development, to increase the individual's cognitive heritage (Poncelet et al., 2010).

Olfactory learning, related to the recognition of odors and their evaluation, is part of the more complex multisensory information processing. Olfactory stimuli can produce emotional reactions, positive or negative, and recall memories related to certain environments and situations.

Odors influence mood, lead the individual to experience states of alertness or relax, and evoke memories. The enactment of this complex set of capabilities is linked to the emotional and olfactory processes sharing activation mechanisms by the same limbic regions (Royet et al., 2003), which are fundamental in the generation of emotion-based behavior (Jean Ayres, 2012).
Odors tested in laboratory environments influence recognition memory and induce greater emotional memories. Furthermore, it has been shown that in contextually enhanced learning space, linked to a presence of visual and verbal cues provided during the olfactory task, odor recognition has increased (Stagnetto et al., 2006). This underscores the fundamental role acted by the integration of the nature of different stimuli.

2.3 The kinesthetic component and the role of the embodied cognition

The way in which individuals, from early childhood experience and learn about their surroundings, is related to the bodily-kinesthetic approach of using their own body as a means of discover (Gardner, 2018). In fact, several studies showed how there is an increase in cognitive performance and academic achievement in relation to the performance of physical activity (Donnelly et al., 2016). Moreover, it has been demonstrated how embodied cognition, based on this assumption, integrates the potential inherent in movement to the learning of academic content, promoting the active role of the student (Skulmowski & Rey, 2018).
Thus, the body also plays an important role in learning processes; embodied cognition emphasizes the importance of considering the set of sensory patterns that contribute to the processing of information. In fact, it has emerged how multisensory processing and integration can decrease the purely cognitive load required of the child, supporting any difficulties in acquiring learning content (Henriksen et al., 2023)
Students learn more when they directly apply their knowledge in real-life situations. The implementation of practical activities, which directly involve the student, allows them to increase the level of confidence and trust. Unlike the emotions experienced as a result of predominantly theoretical approaches in which the student does not feel that degree of involvement (Hernández del Barco et al., 2022). Furthermore, fun, which underlies processes of attention, immersion and emotion, and interactive learning is a powerful pedagogical factor that, applied within school contexts, can facilitate memorization and, consequently, intervenes in knowledge acquisition (Rambli et al., 2013).

2.4 The digital multisensory storytelling as a new methodology

An increase in the important capabilities inherent within storytelling and digital storytelling modes is the consideration of aspects of a multisensory nature, which are basic to learning processes. Indeed, the integration of sensations allows the learner to develop mechanisms that support the consideration of the nature of the different stimuli with which they interface within learning environments. So, we can consider multi-sensory storytelling as an integration to the traditionally one, that only use audio and video aspects, with additional stimuli of a multisensory nature. In this case, the individual experiences an environment in which his or her senses are simultaneously stimulated; it has been shown how, in learning environments with such characteristics, individuals with intellectual disabilities show improvement in information acquisition (Matos et al., 2015). Since the learning process is transversal among all individuals, it is inferred that the integration of stimuli with a multisensory nature can increase the quality of the learning process. In addition, the important development of technology has also made it possible to bring back to the educational landscape tools that aim to enhance the classical methods used. Thus, a further enrichment to the classical mode of storytelling, can be found in the introduction of digital aspects within the present method. Finally, the inclusion of digital features to support multisensory ones allows for the enhancement of the use of multiple senses simultaneously and improve the pupil's motivation to learn (Di Fuccio et al., 2016).

3. Emotions and cognition

"We are sentient creatures who think and thinking creatures who feel" (Damasio, 2021). Emotions are involved in a lot of functions related to cognitive aspects, interaction and action. So, they play an importance even within educational environments. Affective processes must therefore be thought as complementing and enriching of those purely liked to cognitive nature, because of their aspects of personalization of knowledge acquisition. It is agreed that the cognitive process cannot be separated from the emotional one, since the latter is linked to the essence of the individual and determines his or her actions. The environment within which the complex reality of learning takes shape is articulated and linked to the subject's experience of emotions with a contextual character that guide child' action mode that are associated to the specific space of acquisition. Moreover, it is important to emphasize that the integration of the cognition-emotion process is linked to the sharing of the same brain networks, which characterize the functioning of such complex processes (Gu et al, 2012). Specifically, it has been

shown that negative contexts impair the performance of a word recognition task compared to neutral environments. Furthermore, positive emotional conditions are related to a given setting associated with higher accuracy of information acquisition in the early stages of learning compared to neutral environmental contexts (Zhao & Guo, 2023; Hernández del Barco et al, 2022). This evidence supports the role acted by the positive percept on learning facilitation, underscoring how is crucial to take into account the multitude of factors that influence and shape this complex process. Several studies have shown how there is a direct link between emotions and learning and how these influence students' academic achievement. In fact, emotions play a fundamental role in modulating attentional state and motivation; processes that underlie the acquisition of information (Carmona-Halty et al., 2021). Emotions give greater salience to the concepts learned and allow to keep a vivid and lasting memory. It turns out to be crucial to create a learning environment that takes into account students' interests and supports their natural desire of knowledge and increase self-efficacy. The well-being of the student turns out to be linked to the consideration of several factors such as fun, which is often alien to the classical conception of the learning process, linked to attentional, immersive and emotional processes, as well as interactive learning. These factors should be considered as powerful pedagogical tools that, applied within school settings, can facilitate memorization and, consequently, intervene in knowledge acquisition (Ramble et al., 2013). Taking into account the fundamental role played by the learning environment, and related emotions, several interventions have been implemented in order to create a positive school climate, which includes supporting students in coping with stress and improving learning and emotion management skills (Bottaccioli et al., 2023; Mahoney et al., 2021). It is understood how the complex and articulated learning process must take into account the individual as a human being, endowed with specific desires, thoughts, emotions and feelings. The school landscape must therefore take into account the potential inherent in each child, accompanying them on a path of active learning, in which they feels free to experiment, make mistakes and increase their knowledge, without alienating from the self' emotions.

4. Research

4.1 Research hypothesis

The above scientific evidence emphasizes how the technological component increases attentional processes and supports internal motivation to learn. In addition, it was highlighted how the introduction of multisensory stimuli enriches the perception process, facilitating emotional analysis of the context. Finally, it emerged how emotions experienced during education play an important role in strengthening cognitive acquisition. So, the purpose of this research is verify that the digital multisensory storytelling compared to conventional storytelling, produces higher results. Specifically, it is intended to assess the child's ability to recall in oral form the most important points of the story heard and to detect the emotion felt.

4.2 Sample

The sample is composed by 40 children of 5-year-old, divided in 50% male and 50% female and attending 3 classes in three different preschools of Roman territory. In recruitment, the only inclusion criterion concerned third grade attendance, while there were no exclusion criteria. The children took part in the research following the signing of informed consent by their parents. In addition, in order to respect privacy, the researchers ensured the anonymity of all participants. Classes were randomly assigned to one of two groups (EG n= 31; CG n= 9); subjects diagnosed with behavioral disorders were also included in the sample.

4.3 Tools

An experimental protocol was created to carry out this study. It was composed of different assessment tools, investigating the various areas of interest. A specifically drafted recording protocol was used in order to assess the children's ability to orally retelling the previously presented story and quantify the salient points acquired. In addition, during this administration, EMOJ software was used in order to detect the emotion felt by the child during this retelling phase.

4.3.1 EMOJ

EMOJ is a software, realized in 2017 by the Polytechnic University of Marche, which detects in real time the emotions felt by the subject, through the images captured by the video camera installed on a technological device. This recognition is done through the encoding of facial expressions and the analysis of related mimicry signs. The emotions analyzed are joy, surprise, sadness, anger, disgust and fear. It allows for the detection of the distribution of emotional mood among all students who took the test. In addition, the intensity of the emotional state is measured on a scale from 0 to 100, where 0 indicates totally neutral facial expressiveness.

4.3.2 Recording Protocol

The recording protocol was designed on the model of the test "M6 - Narrative Memory (MNa)," contained in the NEPSY-II test battery. The purpose is to assess narrative memory under two conditions: spontaneous and guided reconstruction. After listening to the story, the child was asked to repeat it freely; then he or she was asked questions to guide the recall of any information that did not emerge during the spontaneous retelling. This protocol consists of 18 items, divided into 3 levels of difficulty: the first level includes basic information regarding the subjects, time and place of the story; whereas, the following levels contain gradually more detailed information, requiring greater abstraction skills. Some items focus on the recognition of elements of an emotional nature. Each item is awarded 2 points for spontaneous reconstruction, 1 point for guided reconstruction, and 0 points for incorrect or no answers. The total scoring system is given by the sum of the values obtained. The questionnaire took about 10 minutes for each individual child.

4.4 Method

The study was conducted by comparing the application of storytelling, presented to the control group, with digital multisensory storytelling, proposed to the experimental group.

The interventions were conducted during school hours, with previous permission from parents and school staff. Each class participated in the respective interventions in the presence of the reference teacher. In both cases, was used the book "The Three Little Owls", by Martin Waddell (1992). This book focused on the theme of attachment and it was chosen because it is age-appropriate for the sample and has dynamics capable of eliciting emotional activation. The same narrative voice was adopted in both digital narration and traditional book reading, since it could determine the quality of the information shared.

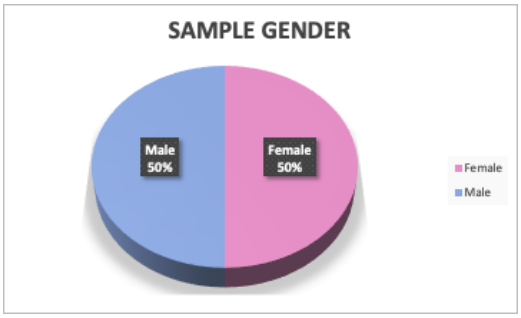
In the experimental group, the story was projected on a neutral wall. The video, lasting 5 minutes, turns out of the same images from the book, but presented in animated form. In order to create a totally immersive surrounding environment and recreate the nighttime and forested setting of the narrative, lights depicting the stars and moon were projected inside a suitably darkened room. In addition, olfactory stimuli were presented through an environmental perfumer that diffuses the characteristic smell of pine. As an auditory stimulus, a musical background was included, consisting of the distinctive sounds of the wood at night and the cry of the owl, that was the animal protagonist of the story. Once the children entered the room, they placed themselves on a structure visual and tactile recalling the wood floor. So, the set of stimuli were proposed in order to solicit the simultaneous activation of different sensory channels, determining the multisensory component in the digital storytelling methodology.

Differently, in the control group, the story was read and, at the same time, the book's illustrations were shown to the children.

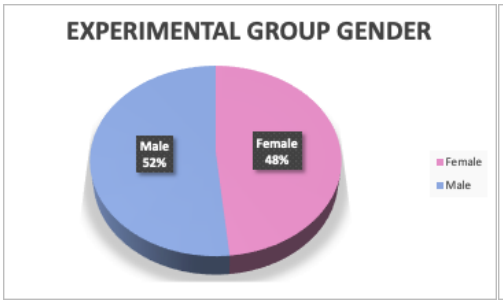
In both groups, following the presentation of the story, the administration phase began. The assessments were conducted individually and under similar environmental conditions. The child was asked to retell the presented story, positioning himself or herself frontally to the assessor in order to obtain an optimal framing of the face by the digital device camera. In this way, the EMOJ software was able to adequately detect the emotion felt by the child at the time of retelling. Simultaneously, the recording protocol was compiled by the evaluators based on the information exhibited by the child in order to assess the degree of salient points' acquisition of the story.

4.5 Data analysis

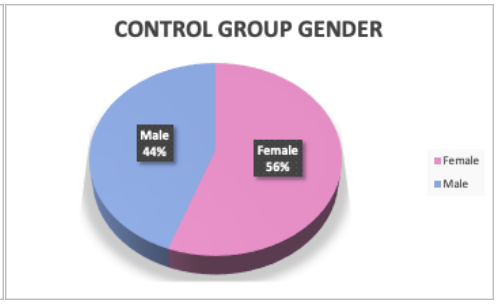
The sample is equally divided between males and females (Graph 1). The gender distribution is homogeneous in both the experimental and control groups (Graph 2;3).



Graph. 1 (Gender percentages of the sample)



Graph. 2 (Gender differences within the experimental group)



Graph. 3 (Gender differences within the control group)

Descrittive

	Metodo	N	Media	Mediana	SD	Minimo	Massimo
Results	DMS	31	22.2	22	1.70	19	26
	ST	9	16.4	16	1.13	15	18

Table 1 (Descriptive static)

This Table 1 shows the descriptive statistics for two groups (digital multisensory storytelling, DMS and storytelling, ST); specifically, the central tendency and variability indices are shown.

In order to perform the statistical analyses, JAMOVI software (version 2.3.26) was used.
For data analysis, the Independent Samples T-Test was first used, which can be used by having a qualitative independent variable (storytelling methodology) with 2 categories, digital multisensory storytelling (DMS) and storytelling (ST). The necessary applicability conditions of the test were met by the data in the present study. Specifically, each statistical unit represented a different subject (independent observations); the dependent variable followed a normal distribution in the population (normality); and the standard deviation of our dependent variable was equal in both populations (homogeneity). The normality hypothesis was tested by the Shapiro-Wilk test (Table 2), which was not significant (p value > 0.05). Homogeneity was tested by Levene's test (Table 3), which was not significant (p value > 0.05). Therefore, the assumptions of normality and homoschedasticity are met.

Test di Normalità (Shapiro-Wilk)

	W	p
Results	0.972	0.404

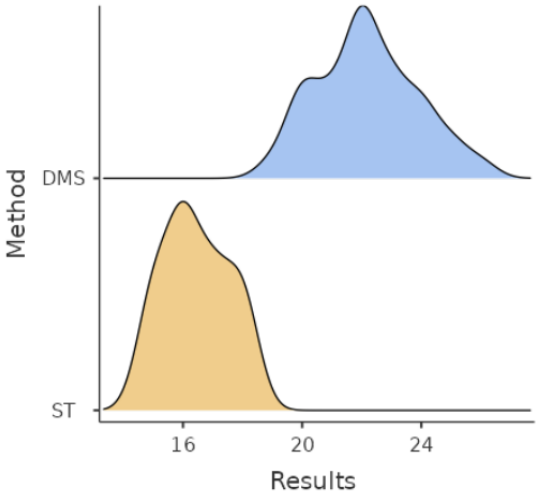
Table 2 (Shapiro-Wilk Test)

Test di Omogeneità delle Varianze (Levene)

	F	gdl	gdl2	p
Results	1.22	1	38	0.276

Table 3 (Levene's Test)

These respected conditions are also visible in the density Graph 4 below, in which the distributions of the scores obtained by the two groups are shown.



Graph. 4 (Density graph)

The independent-samples t-test was used to analyze the data and compare the results obtained in the control and experimental groups. Statistical significance (α) was set $p < 0.05$.

Test t a campioni indipendenti

		Statistiche	gdl	p		Dimensione dell'Effetto
Results	t di Student	9.50	38.0	< .001	d di Cohen	3.60

Nota. H_a $\mu_{DMS} \neq \mu_{ST}$

Table 4 (Independent Samples T-Test)

The averages identified in the two groups differed from each other in a statistically significant way ($t_{38} = 9.50$; $p < .001$), the p-value being below the level of significance (α). So, such sample data allow us to accept the experimental hypothesis. In addition, Cohen's d was used to determine the effect size for the pairwise comparisons made, which can be interpreted as small ($0.20 \leq d < 0.50$), moderate ($0.50 \leq d < 0.79$) and large ($d \geq 0.80$). This index is large ($d = 3.60$), showing an important effect of the independent variable, namely methodology, on the dependent one, represented by learning outcomes.

In addition, we used factorial ANOVA, having two independent variables (method and gender), both with two levels (DMS-ST and F-M, respectively) and one quantitative dependent variable, represented by learning outcomes. A requirement for the ANOVA test is that the variances of each comparison group are equal. This condition is tested using the Levene statistic (Tale 5). As the p-value > 0.05, the homogeneity of the variances was tested.

Test di Omogeneità delle Varianze (Levene)

F	gdl1	gdl2	p
0.689	3	36	0.565

Table 5 (Levene's Test)

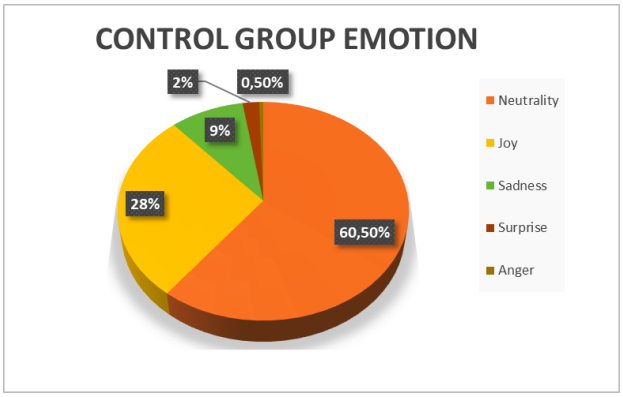
Thus, we performed the factorial ANOVA.

ANOVA - Results

	Somma dei Quadrati	gdl	Media Quadratica	F	p	η^2
Method	231.33	1	231.33	96.725	< .001	0.717
Gender	4.02	1	4.02	1.679	0.203	0.012
Method ✻ Gender	1.18	1	1.18	0.491	0.488	0.004
Residui	86.10	36	2.39			

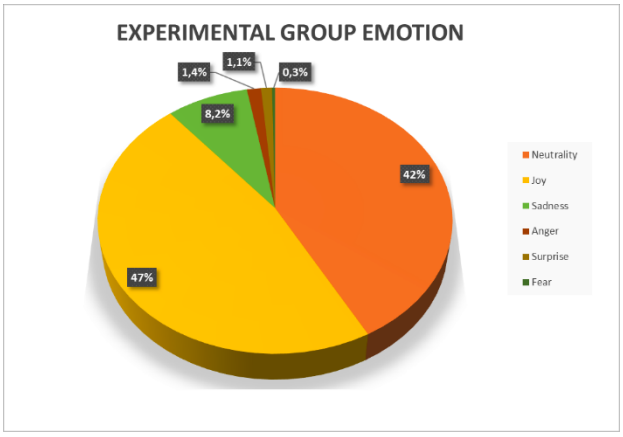
Table 6 (ANOVA Test)

As evident in Table 6, the method factor ($F_{1,36}$ =96.725; $p < 0.001$) provided a statistically significant result, showing a difference in the results between the two methods, regardless of the gender of the subjects. Differently, the gender factor ($F_{1,36}$ = 4.02; p=0.203) was not significant: males and females achieved the same results in both groups. Finally, the method-gender interaction was not significant.



Graph. 5 (Control group Emotion)

Graph. 5 illustrates that the control group showed, during the retelling phase, a predominantly neutral facial expression (60%). In the presence of emotional activation, however, the emotions detected were joy (28%), sadness (9%), surprise (2%) and anger (0.50%).



Graph. 6 (Experimental group Emotion)

Graph. 6 shows that in the experimental group the predominantly detected emotion, during the retelling phase, was joy (47%), followed by sadness (8.2%), anger (1.4%), surprise (1.1%) and fear (0.3%). A neutral facial expression was found to be present at 42%.

5. Discussion

Scientific evidence has shown how the use of technological tools enables the creation of dynamic learning contexts, support the maintenance of attention and stimulate motivation to learn (Henriksen et al., 2023). Further studies have shown how sensory stimuli convey descriptive information about their surrounding environment, thereby enriching the perception process, and how, as a result, the multisensory context enhances information acquisition (Li & Deng, 2022). Based on these understandings, we integrated the digital and multisensory components to storytelling, going on to propose digital multisensory storytelling to five-year-old children. In this methodology, the story was video projected, and, in addition to voice and images traditionally implicated, further stimuli were integrated, simultaneously soliciting the senses and bringing to life the setting characteristic of the narrative.

The purpose of this study was to compare the outputs resulting from digital multisensory storytelling, with those resulting from storytelling. Specifically, the first objective was to assess whether digital multisensory storytelling improved children's ability to orally recall the highlights of the story presented.

The results obtained showed that the narrative methodology used influenced information acquisition in children: especially, children who participated in digital multisensory storytelling recalled more details regarding the story, compared with children who were recipients of conventional storytelling. This result turns out to agree with the findings of the literature and in line with what was expected, confirming the first part of our hypothesis: the presentation of a story through a technological tool, combined with the integration of multisensory stimuli, had a positive effect on the memorization of the presented content.

In the experimental group, a child began to recount spontaneously personal experienced life situations linked to the content of the presented story, demonstrating how digital multisensory storytelling stimulated discussions in the subjects.

In addition, it was investigated whether these results were influenced by the gender variable. The sample, as shown in Graph 1, was equally divided by gender (50% male and 50% female). Analysing the two groups specifically, the experimental group had 52% males and 48% females, whereas, the control group consisted of 44% male children and 56% female children, as respectively visible in Graphs 2 and 3. The results showed that males and females achieved similar results in both methodologies: thus, the gender variable does not affect children's ability to recall in memory the salient points of the narrated story.

Existing literature has shown how sensory stimulations in the environment, in addition to enriching the perception process, support the emotional processing of information, by virtue of convergence within the cerebral limbic system (Domínguez-Borrà et al., 2019). Based on this evidence, the second objective of the present work was to verify whether the subject was emotionally activated in the retelling phase, and if so, it was intended to assess the type of emotion predominantly experienced. The Graph 4 shows that in the children who were the recipients of the storytelling, the presence of neutrality (60%) was detected, corresponding to an emotional state intensity of 0 and a totally neutral facial expression. In contrast, a higher level of emotional activation was recorded in the experimental group, amounting to a total of 58% (Graph. 5). In both cases, the main emotion detected was joy, present at 47% in the children who participated in digital storytelling and 28% in who took part in conventional reading.

Finally, based on the scientific evidence that positive emotions experienced within a learning environment support cognitive processes by positively influencing the level of information acquisition (Zhao & Guo, 2023), in this paper we aimed to investigate the relationship between oral reconstruction and contextually experienced emotion. The results showed that children, who were presented with digital multisensory storytelling, recorded higher abilities in recalling story details and, at the same time, higher emotional activation. So, in agreement with the literature, these data demonstrate a good relationship between the level of information acquisition and the positive emotions experienced in the retelling phase. Despite the positive outcomes of the research, the use of specific technological tools for the implementation of narrative learning camps should be considered.

From this study, therefore, a close relationship emerged between narrative methodology and the acquisition of information, confirming that digital multisensory storytelling positively influences the ability to recall the story and a greater emotional activation in the retelling phase follows from it. However, it would be essential to reproduce this research with a larger sample and with different age groups in order to determine a more stable relationship between the variables considered.

Conclusions

In conclusion, our research helped to demonstrate the effectiveness of using digital and multisensory storytelling within childhood educational contexts. This methodology was found to be functional in improving the level of information acquisition and emotional activation in children. Indeed, today, children are digital natives and it is essential to integrate technology within learning processes, developing their digital skills. It is necessary to mention some limitations of this study, such as the use of non-standardised and validated instrument, that is the recording protocol, and the limited sample size. This work represents an initial study. The intention is to develop the research: (1) with different age groups, (2) with the ultimate aim of developing a structured protocol (3) with the use of digital devices, combined with various simultaneously stimulation thanks to the new collaboration between the HERACLE research laboratory and EASYLABS, which provides the SHX domotic console with environmental stimuli (voice kit; soap bubble machine; fan; stars; vibro-acoustic pillows; fiber optics) for research. In addition, the interactive video-projection system will be provided, which involves collaboration with EASYLAB for digital story construction.

References

Beauchamp, M., Lee, K., Argall, B. & Martin, A., (2004), Integration of Auditory and Visual Information about Objects in Superior Temporal Sulcus, *Neuron*, vol. 41, n. 5, pp. 809-823, https://doi.org/10.1016/S0896-6273(04)00070-4.

Bottaccioli, A.G., Mariani, U., Schiralli, R., Mari, M.G., Pontani, M., Bologna, M., Muzi, P., Giannoni, S.D., Ciummo, V., Necozione, S., Cofini, V., Chiariotti, L., Cuomo, M., Costabile, D. & Bottaccioli, F., (2023), Empathy at school project: Effects of didactics of emotions on emotional competence, cortisol secretion and inflammatory profile in primary school children. A controlled longitudinal psychobiological study, *Comprehensive Psychoneuroendocrinology*, vol. 14, p. 100183, https://doi.org/10.1016/j.cpnec.2023.100183.

Brink, T. T., Urton, K., Held, D., Kirilina, E., Hofmann, M., Klann-Delius, G., Arthur M. J., & Kuchin, L. (2011), The role of orbitofrontal cortex in processing empathy stories in 4-to 8-year-old children, *Front. Psychol*, 2(80), https://doi.org/10.3389/fpsyg.2011.00080.

Carmona-Halty, M., Salanova, M., Llorens, S. & Schaufeli, W., (2021), Linking positive emotions and academic performance: The mediated role of academic psychological capital and academic engagement, *Current Psychology*, vol. 40, pp. 2938-2947, https://doi.org/10.1007/s12144-019-00227-8.

Catalano, H. & Catalano, C. (2022), Using digital storytelling in early childhood education to promote child centredness, *ERD 2021 9th International Conference Education, Reflection, Development*, doi:10.15405/epes.22032.16.

Damasio, A., (2021), *Feeling, Knowing Making Minds Conscious*, Pantheon Books, New York.

Di Fuccio, R., Ponticorvo, M., Ferrara, F., Miglino, O., (2016), Digital and Multisensory Storytelling: Narration with Smell, Taste and Touch, *Lecture Notes in Computer Science*, v. 9891, 509-512, https://dx.doi.org/10.1007/978-3-319-45153-4_51.

Domínguez-Borràs, J., Guex, R., Méndez-Bértolo, C., Guillaume Legendre, G., Spinelli, L., Stephan, M., Frühholz, S., Mégevand, P., Arnal, L., Strange, B., Seeck, M. & Vuilleumier, P., (2019), Human amygdala response to unisensory and multisensory emotion input: No evidence for superadditivity from intracranial recordings, *Neuropsychologia,* vol. 131, pp. 9-24, https://doi.org/10.1016/j.neuropsychologia.2019.05.027.

Domínguez-Borràs, J., Moyne, M., Saj, A., Guex, R. & Vuilleumier, P., (2020), Impaired emotional biases in visual attention after bilateral amygdala lesion, *Neuropsychologia,* vol. 137, n. 3, p. 107292, https://doi.org/10.1016/j.neuropsychologia.2019.107292 .

Domínguez-Borràs, J. & Vuilleumier P., (2022), Amygdala function in emotion, cognition, and behavior, *Handbook of Clinical Neurology*, vol. 187, pp. 359-380, https://doi.org/10.1016/B978-0-12-823493-8.00015-8 .

Dong, H., Lil, N., Fan, L., Wei, J. & Xu, J., (2022), Integrative interaction of emotional speech in audio-visual modality, *Frontiers in Neurosceince,* vol.16, https://doi.org/10.3389/fnins.2022.797277.

Donnelly, J., Hillman, C., Catelli, D., Etnier, J., Lee, S., Tomporowski, P., Lambourne, K. & Szabo-Reed, A., (2016), Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children A Systematic Review, *Medicine & Science in Sports & Exercise,* vol. 48, n. 6, pp. 1197-1222, doi:10.1249/MSS.0000000000000901.

Fuhrman, O., Eckerling, A., Friedmann, N., Tarrasch, R. & Raz, G., (2020), The moving learner: Object manipulation in virtual reality improves vocabulary learning, *Journal of Computer Assisted Learning,* vol. 37, n. 3, pp. 672-683, https://doi.org/10.1111/jcal.12515.

Gao, C., Weber, C. & Shinkareva, S., (2019), The brain basis of audiovisual affective processing: Evidence from a coordinate-based activation likelihood estimation meta-analysis, *Cortex*, vol. 120, pp. 66-77, https://doi.org/10.1016/j.cortex.2019.05.016.

Gardner, H., (2018), *Formae mentis: saggio sulla pluralità dell'intelligenza*, Feltrinelli, Milano.

Gu, X., Liu, X., Van Dam, N., Hof, P. & Fan, J., (2012), Cognition–Emotion Integration in the Anterior Insular Cortex, *Cerebral Cortex*, vol. 23, n. 1, pp. 20-27, https://doi.org/10.1093/cercor/bhr367.

Henriksen A., Katarzyna Topor M., Hansen R., Damsgaard L., Veber Nielsen A., Wulff-Abramsson A., Wienecke J., (2023), Virtual reality and embodied learning for improving letter-sound knowledge and attentional control in preschool children: A study protocol, *Computers & Educational: X Reality,* vol. 2, p. 100019.

Hernández del Barco, M., Cañada, F., Cordovilla Moreno, A. & Airado-Rodríguez, D., (2022), An approach to epistemic emotions in physics' teaching-learning. The case of pre-service teachers, *Heliyon*, vol. 8, n. 11, p. 11444, https://doi.org/10.1016/j.heliyon.2022.e11444.

Hsu, C. T., Jacobs, A. M., Citron, F. M., & Conrad, M. (2015), The emotion potential of words and passages in reading Harry Potter–An fMRI study. Brain Lang, 142, 96–114, https://doi.org/10.1016/j.bandl.2015.01.011.

Henriksen, A., Katarzyna Topor, M., Ahmt Hansen, R., Damsgaard, L., Veber Nielsen, A., Wulff-Abramsson, A. & Wienecke, J., (2023), Virtual reality and embodied learning for improving letter-sound knowledge and attentional control in preschool children: A study protocol, *Computers & Educationa: X Reality,* vol. 2, pp. 100019, https://doi.org/10.1016/j.cexr.2023.100019.

Indriani, S., Suteja, H., (2023), Fostering reading interest through digital storytelling for young learners in the early childhood, *Journal of Education and Learning (EduLearn)* 17(2):301-306, doi: 10.11591/edulearn.v17i2.18372.

Isbell, R., Sobol, J., Lindauer, L., and Lowrance, A. (2004), The effects of storytelling and story reading on the oral language complexity and story comprehension of young children. *Early Child. Educ. J*. 32, 157–163, doi:10.1023/B:ECEJ.0000048967.94189.a3.

Jean Ayres, A., Muratori, F. & Campatelli, G., (2012), Il bambino e l'integrazione sensoriale. Le sfide nascoste della sensorialità, Giovanni Fioriti Editore, Roma, p. 93.

Lehne, M., Engel, P., Rohrmeier, M., Menninghaus, W., Jacobs, A. M., & Koelsch, S. (2015), Reading a suspenseful literary text activates brain areasrelated to social cognition and predictive inference, *PLoS One*, 10(5), https://doi.org/10.1371/journal.pone.0124550.

Li, J. & Deng, W. S., (2022), Facilitation and interference effects of the multisensory context on learning: a systematic review and meta-analysis, *Psychol Res.,* doi: 10.1007/s00426-022-01733-4.

Li, S., Tang, Y. & Zheng, Y., (2023), How the home learning environment contributes to children's social–emotional competence: A moderated mediation mode, *Frontiers Psychology*, vol. 14, https://doi.org/10.3389/fpsyg.2023.1065978.

Mahoney, J. L., Weissberg, R., Greenberg, M., Dusenbury, L., Jagers, R. J., Niemi, K., Schlinger, M., Schlund, J., Shriver, T., Van Ausdal, K. & Yoder, N., (2020), Systemic

Social and Emotional Learning: Promoting Educational Success for All Preschool to High School Students, *American Psyghologist*, vol. 76, n. 7, pp. 1128-1142, https://doi.org/10.1037/amp000070.
Matos, A., Rocha, T., Cabral, L. & Bessa, M., (2015), Multi-sensory storytelling to support learning for people with intellectual disability: an exploratory didactic study, *Procedia Computer Science,* pp. 12-18*,* doi:10.1016/j.procs.2015.09.244.
Merjovaara, O., Nousiainen, T., Turja, L., & Isotalo, S. (2020), Digital Stories with Children: Examining Digital Storytelling as a Pedagogical Process in ECEC. Journal of Early Childhood Education Research, 9(1), 99-123. https://journal.fi/jecer/article/view/114125.
Monacis, D. & Colella, D., (2019), The contribution of technologies for learning and development of motor skills in early age, *Italian Journal of Educational Research*, vol. 12, n.22.
Montes-Lourid, P., Vincente, A., Gonzalez, B. & Gonzalez, F., (2015), Neural activity in monkey amygdala during performance of a multisensory operant task, *Journal of Integrative Neuroscience,* vol. 14, n. 3, pp. 309-323, https://doi.org/10.1142/S021963521550020X.
O'Byrne, W. I., Stone, R., & White, M. (2018), Digital Storytelling in Early Childhood: Student Illustrations Shaping Social Interactions. *Frontiers in psychology*, *9*, 1800, http://doi.org/10.3389/fpsyg.2018.01800.
Poncelet, J., Rinck, F., Bourgeat, F., Schaal, B., Rouby, C., Bensafi, M. & Hummel, T., (2010), The effect of early experience on odor perception in humans: Psychological and physiological correlates, *Behavioural Brain Research*, vol. 208, n. 2, pp. 458-465, https://doi.org/10.1016/j.bbr.2009.12.011.
Rahiem, M.D.H. (2021), Storytelling in early childhood education: Time to go digital. *International Journal of Child Care and Education Policy,* 15, 4 https://doi.org/10.1186/s40723-021-00081-x.
Rambli Awang, D., Matcha, W. & Sulaiman, S., (2013), Fun Learning with AR Alphabet Book for Preschool Children, *Procedia Computer Science,* vol. 25, pp. 211-219, https://doi.org/10.1016/j.procs.2013.11.026.
Romero-Ayuso, D., Toledano-González, A., Rodríguez-Martínez, M., Arroyo-Castillo, P., Matías Triviño-Juárez, J., González, P., Ariza-Vega, P., Del Pino, G. & Segura-Fragoso, A., (2021), Effectiveness of Virtual Reality-Based Interventions for Children and Adolescents with ADHD: A Systematic Review and Meta-Analysis, *New Research in Children with Neurodevelopmental Disorders,* vol. 8, n.2, https://doi.org/10.3390/children8020070.
Royet, J., Plailly, J., Delon-Martin, C., Kareken, D. & Segebarth C., (2003), fMRI of emotional responses to odors: influence of hedonic valence and judgment, handedness, and gender, *NeuroImage*, vol. 20, n. 2, pp. 713-728, https://doi.org/10.1016/S1053-8119(03)00388-4.

Sarko, D., Nidiffer, A., Powers, A. R., Ghose, D., Hillock-Dunn, A., Fister, M., Krueger, J., & Wallace, M. T., (2012), *Le basi neurali del processi multisensoriali,* CRC Press/Taylor & Francis, Boca Raton (FL).

Shemy, N. S. (2021), The impact of digital storytelling on motivation and achievement in teaching scientific concepts for pre-school students. *European Journal of Education Studies***,** v. 7, n. 12, http://dx.doi.org/10.46827/ejes.v7i12.3627.

Shin, D., (2017), The role of affordance in the experience of virtual reality learning: Technological and affective affordances in virtual reality, *Telematics and Informatics*, vol. 34, n. 8, pp. 1826-1836, https://doi.org/10.1016/j.tele.2017.05.013.

Skulmowski, A. & Rey G., (2018), Embodied learning: introducing a taxonomy based on bodily engagement and task integration, *Cognitive Research: Principles and Implications,* vol. 3, n. 6, https://doi.org/10.1186/s41235-018-0092-9.

Stagnetto, J.M., Rouby, C. & Bensafi M., (2006), Contextual cues during olfactory learning improve memory for smells in children, *European Review of Applied Psychology*, vol. 56, n. 4, pp. 253-259, https://doi.org/10.1016/j.erap.2005.09.012.

Tisza, G. & Markopoulos, P., (2021), FunQ: Measuring the fun experience of a learning activity with adolescents, *Current Psychology*, vol. 42, pp. 1936-1956, https://doi.org/10.1007/s12144-021-01484-2.

Zhao, J. & Guo, J., (2023), The temporal mechanism of contextual emotions' effects on novel abstract and concrete word learning, *Neuroscience Letters*, vol. 805, p. 137227, https://doi.org/10.1016/j.neulet.2023.137227.