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Mortino and the Blue Pearl Heart: a structured-narrative journey through pupils' attitude in mathematics

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Abstract: This paper is situated within the field of research on how mathematics activities embedded in a storytelling setting may influence attitude towards mathematics, in primary school children. It is widely recognized in the literature that the affective dimension has a significant role in mathematical learning, especially when the subject-related prejudices may induce pupils' anxiety. From early schooling, a mnemonic, rigid vision of mathematics risks establishing a didactical contract detached from a critical and relational approach to the discipline. This paper proposes the analysis of an experiment based on an original story, that integrates a triadic narrative arc, story-based problems and gamification dynamics, in order to promote an encouraging and supportive learning environment in a 2nd grade classroom. Grounded in the three-dimensional model of attitude, we investigate how storytelling and gamification might facilitate a positive perception of mathematics for pupils.

2020 Mathematics Subject Classification: Primary 97C70; Secondary 97K50, 97C20.

Keywords: storytelling; gamification; attitude towards mathematics.

1. Introduction

Research in mathematics education has consistently shown that students often perceive the discipline as difficult and problematic, leading them to develop a widespread negative attitude toward the subject [28]. In this regard, the instructional methods teachers use to introduce mathematics to students play a crucial role. The early school years are highly formative for pupils, helping promote a conception that is both positive and stimulating. Mathematics is often perceived as a set of mnemonic rules and abstract concepts far removed from children's daily lives [27]. Such a restricted perspective on mathematics could reinforce misconceptions that, in turn, generate further difficulties. Continuous frustrating experiences might induce such emotional resistance as to lead pupils to develop anxiety [28]. Observing students' attitude towards mathematics is important for understanding what they feel, what they think of

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the discipline and the confidence in their own abilities [9]. To address these prejudices, the present research proposed an experiment based on storytelling in a 2nd-grade class through *Mortino e il Cuore di Perla Blu* (in English: *Mortino and the Blue Pearl Heart*), an original story written by the second author of the paper. The storytelling, inspired by narrative structures commonly used in film studies, was used to design a mathematical learning path aimed at supporting pupils' emotional involvement. In addition, game dynamics were integrated to encourage engagement with the discipline and improve the affective bond between pupils and the main character. Among the teaching tools, the story-based problems proposed by Zan [26] have been adopted to promote an image of mathematics as a personal challenge, fostering pupils' inferential skills and strengthening their own self-confidence in the learning process. Within mathematics education research, the affective domain and, more specifically, the investigation of attitude, has become central to understanding how students approach mathematical activities and construct meaning through them. Nevertheless, the present research suggests that storytelling, gamification and mathematics are often framed as separate strands or used as occasional complementary elements in individual lessons, rather than being integrated within a unified structure over long-term instructional practice. In such a structure, the three elements can be seen as an interconnected system throughout the whole learning experience: the establishment of meaningful connections between the character and the pupils requires time and sustained practice, enabling children to gradually adapt to the educational experience and internalize it as their own. Specifically, narrative structures inspired by cinematic storytelling, together with engagement fostered by gamification, remain relatively underexplored as elements supporting mathematical learning experiences. More specifically, this contribution seeks to examine how such a pedagogical approach may affect the multidimensional nature of pupils' attitude towards mathematics. Beyond their role as pedagogical strategies, in this study storytelling and gamification are conceived as interrelated processes supporting affective participation and meaning-making in mathematics, through identification with the protagonist and involvement in goal-based tasks. Identification with *Mortino* enhances the motivational effects of gamification by increasing a sense of responsibility for participation, while game dynamics reinforce the continuity of narrative engagement. The study therefore addresses the following research question: *how does a gamified narrative structure inspired by cinematic storytelling and narrative-based problem solving influence pupils' attitude towards mathematics?*

2. Literature review

Within educational research in mathematics, attitude is regarded as an essential component of the affective domain, as it influences individuals' decision-making processes and, consequently, shapes their behaviour towards a given subject [2]. Such an attitude is primarily formed through pupils' school experiences and may be influenced by teaching practices and educational contexts [16]. Currently, mathematics learning is often perceived by students as largely rote-based or abstract, preventing them from relating it to real-life situations and reducing the discipline to a mere set of rules [6]. In recent years, however, storytelling has enabled pupils to engage with mathematical activities in a more meaningful and immersive way through the creation of characters and storyworlds closely connected to their own reality [19]. Through the identification process encouraged by a story, children are guided towards the discovery of their emotions and sense of self: narratives suggest that the goals to which pupils aspire can only be achieved by courageously confronting challenges and difficulties involved in the construction of their identity [4]. One of the most widely consumed storytelling forms today can be found in cinematography, owing to its ability to capture and sustain attention over extended periods of time [8]. Visual storytelling in mathematics education promotes the contextualisation of disciplinary concepts by reconstructing a narrative universe responsive to students' educational

needs [21]. It also contributes to developing problem-solving skills [1], while enhancing motivation and engagement process, which are particularly beneficial in contexts where anxiety is likely to surface [14]. Alongside stories, gamification plays a significant role, specifically when associated with pupils' involvement [21]. The creation of a gamified design is based on the use of structured levels, namely progressive challenges that sustain engagement and guide users towards the final goal without inducing cognitive overload [15]. To further strengthen the motivational process, virtual or tangible rewards are employed in order to reinforce pupils' sense of autonomy and progressive advancement within the game. These elements must be carefully balanced to avoid the loss of user interest before the gaming experience is completed.

2.1. Theoretical background

It is well established within the mathematics education literature that the affective domain plays a crucial role in the teaching and learning processes of students, significantly influencing their performance and engagement [18, 29]. In particular, researches confirm how attitude towards mathematics is a relevant component in the affective domain [2]. Extensive research has highlighted how mathematics anxiety and students' beliefs about the nature of the discipline can act as powerful mediators, often shaping their persistence and cognitive approach to problem-solving [23]. Such negative preconceptions often lead to an increasingly complex relationship with the discipline; if consistently experienced throughout their educational path, these feelings can escalate into what has been defined as *Mathophobia* [28, p. 13]. This specific term is the fear of practising mathematics, but it is also the emotional resistance to approach it. As discussed in the Literature review section, storytelling primarily operates at the cognitive and emotional levels through identification with a character, thereby influencing the meaning that pupils attribute to their experience of mathematics [4]. Gamification, by contrast, has a stronger impact on the behavioural and motivational dimensions through reinforcement mechanisms that provide pupils with a sense of progress and an increased perception of control over activities [21]. Within the affective dimension, any anxiety that may emerge during a task is likewise not a unidimensional phenomenon, but rather involves these same cognitive, emotional, and behavioural aspects [12]. The *Three-dimensional Model of Attitude* (TMA) proposed by Di Martino and Zan [9] (Figure 1) captures the multidimensional nature of attitude towards mathematics, relevant in the context of an experiment combining multiple aspects related to both storytelling and gamification.

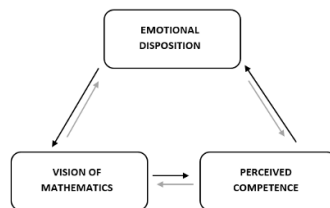


Figure 1. Three-dimensional model of attitude toward mathematics. Adapted from Di Martino and Zan [9].

The TMA model consists of the following dimensions:

- *Emotional Disposition* refers to how we feel when we think about mathematics.
- *Vision of Mathematics* represents what pupils think of the discipline and what characteristics they attribute to it.
- *Perceived Competence* is the individual's perception of being good (or not) when tackling a mathematical task.

Although these are three separate elements, they are closely interconnected, and this must be

considered in the teacher's daily classroom practice. Indeed, the emotional dimension significantly influences a student's vision of mathematics. Research shows as in many cases this element is strongly characterised by fear of failure, anxiety, and a strong sense of frustration when students face a problem to solve. The vision of mathematics is influenced by students' past experiences and has repercussions on their future behaviour and their emotions [9]. Telling a story in mathematics makes concepts easier to understand and remember because it has a strong capacity to connect with our strongest emotions [30]. The ability of narrative to make human experience universal can help students rehabilitate that sterile side of mathematics [5]. As discussed in the Literature review, the present research drew upon one of the most effective tools currently employed for capturing and sustaining pupils' attention, namely visual storytelling in the cinematography field [8]. Popular movies often adopt recurrent narrative structures that may support viewers' emotional engagement and interest throughout the story [24]. The following narrative guidelines were considered to support pupils' engagement: 1) storytelling is expected to present a narrative featuring at least one clearly recognisable main protagonist, characterised through identifiable physical or emotional traits, and driven by a clear narrative goal to be achieved [27]; 2) storytelling is characterised by change: characters are not static entities and, in order to teach us something, they must challenge themselves [25]; 3) storytelling is characterised by a solid narrative structure. The three-act structure proposed by screenwriter Syd Field [13] serves as a classic narrative framework to organise a progression of a story [25]. Act I introduces a character's daily life and its subsequent disruption, portraying the protagonist in his everyday environment; this initial phase is particularly useful to establish an immediate connection with the readers' reality by depicting familiar experiences, such as moments of play, affection from loved ones, or small daily difficulties. Act II describes the development of a strategy to overcome adversity and represents the phase where the narrative action intensifies: although the main character faces a major setback at the end of the first act, often losing what is most precious to him, he is continuously presented with opportunities for growth and positive change. Finally, Act III resolves the narrative arc as the character achieves his goal, overcomes the remaining obstacles, retrieves what was lost, and ultimately restores peace and balance to the storyworld; 4) at Act transitions, stories often include turning points, namely transformative moments that altogether produce significant emotional shifts in the viewer, moving from an initial phase of peace (or equilibrium) to an intermediate phase of disruption and a subsequent return to stability [8]. The narrative structure typically presents a main character living a peaceful life, until an unexpected event disrupts the storyworld (first turning point). The protagonist is then defined by the pursuit of a narrative goal despite an initial defeat (second turning point). Finally, the character emerges as a hero capable of achieving success despite fears, ultimately establishing a renewed equilibrium (third turning point). In mathematics education research, there are specific types of texts that may share common features with narrative acts and that could have a significant impact on students' emotional dimension. In the *C&D Model for the analysis (and reformulation) of text* [26], a narrative-structured problem has its body introducing a sequence of events, followed by a problem-situation just as in Act I. The problem's question invites students to analyse what they have to seek a resolution, as in Act II. Pupils provides an answer, as the protagonist does with his goal in Act III. Therefore it is possible to find elements of similarity between narrative problems and the Acts structure, with the problem context corresponding to Acts I–II and the problem question to Act III. According to Zan [27], a story must include at least one character (whether real or fictional) who pursues a goal over time starting from an initial problem situation. In Acts I and II, a context is established that closely resembles that of a narrative problem: a main character is introduced within an ordinary world that is subsequently disrupted by an unusual and distressing event, thereby creating a situation that calls for resolution. This context also provides relevant logical information, just as Act II presents

a sequence of events in which the protagonist evaluates the tools and resources available, using them to make decisions to resolve the situation. Zan [27] and Virzì [25] also identify the following crucial elements as shared between narrative texts and the three-act structure:

- *temporal progression*, as a linear succession of events;
- *verisimilitude*, which makes the story credible, based on what the reader knows about the world;
- *causality*, which explains why the characters act. If there is a clear goal perceived as true by the protagonist, the student stops seeing the mathematical problem as external and feels it as a personal challenge.

Within the Act III, the problem question finds its resolution. Both share a problem-solving process involving choices and strategies to be evaluated in order to achieve a goal. Zan [26] argues that if teachers intend to elicit an action from a pupil (such as resolving a problem situation), it is necessary to communicate explicitly a request that is meaningful to students. In Act III, the story provides the answers necessary to overcome the problem and determine whether the narrative goal has been achieved. Both involve a problem-solving process based on evaluating choices and strategies. To strengthen the connection between mathematics and game dynamics, different aspects of gamification are considered [22]. Shallow gamification uses physical or intangible rewards (such as points or leaderboards) to capture attention [20]. However, extrinsic motivation may fade quickly in the absence of intrinsic motivation, understood as the learner's own willingness to engage. Mozelius [20] instead refers to deep gamification, characterised by game dynamics that create an affective dimension and a stronger bond between the fictional character and the students. Both types of engagement are necessary, as they make mathematics enjoyable and interactive in the short term, and more humanised over time [7].

3. Methods

3.1. Participants

The research *Mortino and the Blue Pearl Heart* was conducted during the 2024-2025 academic year in a 2nd-grade class of 21 participants, all aged 7. The activities were carried out in collaboration with the class teacher, whose role was as an observer. The second author, a trainee teacher who has been involved with the class since the first year of primary school, acted as both the designer and the facilitator responsible for conducting all classroom activities throughout the intervention. The mathematical core of the investigation included the two fundamental operations of the additive structures, in coherence with the teacher's instructional planning. The prerequisites defined in the documentation included mastery of natural numbers beyond 100 and knowledge of the properties of the arithmetic operations studied. The educational objective for the class was therefore to strengthen pupils' mastery of additive structures. In addition, a second objective that more specifically shaped the research design was the use of gamified storytelling as an innovative way to direct attention and foster engagement, contrasting with practices already familiar to the pupils, and to examine its effects on students' attitudes towards mathematics.

3.2. The design

The research was structured over a 6-week planning period focused on classroom observation and the collection of information to support the development of gamified storytelling, followed by a 6-week period of active experimentation with the pupils. The design was conceived according to a layered and interdependent structure, in which the narrative serves as the outer shell, the gamification dynamics constitute the intermediate level, and mathematics represents

the core of the overall experience. The story provides a unifying narrative thread and serves as the initiating mechanism for the gameplay phases; these, in turn, include mathematical challenges that allow the narrative to progress. Their introduction is also deliberately gradual. Through identification with the protagonist, storytelling acts as the main driver of a different way in which pupils perceive their participation in the activities: it is essential that students feel a voluntary need to use additive structures, not because they are prescribed by the school curriculum, but in order to help the character.

In the second author's story, several narrative design principles were incorporated, including a basic story aligned with pupils' interests, its structural division into Acts describing the temporal progression, and turning points conceived as narrative pivots, used to encourage pupils' emotional involvement in the narrative. The story introduces Mortino, a little spirit king with a great Blue Pearl heart who lives in the magical *Bosco di Cuorgentile* (*Kindheart Forest*). He loves flying freely, playing within nature, and spending time with those he cares about and his heart is always radiant. His peaceful life continues undisturbed until mysterious Black Shadows emerge from the depths of the earth to consume all the light in the world, plunging the forest into coldness and fear. Mortino's precious heart is stolen, the only light capable of preserving the magic of the realm. Frightened yet determined not to give up, he embarks upon a journey, asking the pupils for help in saving his home. To support this narrative, the present study introduced gameplay dynamics in the form of actions that pupils must carry out, with the problems themselves constituting the tools that enable these actions. Storytelling and gamification worked together to create a strong emotional bond between pupils and mathematics. This connection between the students and the storyworld was fostered by enabling a familiar visual identification with Mortino from the outset. Indeed, the research began with an aesthetic study of the narrative universe, based on the participants' graphic productions. The character and his storyworld evolved visually to reflect difficulties and changes throughout the narrative arc. To follow Mortino's adventures with greater engagement, a book-style digital product was created: using PowerPoint software, images that had previously been hand-drawn by the second author were then digitized on the platform. Each image, depicting the most significant scenes of the story, was also accompanied by written text that followed the narrative, as shown in Figure 2.



Figure 2. Extract from the digital book.

Subsequently, the gamified narrative structure was designed according to 3 Phases. In Phase 1, the first activity with pupils was the individual game *What does maths taste like?*, inspired by those reported in [10]. Its educational aim was to establish a bond of trust between pupils and the discipline through a playful task that associated a food (liked or disliked) with maths. The rationale behind this initial task was to enable the observation of pupils' emotional disposition towards mathematics through a playful approach that departs significantly from a more structured assessment context. The activity lasted 15 minutes and aimed to connect mathematics to personal experiences in a fun and creative way. Thereafter, a 30-minute individual questionnaire was administered to the participants, consisting of two semi-structured

questions: “*Maths is pleasing when*” and “*Maths is not pleasing when*” . Students were left the freedom to respond orally to encourage more spontaneous verbalisations. The second activity, by contrast, shifted the focus from merely monitoring pupils’ emotional disposition to exploring their perceived competence. Within the research design, this activity was intentionally positioned after the playful task in order to progressively introduce a more reflective perspective, alongside the previous positive experience, on pupils’ relationship with mathematics, including possible negative attitude. The main objective was to foster an engaging environment that would encourage pupils to express themselves more freely after the game-based activity. It also aimed at investigating how their perceived competence may vary across both more pleasant and more challenging experiences with mathematics. At the end of Phase 1, all the participants were subjected to an individual questionnaire lasting 15 minutes. The first input was structured consisting of a multiple-choice question (one positive and one negative emoticon); the second input was semi-structured, to detect the reasons for the previous choice. The final task reintroduced a multiple-choice format to monitor pupils’ emotional responses. However, the concluding item was designed to go beyond identifying whether pupils sometimes feel uneasy with mathematics, by asking them to explain the reasons behind such feelings. This enabled the study to capture potential changes in both emotional disposition and perceived competence when moving from a game-based context to a more structured task, which pupils often associate with less enjoyable aspects of mathematics.

Phase 2 involved narrating Act I of the story to the pupils, with mathematical problem-situations that unfolded alongside the narrative progression. Starting from an initial equilibrium, the story introduced the breakdown of the equilibrium that formed the basis for the narrative problems. Accordingly, this Phase also included 2 distinct Tasks designed to follow the development of the plot. Within this design, additive structures were embedded as the functional requirements needed to resolve the character’s situation. These two activities shared the same structural design, comprising a problem followed by a subsequent discussion of the solution. This methodological choice was intended to foster multiple experiences with narrative problems, while simultaneously providing a sense of reassurance through the application of previously tested procedures. Task 1 consisted of a narrative problem administered to 4 cooperative groups. Within this design, pupils worked without predefined roles, and the task was structured to require positive interdependence. Each group had to engage with the problem in 30 minutes, being granted maximum freedom in the written formalisation of calculation procedures, with the request to document any divergent solving strategies among members of the same group. The problem was prepared by trying to avoid keywords that typically indicate which operation should be used, as shown in the text below:

Mortino arrives at the Grotta Brulla, abandoned for a very long time. The forest is dark without its colors, and strange noises can be heard among the leaves. The little spirit trembles because the village elders used to say in their stories that the Black Shadows were hidden there. To lift the heavy door, Mortino must follow the instructions on the large sign from the Stone-Diggers and find a total of 268 stones. “Where will I ever find so many stones? And besides, I’m s-s-scared and w-what... what is that?” Mortino cries out when something moves the bushes. Frightened, he starts running through the forest but trips and - poof! - falls into a lake. He is about to cry, angry, when he notices that the water is shining brightly. What a surprise when Mortino sees the many glowing stones at the bottom. Overjoyed, he uses magic to weave a basket and carry it. When he returns to the Grotta Brulla, he realizes too late that some stones have rolled away. Mortino counts them and only 137 are left. He must go back and retrieve the lost stones before night falls. “What a long road ahead, again!!! And how exhausting to have to count again!!! I really need someone to help me,” said the little spirit, very dejected. Can you help Mortino count how many stones he must recover to unlock the door?.

A collective solution discussion [3] was conducted by the second author for the verbalisation of the strategies used and the justification of choices made, in 30 minutes. This educational tool was valuable not only for its capacity to foster critical thinking regarding the choices made by students, but also for detecting the effects that storytelling had produced on the pupils' verbalisation concerning their vision of mathematics. The discussion was structured as follows:

- shared re-reading of the text of the problem;
- verification of the understanding of the problem-situation and its relative requests;
- verbalisation of the processes and solving strategies adopted;
- introduction of teacher's guiding questions inputs aimed at generalising the procedure;
- evaluation of the coherence between the solution provided by the participants and the question posed by the problem, with relative argumentative justification.

The students called into question their traditional practices. The objective of the activity was to observe the influence on the students' vision of mathematics in the presence of activities differing from traditional routines. At the end of Task 1, an individual semi-structured questionnaire was administered in 15 minutes to evaluate pupils' emotional disposition and motivation before and after the activity. The questionnaire was divided into three sections. The first two sections provided two multiple-choice questions to monitor the evolution of the emotional state: the first one referred to the moment before the problem solving phase; the second one related to the post-solving and solution discussion phase; the last section included an open-ended question to detect spontaneous verbalisation regarding individual motivation about the previous selection.

Task 2 replicated the design developed for Task 1 in its problem-solving task and collective solution discussion, using a new narrative text to continue the story as shown below.

Mortino slowly enters the Grotta Brulla; it is very deep and dark. He can hear the sound of his footsteps and his breathing is very fast. How scary! He looks to the right, then turns to the left, but no Dark Shadow can be seen anywhere. Mortino is still alone. He takes a deep breath and thinks that soon he will be back home, with his sweet little spirit Monsi-Lillà. Mortino takes a closer look at the cave and notices that there are 122 lit torches along the walls, but they are not enough to illuminate the entire rocky corridor. Mortino doesn't want to walk in the dark; he is too scared. Other unlit torches have fallen to the ground. Mortino picks up some of them from the dusty floor and knows that at most he could light 150 torches, no more, otherwise he would run out of all his energy. The magic is almost gone, and because of this, Mortino feels a bit dizzy and not very well. The little spirit leans tiredly against the wall and says, "What a mess, I can't count. What should I do? I need help!". Can you help Mortino count how many more torches he needs to light to illuminate the dark corridor?.

To fuel engagement, for every mathematical challenge solved and discussed in Task 1 and 2, the students received a collective bonus: a puzzle piece which, once assembled, would reveal the identity of Mortino's enemy (Figure 3).



Figure 3. Puzzle reward tiles.

Rather than a dark shadow, as initially suggested by the digital book, the assembled figure

reveals a candid spirit. Within the gamified design, this mechanism was employed to further heighten curiosity regarding the mysterious identity of the true culprit behind the chaos in the Forest, then revealed in the next stage.

Phase 3 involved narrating the end of the story through the digital book. After addressing the mathematical challenges and finally restoring Mortino's heart, the experiment highlighted a significant turning point, described as the moment in which pupils emerge as heroes of the forest's destiny. The semi-structured questionnaire, administered at the end of the intervention, aimed to capture how this moment influenced pupils' emotional disposition and perceived competence. Participants completed the individual questionnaire in 15 minutes. In two multiple-questions, participants had to select one of four emoticons, based on a gradient of intensity from negative to positive: distress, insecurity, ease, and enthusiasm. The final section included an open-ended question designed to capture spontaneous verbalizations regarding participants' individual motivation to continue supporting Mortino.

For the creation of this mathematical-narrative structure, as shown in the image below, the Acts of the narrative arc and the three main Phases were paired according to the following points (Figure 4).

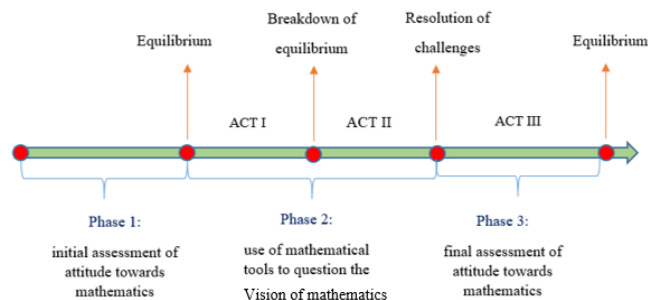


Figure 4 - Sequential integration between Acts and Phases

Figure 4. Sequential integration between Acts and Phases.

To comprehend the overall architecture of the intervention, Figure 4 outlines the sequential integration between narrative dynamics and research phases. Furthermore, it demonstrates how to define the transition between states of equilibrium and moments of crisis within a story arc divided into Acts and gameplay layers.

In Act I, Mortino was presented to the pupils in a situation of calm within his world. This segment begins from an initial state of stability, which frames Phase 1. This phase establishes the students' own initial equilibrium, assessing their emotional and cognitive attitudes toward mathematics before the narrative dynamic changes. At the end of this Act, the story broke this balance to request the direct intervention of the pupils to save Mortino. The disruption of the narrative equilibrium serves to introduce the subsequent mathematical structure

In Act II, Mortino used his skills for chasing his enemy, just as the pupils utilised problem-solving to unlock new clues. This segment represents the core of the project, positioned between Act II (the breakdown of equilibrium) and Phase 2 (the use of narrative problems). In narrative terms, it corresponds to the moment of conflict; from a pedagogical perspective, it is the point at which pupils begin to question their view of mathematics.

In Act III, the narrative structure concluded the journey while the mathematical structure provided solutions to the problem-situation. Once the narrative crisis has been resolved, the third segment marks the beginning of the downward trajectory towards the resolution of the challenges that emerged. This part of the structure (Act III and Phase 3) is dedicated to re-

assembling the overall storytelling framework. The focus shifts to the final assessment of pupils' attitudes towards the discipline, a necessary step to evaluate the impact of the intervention. The narrative process reaches a renewed state of equilibrium. However, this is not a return to the initial state: the visual milestone indicates an evolved form of equilibrium, in which students' attitudes are redefined compared to the first segment.

3.3. Data collection and analysis

Qualitative content analysis, grounded in the Three-Dimensional Model of Attitude [9], was employed to examine the research data through a deductive approach [17]. TMA dimensions are useful for an in-depth examination of how a gamified narrative structure may influence pupils' attitude, particularly in relation to experimental activities where the challenging of established routines may be associated with anxiety-related experiences. The findings were organised according to three predefined categories, coming from TMA model:

1. emotional disposition was assessed by identifying references to pupils' feelings towards mathematics. The analysis distinguished between positive, negative, and ambivalent emotional expressions, as well as shifts in emotional responses across the different phases of the study, drawing on evidence from emoticon selections and written statements completed before and after the tasks;
2. perceived competence was analysed through statements referring to pupils' self-perception in solving mathematical tasks, distinguishing between expressions of confidence and autonomy and of uncertainty especially in relation to their willingness to support the main character after the tasks;
3. vision of mathematics was coded through pupils' explanations and justifications of solutions, distinguishing between procedural reasoning based on task routines and contextual or narrative reasoning linked to the story-based problems.

The data were collected across three phases. Phase 1 involved pupils' individual associations between mathematics and food, recorded on an interactive whiteboard. These data provided initial material for coding emotional disposition towards mathematics in a playful context. In the subsequent activity, the second author transcribed pupils' oral responses based on field notes. Statements expressing liking or disliking of mathematics were then systematically identified and included in the data. This was followed by the collection of individual written protocols. Emoticon selections from a multiple-choice questionnaire were used as indicators to track emotional responses in both playful and non-playful contexts. Open-ended written responses were subjected to qualitative content analysis in order to code expressions of emotional disposition towards mathematics, with particular attention to lexical choices in pupils' productions. Coding also captured evaluative language (positive or negative) associated with the disruption of the storyworld introduced in Act I, which was suggestive of emotional disposition towards mathematics following a key turning point. In Phase 2, Task 1 involved the collection of worksheets containing pupils' written productions in order to investigate the impact of gamified storytelling on pupils' vision of mathematics. The worksheets were reviewed to identify procedural routines in pupils' solution strategies. These analyses formed the basis for Task 2, allowing an exploration of whether such routines remained stable, changed, or were absent. The second author reconstructed and transcribed field notes from group discussions. While worksheet data focused on procedural routines, individual responses were inspected to capture whether pupils established connections between mathematical reasoning and the narrative context. Individual written protocols were then collected. Emoticon selections from two multiple-choice items were used as indicators of emotional disposition across phases of the problem-solving activity. Written statements were interpreted to capture perceived competence in terms of confidence, difficulty, and willingness to engage with mathematical tasks

and support the narrative character. In Phase 3, individual protocols were collected after the conclusion of the narrative. Pupils' selections among the four emoticons were recorded to assess changes in their emotional disposition. These data refer to a significant moment following the final turning point of the storytelling and relate to the effect of the narrative resolution on students' emotional disposition. Open-ended responses were analysed to identify expressions of perceived competence, focusing on whether pupils still supported Mortino. Examination addressed references to responsibility towards the storyworld and lexical choices indicating capability to engage with the mathematical tasks and support the narrative character. This reflected sustained engagement with the narrative task and pupils' perceived ability to assist the character despite emotional or cognitive difficulties during the activities.

4. Results

The present section provides evidence intended to examine in relation to our theoretical framework the effects that the narrative-gamified structure has had on pupils' attitude towards mathematics.

4.1. Emotional Disposition

The emotional disposition was examined in relation to pupils' reported emotional responses to the learning experience. At each phase, the study documented pupils' selected emotional states and their responses before and after the different activities. In Phase 1, in *What does the math taste like*, all participants associated mathematics with terms that only referred to their own favourite foods such as pizza, lasagna, hamburger, ice-cream or fried fish. In this initial activity, responses indicated a generally positive emotional disposition across the class. In the subsequent semi-structured protocol, despite the request to select only one of the opposing options provided, two pupils ticked both the positive and negative option, as shown below.

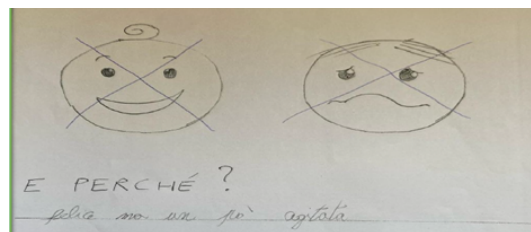


Figure 5. Phase 1 protocol extract .

S10²: *I feel happy but a bit agitated too.*

S10 shows an ambivalent emotional expression. In a task that pupils didn't perceive as a game, but rather as an evaluation of their own feelings, ambivalent emotional responses were observed. The terms *happy* and *agitated* coexisted within the same statement, showing the emergence of negative emotional elements alongside positive ones in pupils' responses.

S16: *I am happy because I feel good in mathematics but I didn't like it when the teacher used to get angry.*

S16 response also shows ambivalent emotional expressions. In this statement as well, the terms *happy* and *I didn't like it* coexist, demonstrating that the pupil also didn't enjoy the subject

²All the label S followed by a numerical value serves as an anonymous identifier for the students.

when the student-teacher relationship was shaken in some didactic situations. In Phase 2, the data derived from students' selections indicated a general tendency towards the consolidation of positive emotional states already present in Phase 1: pupils predominantly selected positive emoticons, without exhibiting emotional fluctuations throughout the experience in this phase. In addition, most pupils selected positive emoticons during the later phases. Whereas ambivalent responses were observed in Phase 1, no ambivalent emoticon selections were recorded in Phases 2 and 3. Positive emoticons were the most frequently selected responses. A limited number of participants continued to express a negative emotional disposition.

In Phase 3, the results of the last semi-structured protocol showed the following changes in relation to emotional disposition. The analysis of responses showed no ambivalent selections, with most pupils marking positive emoticons. A single uncertain response was recorded. The majority of students selected positive emoticons and something changed in their written statements too.

S8: *I'll give him the strength and joy to continue searching for his heart.*

S18: *Don't give up, you can do it, and how would you live without your heart?*

Although in Phase 1 ambivalence had emerged, and in Phases 2 and 3 a partially negative emotional disposition had been observed, responses expressed emotional support towards Mortino, encouraging him not to give up.

4.2. Perceived Competence

As discussed in the Theoretical background, perceived competence refers to pupils' reported sense of autonomy, confidence, and ability to engage with mathematical tasks. This dimension is assessed throughout the experiment to examine pupils' reported sense of competence in relation to assisting Mortino across activities.

In Phase 1, in the questionnaire following the mathematics-food matching game, only 5 participants reported statements in which they disliked mathematics in certain circumstances. Among these, 2 pupils referred specifically to aspects related to their perceived competence :

S10: *I don't like it very much when I have difficulty learning new things.*

S13: *I don't like mathematics when there are new difficult things.*

S10 and S13 stated that there were instructional situations in which they didn't like the subject and provided a reason to support their statements. These two pupils reported terms referring to perceived difficulties in mathematical practice:

S10: *I have difficulty learning new things.*

S13: *new and difficult things.*

In particular, pupils' responses indicate insecurity when they are required to engage with unfamiliar tasks. In Phase 2, changes in pupils' responses were observed. Despite the difficulties reported when pupils faced unfamiliar tasks in Phase 1, students, as shown in the examples below (S10 and S13), reported willingness to assist the main character across activities:

S10: *Yes, I want to help him.*

S13: *I like it because I am learning to reason by myself.*

About this attitude's dimension, S10's and S13's responses showed that both negative and positive evaluations of competence were present in Phase 1, while an increase in positive evaluations was observed in Phase 2.

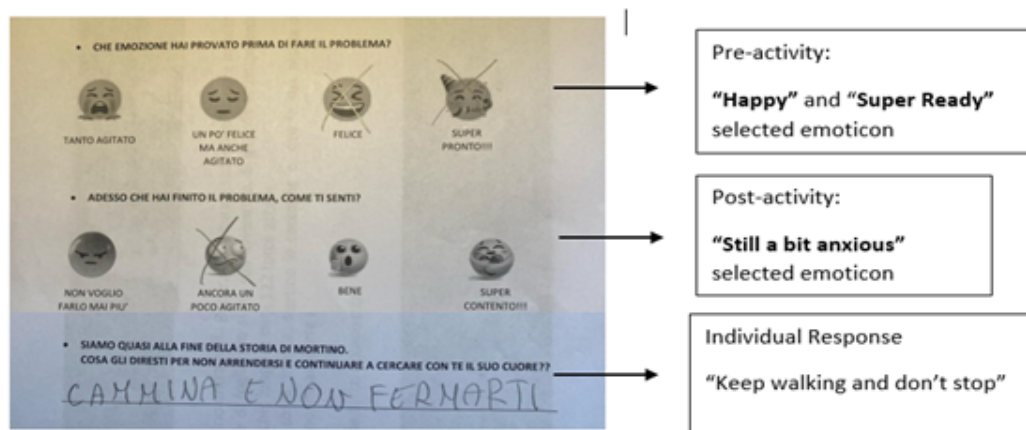


Figure 6. Phase 3 protocol extract.

In Phase 3, all students provided encouragement for Mortino in difficulty, as shown in the extract above (Figure 6).

The following statement was reported by a student.

S4: *I got anxious because I was unsure about the correctness of the operation I had done.*

In Phase 2, not all students reported having overcome anxiety when approaching problem-solving tasks and of feeling confident when facing it. S4's statement reported anxiety related to uncertainty about the correctness of his solution. This example included the expression "I was unsure", indicating uncertainty in Phase 2. The same student revised his statement in Phase 3, as shown below.

S4: *Teacher, why? Don't you help your friends?*

S4 selected an emoticon that still partially reflected insecurity; however, his response to the open-ended question included expressions of encouragement towards Mortino, despite that specific marking.

4.3. Vision of Mathematics

Regarding the vision of mathematics, the present study investigated potential changes in attitude resulting from the combined use of narrative principles and gamified dynamics in conjunction with story-based problems, particularly when children engaged with unfamiliar tasks. In Phase 2, the analysis of the problem-solving protocols highlighted the following results. In Task 1, the groups established similar routines in their written protocols:

- participants structured their problem-solving according to the specified categories: *Data; Operation (linear/column); Answer; Reasoning;*
- routines also included the use of coloured pens or tables to categorise place values; no attempts at graphic representation to better clarify their problem-solving strategy;
- the adoption of selective reading strategies to identify keywords for operations;
- both *Answer and Reasoning sections* were limited to indicate the numerical value resulting from the calculations, as follows (Figure 7).

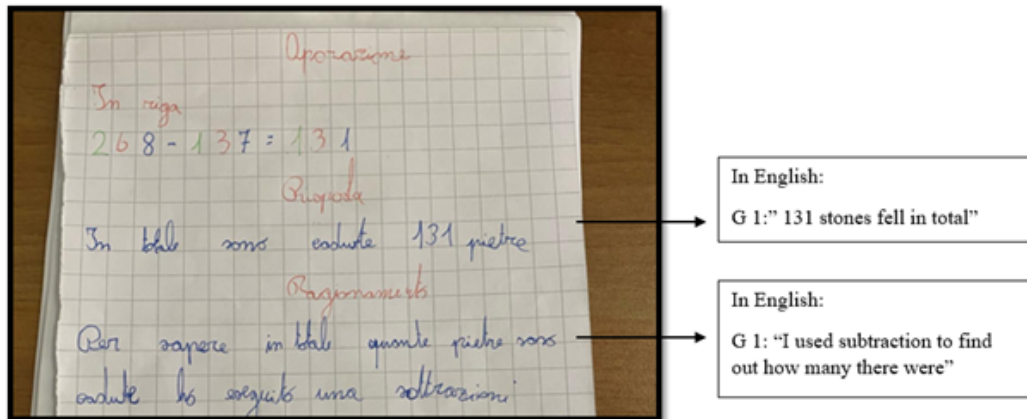


Figure 7. Phase 2 protocol extract.

In Task 1, argumentative interaction during solution-based discussion was characterised by a marked prevalence of teacher scaffolding questions, in contrast to the teacher's direct questions. The students' arguments didn't present explicit connections to the narrative purpose but instead provided justifications based on the routines they used, as shown below:

S4: *No, because 'altogether' is not a subtraction word, teacher, but it's one of addition.*

S20: *I didn't understand, and I did the addition because I didn't see the words for subtraction.*

In Task 2, there were differences compared with Task 1 due to the absence of the following routines within the protocols:

- the four groups no longer circled numerical data or underlined the interrogative clause;
- the pupils no longer used coloured pens to differentiate the terms of the chosen operations;
- in their *Reasoning category*, more frequent references to two types of analysis were observed in relation to the based- story problem in their statements: the narrative purpose and the reasoning behind the chosen operation linked to the narrative elements.

G1³: *To help Mortino pass through the dark corridor, I intended to use 272 torches (122+150).*

G2: *To find out how many torches are lit, I performed an addition because the problem states that the fallen bulbs are then switched back on.*

G3: *To find out how many torches still need to be lit, I performed a subtraction (because) to reach 150, 32 are missing.*

G4: *To find out how many torches are in the cave, I performed an addition because Mortino collects another 20.*

During the collective discussion in Task 2, there has been a more balanced distribution between the two input types; a reduction in external mediation and an increase in spontaneous interventions by the participants were observed.

S11: *With subtraction, we take away the lights and then Mortino is in the dark. We already have 122, and then he collects more, so it's an addition.*

³The label G followed by a numerical value serves as an identifier for each group.

S5: *We help Mortino do the addition because at the beginning we have 122 torches, but then he also picks up the ones on the ground. Teacher, so we do $122 + 20$, which is 142.*

Pupils' arguments presented more explicit connections to the narrative purpose as justification for the chosen operation.

5. Discussion

The present study aimed to investigate how the application of a gamified narrative structure may influence pupils' attitude towards mathematics, through the Three-dimensional Model of Attitude [9]. The findings revealed that changes across the three dimensions didn't occur simultaneously or linearly; rather, the design foregrounded different affective, behavioural and cognitive processes throughout the educational experience.

The analysis highlighted how pupils' emotional disposition towards mathematics showed changes throughout the experiment. Initially, the discipline was associated with positive elements within playful activities, suggesting that the introduction of narrative and game dynamics generated an emotionally reassuring learning environment. However, when pupils were invited to reflect explicitly on their feelings towards mathematics, ambivalent emotional states emerged. As discussed within Literature review, previous school experiences and classroom expectations significantly shape students' emotional responses towards the discipline [16, 9]. When familiar procedural routines were questioned through narrative-based mathematical activities, uncertainty in pupils became more visible. Rather than eliminating fear entirely, the narrative structure appeared to create a context in which pupils could progressively recognise and externalise their emotions towards mathematics. As the gamified experience progressed, students demonstrated greater emotional stability and increasing willingness to engage with activities. Particularly, the narrative structure appeared relevant in supporting this process. As discussed above, storytelling allows children to project emotions and fears onto fictional characters, thereby facilitating emotional elaboration and engagement [4, 5]. By identifying with the main character, pupils interpreted tasks as meaningful actions within a shared story-world, thereby demonstrating empathetic and supportive attitude towards Mortino. Through gamification dynamics, the narrative structure seemed to foster more resilient emotional responses towards challenging tasks. Anxiety therefore did not disappear entirely; however, pupils demonstrated a greater inclination to participate despite experiencing emotional discomfort.

The findings revealed important transformations in the way pupils perceived their own mathematical competence. This dimension was strongly influenced by students' emotional disposition, which initially appeared to depend on the possibility of applying familiar operational routines. Unfamiliar tasks induced insecurity and reduced pupils' initiative, suggesting that their sense of agency was associated more with procedural certainty than with adaptive reasoning processes. Consistent with the theoretical framework, this procedural dependence reflects how students often construct their sense of competence through predictable problem-solving schemes within repetitive school practices [23, 11]. When the gamified layers required interpretation and autonomous reasoning, pupils experienced emotional tension. As the experimentation progressed, however, students demonstrated willingness to participate actively and to persist despite uncertainty. The structured levels sustained their curiosity about subsequent developments and the prospect of receiving reward puzzles. Such results are consistent with studies suggesting that both deep and shallow gamification can reinforce pupils' motivation and control over learning activities [15, 20]. Rather than avoiding difficult tasks, pupils progressively became more inclined to confront them, especially when they perceived their contribution as meaningful within the narrative pathway. The identification process established

with Mortino played a significant role in pupils' motivational engagement; specifically, pupils regarded themselves as responsible for helping the character overcome his setbacks. This form of emotional involvement was found to reinforce their perceived competence, even when anxiety remained present.

Throughout the experiment, pupils' vision of mathematics changed significantly, particularly through the reciprocal interplay between mathematical reasoning and narrative structure. Initially, students approached tasks through routine-based strategies. The findings are coherent with studies suggesting that pupils frequently experience mathematics as highly procedural, abstract and disconnected from meaningful contexts [6, 9]. However, the narrative activities encouraged pupils to gradually challenge these strategies. Mathematical reasoning became increasingly connected to the narrative goals: specifically, pupils began to justify their mathematical choices not only through procedures but also through references to the broader narrative context. This shift suggests that storytelling can support more interpretative and meaningful forms of mathematical reasoning. In addition, the experiment fostered more spontaneous argumentative interactions, with pupils relying less on external guidance and more on shared reasoning processes connected to storytelling. This aspect indicates the emergence of a more participatory vision of mathematics, in which students perceived themselves as active contributors to the problem-solving process rather than passive executors of procedures.

6. Conclusions

The research suggested that the interrelationship between storytelling, gamification and mathematical activities can positively influence pupils' emotional disposition, perceived competence, and vision of the discipline by fostering more meaningful participation in the educational process. In addition, gamified dynamics strengthened distinct forms of motivation and persistence by encouraging responsibility within the learning pathway. In this respect, it became apparent that a gamified narrative structure did not operate as a means of fully eradicating fear. Mathematics anxiety does not disappear entirely; however, pupils can progressively develop greater resilience and willingness to face demanding tasks despite fear. This gradual shift indicates a broader interpretative reading of the role of narrative structure in the learning process. The moments of crisis within the story, namely the emergence of darkness and the loss of Mortino's heart, operated not only as elements of engagement but also as forms of emotional mediation. Mathematical apprehension related to error was partially mediated through the narrative world; rather than being experienced solely as an individual difficulty, it became shared through the collective narrative experience and the relationship established with the main character. The identification process supported pupils in engaging with negative emotions without immediately perceiving them as personal failure. Accordingly, narrative crises provided a supportive context in which mathematical anxiety could be more gradually expressed. Concurrently, these narrative disruptions contributed to a shift in students' mathematical thinking. Pupils who were initially accustomed to rigid routines were gradually exposed to situations in which such strategies were no longer fully sufficient. The narrative problems required operations to be interpreted within the logic of the story and the intentions of the protagonist. In group discussions, pupils increasingly justified their reasoning not only by associating specific words with operations, but also through narrative meaning (considering the consequences of an action within Mortino's world). Thus, through participation in the narrative disruptions, storytelling not only supports pupils' engagement but encourages a gradual transition from procedural to more interpretative approaches to problem solving. A potential limitation of this study resides in its localized context, as the qualitative depth of the observed interactions reflects specific classroom dynamics. Furthermore, while the findings indicate significant transformations, the long-term sustainability of this emotional and cognitive shift remains to be verified, as the re-

sults may be partially influenced by the novelty of the gamified narrative intervention. Further research could explore how this structure might be adapted to different educational contexts, incorporating larger sample sizes and a greater number of classrooms, in order to investigate its long-term impact on pupils' attitude towards mathematics.

Declaration

The contents of this paper stem from Angela Sassone's master's dissertation, under the supervision of the other author of the paper.

References

- [1] Albano, G., & Pierri, A. (2017). Digital storytelling in mathematics: A competence-based methodology. *Journal of Ambient Intelligence and Humanized Computing*, 8(3), 301–312. <https://doi.org/10.1007/s12652-016-0398-8>
- [2] Aquilina, G., Di Martino, P., & Lisarelli, G. (2024). The construct of attitude in mathematics education research: Current trends and new research challenges from a systematic literature review. *ZDM – Mathematics Education*, 57(4), 569–581. <https://doi.org/10.1007/s11858-024-01642-3>
- [3] Bartolini Bussi, M. G., Boni, M., & Ferri, F. (1995). La discussione matematica nella scuola elementare [Mathematical discussion in primary school]. *L'Insegnamento della Matematica e delle Scienze Integrate*, 18(1), 11–42.
- [4] Bettelheim, B. (1976). *The uses of enchantment: The meaning and importance of fairy tales*. Alfred A. Knopf.
- [5] Bruner, J. (2006). *La fabbrica delle storie*. GLF Editori Laterza.
- [6] Chandoria, V. K., Singh, P., & Vajpai, S. (2024). Creating a space for stories and storytelling in mathematics classroom: A pedagogical enquiry. *ShodhKosh: Journal of Visual and Performing Arts*, 5(4), 1893–1904. <https://doi.org/10.29121/shodhkosh.v5.i4.2024.5642>
- [7] Cusi, A., Morselli, F., & Sabena, C. (2025). Humanizing mathematics through innovative task design: Storytelling and gamification in early childhood education. *Journal of Mathematical Behavior*, 77, Article 101204. <https://doi.org/10.1016/j.jmathb.2024.101204>
- [8] Cutting, J. E. (2016). Narrative theory and the dynamics of popular movies. *Psychonomic Bulletin & Review*, 23(6), 1713–1743. <https://doi.org/10.3758/s13423-016-1051-4>
- [9] Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: A bridge between beliefs and emotions. *ZDM Mathematics Education*, 43(4), 471–482. <https://doi.org/10.1007/s11858-011-0309-6>
- [10] Di Martino, P., & Zan, R. (2019). *Problemi al centro: Matematica senza paura*. Giunti Scuola.
- [11] Di Martino, P., & Zan, R. (2020). *Problemi per crescere: Matematica senza paura*. Giunti Scuola.
- [12] Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology*, 7, Article 508. <https://doi.org/10.3389/fpsyg.2016.00508>

- [13] Field, S. (1979). *Screenplay: The foundations of screenwriting*. Dell Publishing.
- [14] Irmayanti, M., Chou, L. F., & Anuar, N. N. Z. (2025). Storytelling and math anxiety: A review of storytelling methods in mathematics learning in Asian countries. *European Journal of Psychology of Education*, 40(1), Article 24. <https://doi.org/10.1007/s10212-024-00927-1>
- [15] Kim, J. T., & Lee, W. H. (2015). Dynamical model for gamification of learning (DMGL). *Multimedia Tools and Applications*, 74, 8483–8493. <https://doi.org/10.1007/s11042-013-1612-8>
- [16] Majeed, A. A., Darmawan, I. G. N., & Lynch, P. (2013). A confirmatory factor analysis of attitudes toward mathematics inventory (ATMI). *The Mathematics Educator*, 15(1), 121–135. https://math.nie.edu.sg/ame/matheduc/tme/tmeV15_1/7.pdf
- [17] Mayring, P. (2015). Qualitative content analysis: Theoretical background and procedures. In A. Bikner-Ahsbals, C. Knipping, & N. Presmeg (Eds.), *Approaches to qualitative research in mathematics education: Examples of methodology and methods* (pp. 365–380). Springer. https://doi.org/10.1007/978-94-017-9181-6_13
- [18] McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575–596). Macmillan.
- [19] Mellone, M., Tortora, R., & Zacks, A. (2013). Storytelling and character identification in the primary mathematics classroom. *Educational Studies in Mathematics*, 84(2), 215–231. <https://doi.org/10.1007/s10649-013-9485-x>
- [20] Mozelius, P. (2021). Deep and shallow gamification in higher education: What is the difference? In *Proceedings of INTED2021 Conference* (pp. 2977–2983). IATED. <https://doi.org/10.21125/inted.2021.0663>
- [21] Ortegón Ángel, J. A., Sánchez Devia, Á. A., & Burbano Gonzalez, D. C. (2025). Transmedia digital narratives in mathematics teaching in educational contexts: A systematic, bibliometric, and structural review (2014–2024). *Frontiers in Education*, 10, Article 1719806. <https://doi.org/10.3389/educ.2025.1719806>
- [22] Sánchez-Arévalo, B. M., Valenciano Valcárcel, J., & Fernández-César, R. (2025). Analysis on the use of gamification in mathematics in primary education: A literature review. *Journal of Research in Mathematics Education*. Advance online publication. <https://doi.org/10.17583/redimat.15132>
- [23] Schoenfeld, A. H. (1992). *Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics*. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334–370). Macmillan.
- [24] Suppia, A. O., & Romanzoti, N. (2019). Três é demais? Problematizando a estrutura em três atos no ensino de roteiro. *Intexto*, 44, 144–160. <https://doi.org/10.19132/1807-8583201944.144-160>
- [25] Virzì, M. C. (2018). *Gli strumenti dello storytelling*. Dino Audino Editore.
- [26] Zan, R. (2012). La dimensione narrativa di un problema: Il modello C&D per l’analisi e la (ri)formulazione del testo. Parte I. *L’insegnamento della matematica e delle scienze integrate*, 35A(2), 107–126.

- [27] Zan, R. (2016). *I problemi di matematica: Difficoltà di comprensione e formulazione del testo*. Carocci.
- [28] Zan, R. (2021). *Mio figlio ha paura della matematica*. Giunti EDU.
- [29] Zan, R., Brown, L., Evans, J., & Hannula, M. S. (2006). Affect in mathematics education: An introduction. *Educational Studies in Mathematics*, 63(2), 113–121.<https://doi.org/10.1007/s10649-006-0308-2>
- [30] Zazkis, R., & Liljedahl, P. (2009). *Teaching mathematics as storytelling*. Sense Publishers.



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