Transforming Math Anxiety into Engagement: The Impact of RPG-Based Gamification on Middle School Students

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Abstract: In both classroom settings and everyday life, it is common to encounter phrases such as "Math is not for me," "I'm not good at scientific subjects," "I can't do it," "I don't understand anything," "What's the use?", and "I've always had bad grades in maths". These expressions reflect various forms of anxiety, frustration, and lack of confidence in one's mathematical abilities. Addressing these negative perceptions is crucial for improving attitudes towards mathematics, especially for students and their academic success. This research presents a case study on gamification's impact on middle school students' perceptions of mathematics in the Italian-speaking region of Switzerland. Inspired by role-playing game (RPG) dynamics, students take the role of fantasy characters navigating a structured world, facing challenges to earn points and progress through the story. The teacher acts as a game master, guiding the narrative while minimizing direct intervention. The game system includes an explorable map, individual and collaborative tasks to improve mathematical and social skills, and a progression system rewarding both academic performance and positive behaviour. Storytelling elements enhance immersion, while challenges requiring problem-solving or strategic skills promote deeper engagement. Preliminary observations suggest reduced maths anxiety and more positive attitudes towards the subject, though results appear to differ by gender. These findings indicate gamification's potential as a supportive educational tool, warranting further research.

Keywords: Mathematics anxiety, Gamification, Middle school education, Game-Based learning, Attitude improvement

1. Introduction

How many times in class, but also in everyday life, do we encounter common phrases about mathematics such as: "Math isn't for me", "I'm not suited for scientific subjects", "I'm not capable", "I don't understand anything anyway", "What's the use?", "I've always had bad grades in math". These expressions are just examples, but they reflect various forms of anxiety, frustration, and lack of confidence in people's mathematical abilities. Addressing these negative perceptions is fundamental to improve students' attitudes towards mathematics and their academic success.

Gamification, which consists of applying game elements to non-game contexts like education, could make learning mathematics more engaging, more motivating, and less frustrating. It also has the potential to transform students' negative perceptions, making mathematics a positive and stimulating experience. By transforming mathematics from a task perceived as arduous into a fun and stimulating activity, gamification can radically change students' perspectives. The healthy and friendly competition encouraged by games can motivate students to improve their skills without feeling overwhelmed.

This research project aims to explore if and how gamification can influence the perception of mathematics among middle school students in Ticino, the Italian-speaking part of Switzerland. Specifically, it investigates whether a gamified approach can contribute to prove students' attitudes and reducing their math anxiety towards the discipline.

2. Theoretical Framework

2.1 Attitude Towards Mathematics

Attitude towards mathematics is a complex construct involving affective (feelings, emotions), behavioral (tendencies, self-efficacy), and cognitive (beliefs, opinions) components, a framework originally described by Rosenberg and Hovland (1960). These dimensions interact dynamically to shape students' engagement and perceptions. Negative beliefs can lead to anxiety and hinder self-efficacy, creating a cycle of avoidance and poor performance (Zan et al., 2006; Mensah et al., 2013). Moreover, research underscores the importance of promoting self-efficacy and intrinsic motivation, as supported by Bandura's (1997) theory of self-efficacy and Ryan & Deci's (2000) self-determination theory. Fostering positive attitudes and confidence is crucial.

2.2 Mathematics Anxiety

Mathematics anxiety is a feeling of apprehension interfering with mathematical problem-solving in academic and daily life. It is influenced by emotional and cognitive factors, fear of errors, working memory load, and can manifest physiologically (Richardson & Suinn, 1972; Luttenberger et al., 2018). Mathematics anxiety negatively impacts performance and can deter students from STEM fields. Incidence varies by gender and age, often increasing during middle/high school, with females frequently reporting higher levels, possibly due to stereotype threat (Else-Quest et al., 2010; Devine et al., 2012, Dowker at al., 2016). Strategies to reduce mathematics anxiety include fostering a growth mindset (Dweck, 2006), using innovative teaching methods like gamification (Hamari et al., 2014), anxiety management techniques, and creating supportive learning environments (Shields, 2005).

2.3 Gamification

Gamification uses game-design elements (like avatars, narratives, feedback, levels, points, competition, collaboration) in non-game contexts to boost motivation and engagement (Deterding at al., 2011). It differs from Game-Based Learning (using full games) and Serious Games (games for specific non-entertainment purposes). In education, gamification aims to increase engagement, motivation, and learning, often providing immediate feedback (Hamari et al., 2014; Dicheva et al., 2015; Alt, 2023). However, potential downsides include superficial learning, unequal competition leading to stress, declining interest over time, and over-reliance on extrinsic rewards (Kapp, 2012; Hamari et al., 2014). Measuring its effectiveness requires rigorous methodology. Some studies show mixed results on attitude impact despite student enjoyment (Karamert & Vardard, 2021; Bragg, 2007).

3. Methodology

To investigate the impact of gamification on students' attitudes and anxiety towards mathematics, this study adopted a research-action design, relying primarily on quantitative data gathered through questionnaires administered before and after the intervention period. The research took place during the 2024/2025 school year within a specific second-yearmiddle school class in Ticino, comprising 16 students (9 females and 7 males) aged 12 to 13 years old. This class presented a dynamic mix, characterized by heterogeneity in student profiles, a lively classroom atmosphere, and observable signs of initial low motivation towards mathematics. It is important to note that the small sample size suggests the findings should be interpreted as context-specific rather than broadly generalizable.

The research unfolded through a sequence of planned phases, beginning with an initial exploratory questionnaire to understand the students' baseline perspectives. The questionnaire was followed by the design of the specific gamification structure tailored for the class. Subsequently, pre-intervention questionnaires were administered to establish baseline measures for attitude and anxiety. The core phase involved implementing the gamified mathematics activities over a seven-week period, primarily during two dedicated weekly laboratory hours. Following the intervention, the same questionnaires were administered again to capture any changes. The final phase involved the analysis of the collected pre- and post-intervention data.

Two validated instruments were selected to measure the key variables. To assess attitudes, the Attitudes Toward Mathematics Inventory in Secondary Education (ATMSE) was utilized (Suherman & Vidákovich, 2022). This instrument, adapted from Tapia and Marsh's (2004) ATMI specifically for the middle school context and translated from English for this study, measures four dimensions across 26 items: Self-perception, Value, Enjoyment, and Perceived Achievement in mathematics. For measuring math anxiety, the Modified Abbreviated Math Anxiety Scale (mAMAS) (Carey et al., 2017) was employed. This 9-item scale is designed for younger students and effectively distinguishes between anxiety related to learning mathematics and anxiety stemming from evaluation situations.

The gamification intervention was designed as an immersive Role-Playing Game (RPG). Students took the roles of "apprentice heroes" within the fantasy narrative of the “Kingdom of Armathia,” embarking on a quest against the "Lord of Shadows." Key gameplay elements were integrated to foster engagement, including an explorable, non-linear map that guided progress, integrated storytelling moments, and a variety of individual and collaborative challenges that required mathematical problem-solving. Students chose from distinct character classes (Mage, Ranger, Barbarian, Thief, Warrior), each possessing unique abilities, and could acquire additional power-ups through purchasable ability/tool cards. Each class is designed to support different gameplay approaches, giving students the opportunity to adopt a style that suits them best. Strategic classes like the Mage and Ranger emphasize puzzle-solving and team support (the mage allowing students to simplify a task, the

ranger allowing to earn more experience points), while aggressive roles such as the Barbarian and Warrior focus on combat and endurance (the barbarian automatically defeating lesser enemies, the warrior having various supporting abilities during fights). The Thief, representing a more tactical style, centres on resource management and manipulating game dynamics (stealing cards from other teams, or avoiding penalties from a failed check).

A multi-faceted scoring system tracked progress: Team Hit Points (THP) reflected collective resilience, Personal Points (PP, represented as Red Dobloons) rewarded positive behaviours and participation, and Experience Points (Exp, represented as Blue Dobloons) were earned through demonstrating disciplinary competence by completing mathematical tasks. Accumulating Exp was necessary to purchase cards and advance through the game's narrative arc, with students collaborating within designated teams. Figure 1 shows some of the in-game elements printed and ready to be used in class: Exp, PPs, a map of the area, purchasable items, and some handouts such as two chapters and one character sheet.

Figure 1: Printed in-game elements used in class

In practice, classroom activities were explicitly framed as missions within this overarching storyline. The journey begins at the Academy of Heroes (Figure 2), a central and symbolic location within the "Kingdom of Armathia". Here, students, transformed into "apprentice heroes," face their first challenges, each set in recognizable areas of the school. There is no predetermined order: students move autonomously, freely choosing their own path. Unlike in a traditional educational journey, student progression is not entirely linear. This approach allows players to decide which challenges to tackle first and in what order to explore the different areas of the map. Among the proposed activities are:

- The Library, where heroes must reconstruct a secret message using equivalent fractions;
- The Alchemy Lab, where they need to construct a cube to seal an unstable magic potion;
- The Canopy, where they design a perfect circle as a magic barrier.

All activities aim to reinforce and deepen the topics introduced and explored during large group classes. The focus is not solely on training specific skills, such as applying formulas, but also on developing problem-solving abilities. The gamified context motivates students not only to practice exercises that might otherwise feel tedious in a traditional setting, but also to engage with complex challenges that students with low self-efficacy might be reluctant to tackle under conventional pressure and performance evaluation conditions.

A group gameplay example can be seen in Figure 3.

Each session typically started with narrative prompts setting the scene, followed by hands-on mathematical tasks often structured collaboratively or leveraging the students' chosen character roles. Throughout this process, the teacher took the role of a game master, guiding the narrative, presenting challenges, monitoring progress, and dynamically adjusting the difficulty or flow based on the students' engagement and understanding.

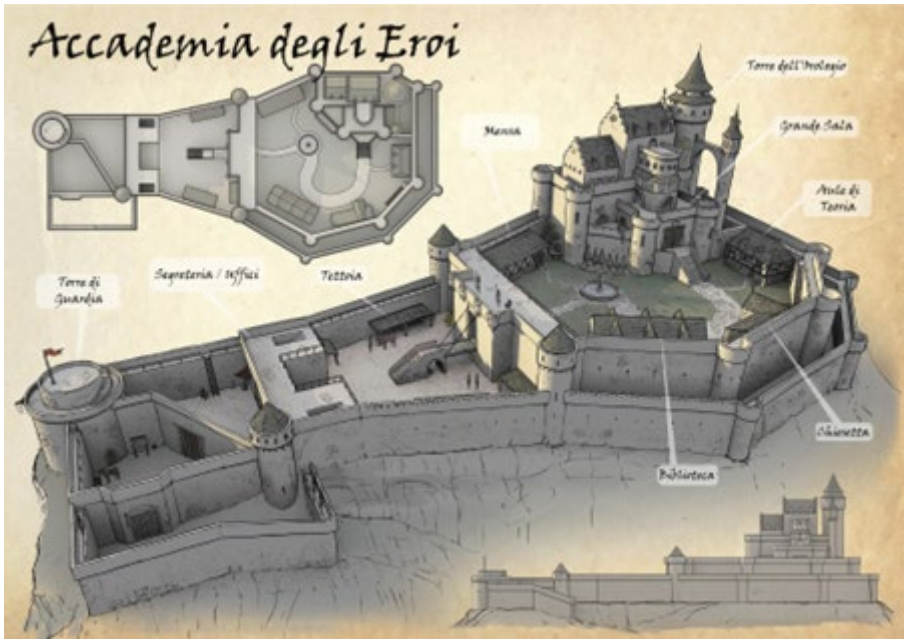

Figure 2: Map of the Academy of Heroes, a central and symbolic place to explore within the "Kingdom of Armathia"

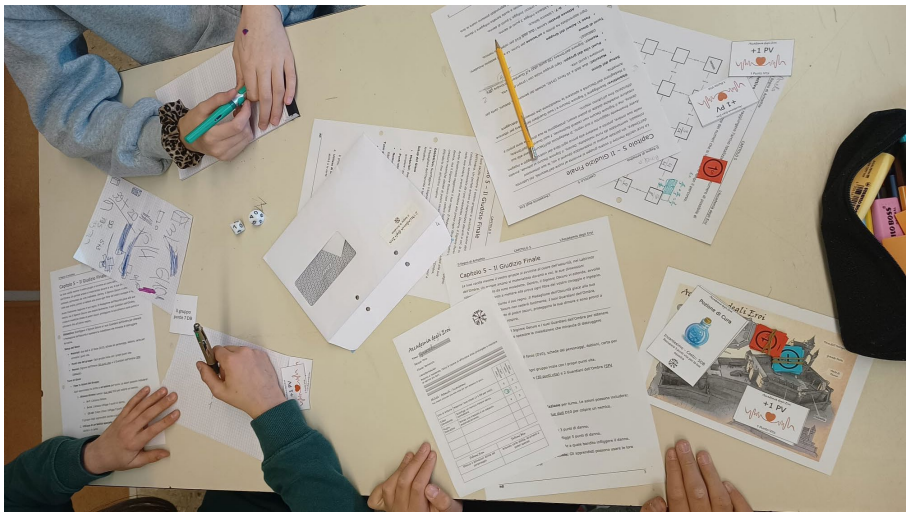

Figure 3: Students engaged in the fifth quest, "The Final Judgment"

4. Results

The analysis of data collected before and after the gamification intervention reveals notable trends and significant differences, particularly concerning gender, in students' attitudes and anxiety towards mathematics.

4.1 Baseline Perceptions Before Intervention

Initial insights were gathered through the exploratory questionnaire administered at the outset. This revealed a distinct contrast in how students perceived mathematics versus games. Mathematics was generally viewed as more complex, demanding, less intuitive, and less enjoyable than games, perceptions that were especially pronounced among female students. While mathematics was acknowledged as useful, this view was held more strongly by male students. Students' engagement with games varied. Although board games and video games were part of their leisure activities, roughly half the class reported not playing video games, a factor supporting the decision to implement a board game / pen-and-paper RPG rather than digital gamification infrastructure for inclusivity. A visual comparison of these initial perceptions regarding mathematics and games across different characteristics is presented in Figure 4.

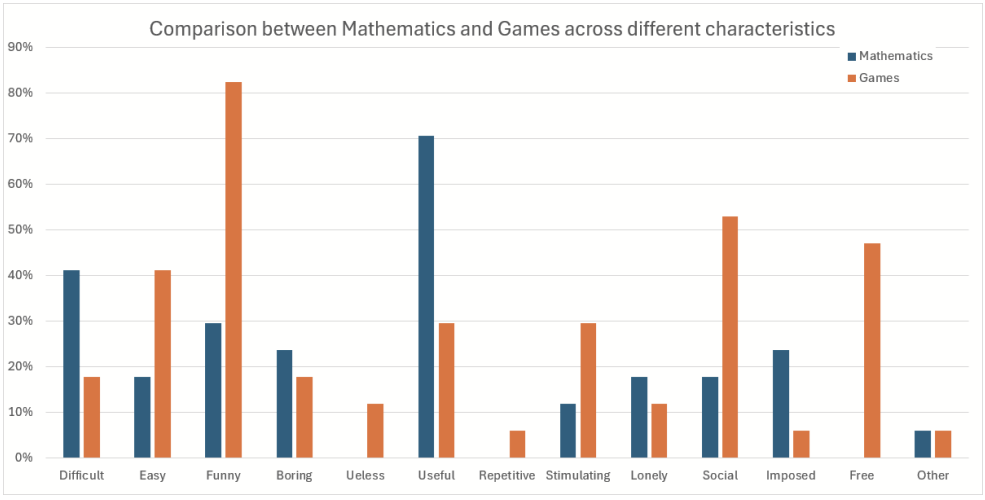

Figure 4: Comparison of students' perceptions between Mathematics and Games across different characteristics

The pre-intervention administration of the Attitudes Toward Mathematics Inventory in Secondary Education (ATMSE) demonstrated high internal consistency (Cronbach's α=0.97). The baseline attitude scores indicated a significant gender difference: male students reported considerably more positive attitudes (indicated by lower scores) than female students across the four measured subscales (Self-perception, Value, Enjoyment, Perceived Achievement) and in their overall scores. Furthermore, while female students' attitude scores were relatively clustered, male students' scores exhibited greater variability, suggesting a wider range of attitudes among them. Figure 5 provides a box plot illustrating these pre-intervention ATMSE responses and the gender comparison.

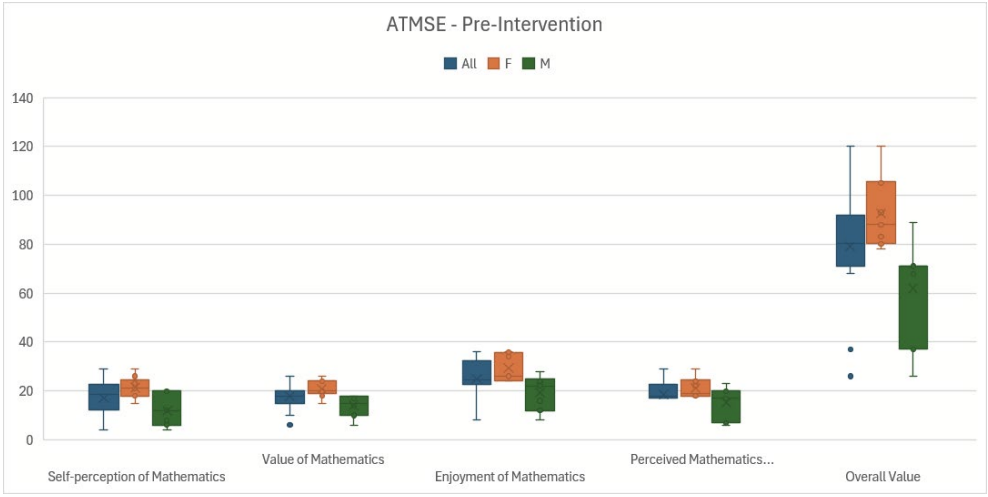

Figure 5: Box plot of ATMSE questionnaire responses pre-intervention, with gender comparison

Similarly, the pre-intervention assessment using the Modified Abbreviated Math Anxiety Scale (mAMAS) showed good internal consistency (Cronbach's α=0.88). Overall, the class reported moderate levels of math anxiety at baseline. However, mirroring the attitude results, a significant gender disparity emerged: female students reported substantially higher levels of anxiety than male students, both concerning anxiety related to learning mathematics and anxiety linked to evaluation situations, as well as in their total anxiety scores. Again, male students' anxiety scores displayed greater variability compared to female students. These baseline anxiety levels, differentiated by gender, can be seen in Figure 6.

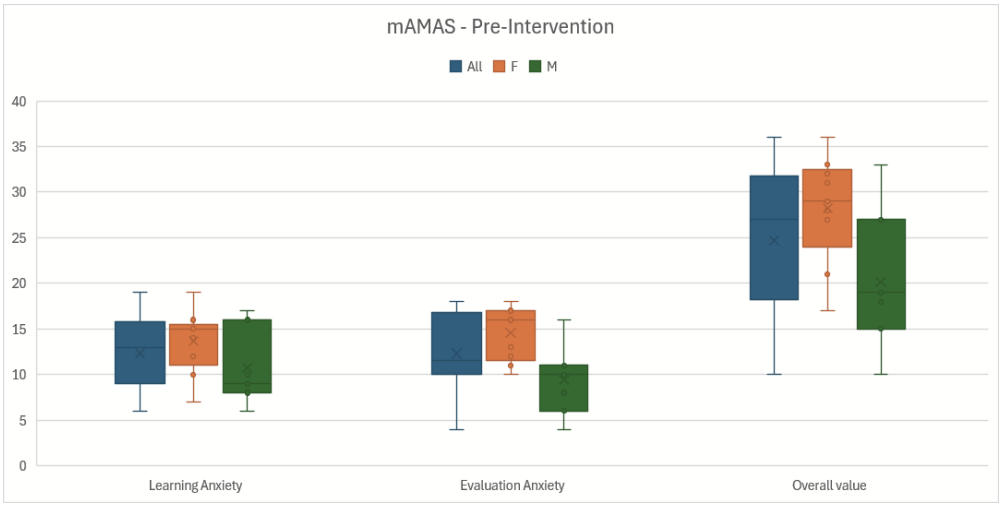

Figure 6: Box plot of mAMAS questionnaire responses pre-intervention, with gender comparison

4.2 Changes Following the Gamification Intervention

After the seven-week intervention period incorporating the RPG-based gamification, we once again administered the questionnaires.

The post-intervention ATMSE results maintained high internal consistency (Cronbach's α=0.97). While male students exhibit again more positive attitudes towards mathematics than female students overall, there was a statistically significant improvement in the average attitude score for the entire class (a decrease of 4.3% in the total score, p=0.014), suggesting the intervention positively impacted overall attitudes. This can be seen in Figure 7. A breakdown of these changes, comparing pre- and post-intervention scores with gender comparisons, is detailed in Table 1.

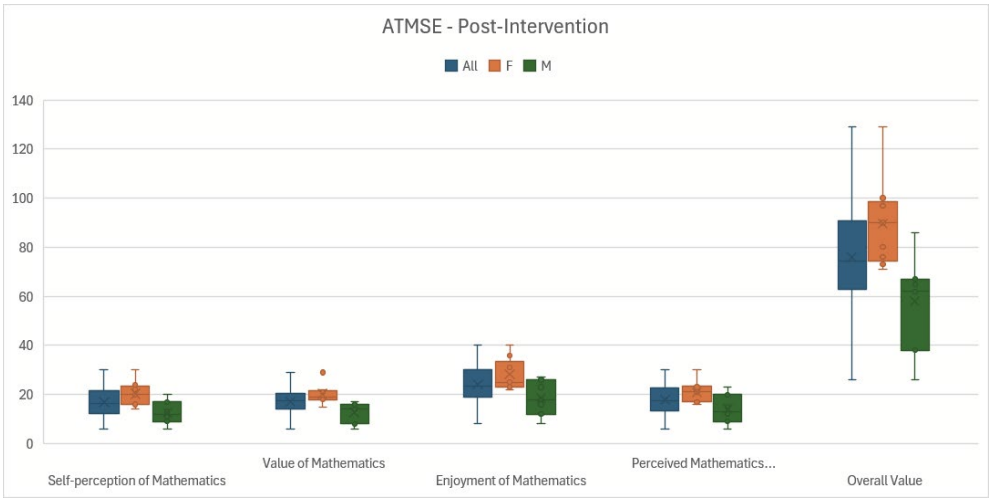

Figure 7: Box plot of ATMSE questionnaire responses post-intervention, with gender comparison

Examining the gender-specific changes in attitude (Table 1) reveals nuances within the overall positive trend. Female students demonstrated improvements across all attitude dimensions, with the largest (though not statistically significant) shifts seen in self-perception (-5.2%) and enjoyment (-3.4%). Their perceived achievement changed minimally (-1.6%). Male students also showed an overall improvement (-6.2% total score, p=0.028), driven by statistically significant gains in their perception of the value of mathematics (-8.2%, p=0.015) and substantial, though not statistically significant, improvements in perceived achievement (-8.4%). The overall improvement in perceived value for the entire group was also statistically significant (-4.6%, p=0.043).

Table 1: Paired Samples Test (ATMSE) with gender comparison of changes in math-related attitudes pre- and post-Intervention

	Gender	N	Mean differences	% Differences	SD	Cohen's d	p-Value
Self-perception of Mathematics	F	9	−1.11	−5.2%	2.62	−0.42	0.239
	M	7	−0.71	−5.4%	1.25	−0.57	0.182
	All	16	−0.94	−5.3%	2.08	−0.45	0.092
Value of Mathematics	F	9	−0.56	−2.7%	1.81	−0.31	0.384
	M	7	−1.14	−8.2%	0.90	−1.27	0.015
	All	16	−0.81	−4.6%	1.47	−0.55	0.043
Enjoyment of Mathematics	F	9	−1.00	−3.4%	2.55	−0.39	0.273
	M	7	−0.71	−3.7%	1.89	−0.38	0.356
	All	16	−0.88	−3.5%	2.22	−0.39	0.135
Perceived Mathematics Achievement	F	9	−0.33	−1.6%	1.22	−0.27	0.438
	M	7	−1.29	−8.4%	2.50	−0.51	0.222
	All	16	−0.75	−4.0%	1.88	−0.40	0.131
Overall Value	F	9	−3.00	−3.2%	5.85	−0.51	0.163
	M	7	−3.86	−6.2%	3.53	−1.09	0.028
	All	16	−3.38	−4.3%	4.84	−0.70	0.014

Turning to math anxiety, the post-intervention mAMAS results yielded good internal consistency (Cronbach's α=0.83). While there was a slight decrease in the average overall anxiety score for the entire group (-7.6%), this change did not reach statistical significance. However, analyzing the results by gender revealed a significant divergence. Female students experienced a statistically significant reduction in their overall math anxiety (-16.9%, p=0.045). This improvement was driven by a significant decrease in anxiety related to learning mathematics (-18.7%, p=0.044) and a notable, though not statistically significant, decrease in evaluation anxiety (-15.3%). In contrast, male students exhibited an increase in overall math anxiety (+9.2%), stemming from non-significant increases in both learning anxiety (+8.0%) and evaluation anxiety (+10.3%). This contrasting pattern in post-intervention anxiety levels between genders is shown in Figure 8 and in Table 2.

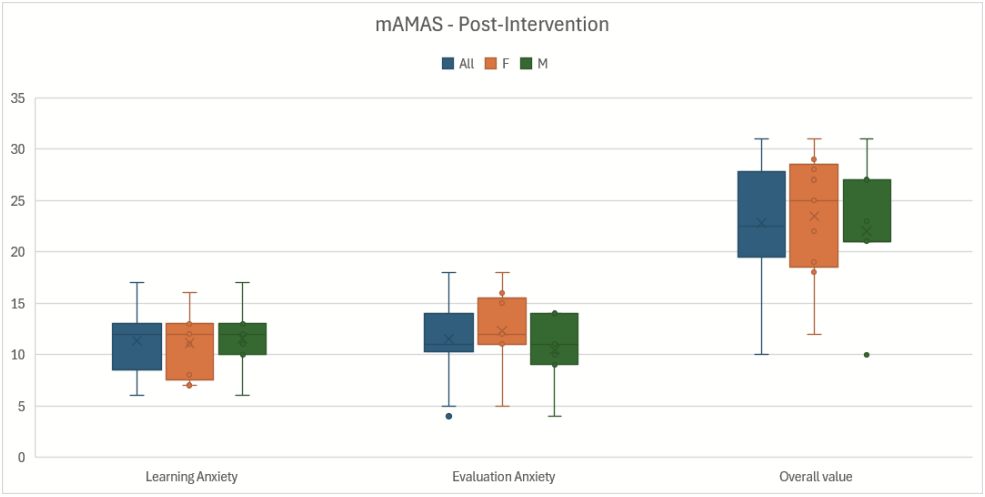

Figure 8: Box plot of mAMAS questionnaire responses post-intervention, with gender comparison

Table 2: Paired Samples Test (mAMAS) with gender comparison of changes in math-related attitudes pre- and post-Intervention

	Gender	N	Mean differences	% Differences	SD	Cohen's d	p-Value
Learning Anxiety	F	9	−2.56	−18.7%	3.21	−0.80	0.044
	M	7	+0.86	+8.0%	2.54	+0.34	0.407
	All	16	−1.06	−8.6%	3.34	−0.32	0.222
Evaluation Anxiety	F	9	−2.22	−15.3%	4.02	−0.55	0.136
	M	7	+1.00	+10.3%	2.45	+0.41	0.322
	All	16	−0.81	−6.6%	3.71	−0.22	0.395
Overall Value	F	9	−4.78	−16.9%	6.04	−0.79	0.045
	M	7	+1.86	+9.2%	3.93	+0.47	0.258
	All	16	−1.88	−7.6%	6.10	−0.31	0.238

5. Discussion

This paper investigated how gamification affects students' attitude and anxiety towards mathematics.

Overall attitude towards mathematics (ATMSE) showed a slight trend towards improvement for the whole group. Female students improved more in self-perception and enjoyment, while male students improved more in perceived achievement and value. This might suggest the intervention helped female students feel more confident and find math slightly more enjoyable, while male students felt they performed better and saw more utility in the subject post-intervention.

The most striking finding relates to math anxiety (mAMAS). While the overall group showed a non-significant decrease, there was a statistically significant reduction in anxiety for female students, contrasted by a non-significant increase in anxiety for male students. This suggests the RPG-based gamification intervention was particularly effective in lowering anxiety for female students in this context, but potentially counterproductive for males.

This gender difference may be given from the different starting points in anxiety levels. Girls, who started with higher levels, may have benefited more from the engaging, narrative-driven, less competitive (compared to typical classroom assessment) environment, reducing pressure. Male students, who started with lower anxiety, might have perceived the game mechanics, especially the accumulation and spending of points (dobloons), as a new form of performance pressure, leading to increased anxiety. The in-class observations highlighted reluctance of students to *spend* earned points, supporting the idea that resource management introduced a pressure element.

The study also implicitly addressed the feasibility of implementing such a gamification approach. Conducting it within smaller lab groups was deemed beneficial for management and immersion. The choice to avoid a digital approach aimed for inclusivity given varying student experience with digital games.

The small sample size limits generalizability. The intervention period was relatively short (7 weeks), which might be insufficient for significant attitude shifts. The study relied on self-reported quantitative data; qualitative data (like interviews or detailed observational notes) could provide deeper insights into students' experiences and the reasons behind the observed gender differences. The high Cronbach's alpha for the ATMSE might indicate item redundancy.

To complement the standardized questionnaire data, students were asked an open-ended question soliciting their personal impressions: "Would you continue this activity? Would you recommend it to other students? Briefly explain why". While the responses obtained (Figure 9) were not extensively detailed, a clear appreciation for the fun and playful aspect of the gamified activities emerged ("Yes, because it is fun", "I would recommend it to other students because it is fun"). Students commonly perceived these activities as lighter and more accessible compared to traditional lessons ("Yes, because it feels like doing a light and fun activity"). On the other hand, it is important to note the feedback from one student who found the dynamic too slow, lamenting a perceived lack of progression in the disciplinary content ("No, because we slow down with the math curriculum"). Although simple, these open-ended responses highlight the general positive reception of the

engaging nature of the gamification but also underscore the challenge of finding activities that maintain appropriate pacing and interest for all learners, pointing towards the need for differentiation even within a gamified structure.

This qualitative feedback reinforces the quantitative findings. The general enjoyment aligns with the slight improvements in attitude but also hints at why the impact wasn't universally positive for anxiety; factors like pacing and perceived progression can also influence student experience alongside the core game mechanics.

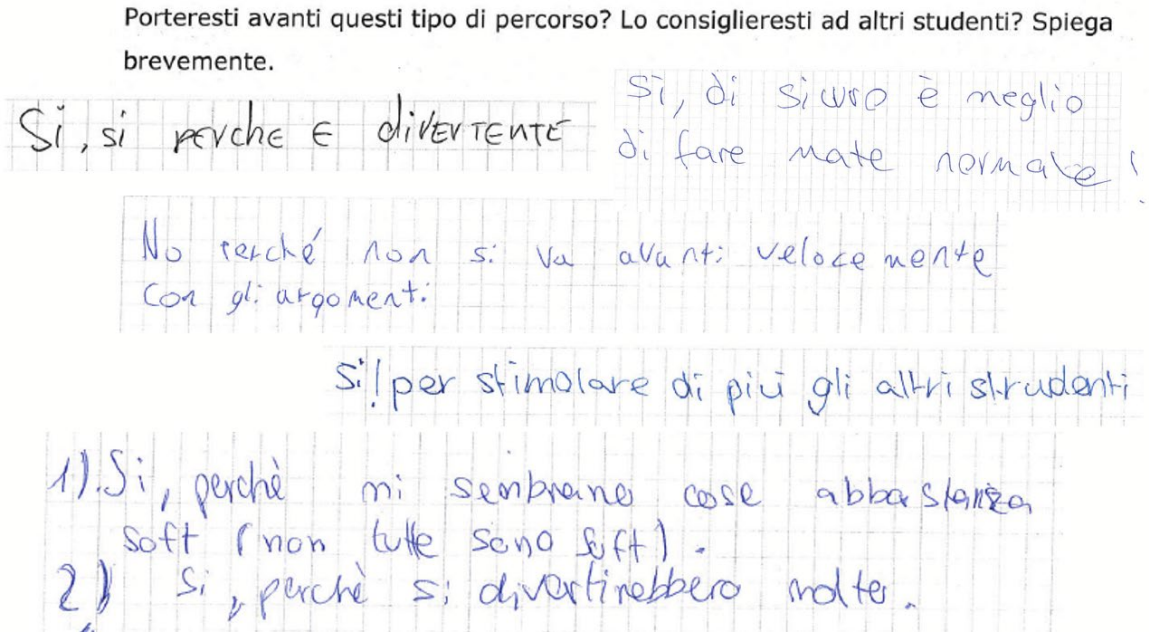

Figure 9: Some of the students' answer to the open-ended question "Would you continue this activity? Would you recommend it to other students? Briefly explain why"

6. Conclusion

This research explored the impact of an RPG-based gamification intervention on a second-year middle school students' attitudes and anxiety towards mathematics within a specific middle-school classroom in Ticino, Switzerland. Although not generalizable, the findings indicate that the effects of gamification are complex and not homogeneous across all students or measures. The intervention showed a statistically significant improvement in the overall attitude towards mathematics for the class, suggesting that the engaging, narrative-driven approach of the gamified activity can indeed foster a more positive disposition towards the subject.

The impact on mathematics anxiety revealed a gender divergence. Female students, who entered the study with higher baseline anxiety, experienced a statistically significant reduction in math anxiety, particularly concerning the learning aspect. This suggests that the gamified environment could potentially be perceived as less pressured and more supportive and was particularly beneficial for them. Conversely, male students showed a non-significant increase in anxiety, suggesting that certain elements of the gamification, possibly related to performance tracking or game resource management, might have inadvertently introduced new pressures for them.

In the qualitative feedback at the end of the activity, students generally reported finding the gamified activities fun, playful, and more accessible than traditional lessons, aligning with the observed improvements in overall attitude. This highlights the affective benefits of the approach. Yet, feedback also included concerns about the pacing being too slow for some, indicating that even within an engaging gamified structure, adjusting to diverse learning speeds and ensuring an adequate challenge remains a critical consideration for teachers.

Ultimately, this study highlights that gamification is not a panacea but rather a pedagogical approach whose effectiveness heavily depends on careful design, adequate mechanics employed, and the characteristics of the learners, including gender. One the one hand, the significant reduction in anxiety for female students is a promising outcome, on the other hand the contrasting result for male students serves as a reminder to monitor implementations closely and adapt strategies to avoid (unintended) negative consequences. The potential to make mathematics more engaging and less anxiety-provoking seem to exist but requires deep understanding

and responsive application. Further research, ideally involving larger, more diverse samples, longer intervention periods, and robust mixed methods designs incorporating detailed qualitative analysis and quantitative measures, is essential to unpack these complexities and guide the effective use of gamification in mathematics education.

Ethics Declaration: The data collection for this study was carried out in accordance with current ethical and institutional guidelines. Informed consent was obtained from the parents/guardians of the participating students, as well as approval from the school principal. All information was treated confidentially and used exclusively for research purposes, in compliance with applicable data protection regulations.

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