

Designing with Generative AI: Ethical and Creative Redesign of Visual Assets in a Statistics Game

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Abstract: In game-based learning, visual elements play a crucial role, particularly in mathematics education, where they often represent numerical information and support conceptual understanding. Nevertheless, copyright constraints may limit the reuse and adaptation of educational games outside their original context, posing both practical and ethical challenges for teachers and researchers. This paper presents the redesign of the educational game *Monster Samples*, a team-based activity aimed at supporting students' understanding of descriptive statistics, particularly mean and median through reverse reasoning tasks. In the game, learners must construct samples of monsters that satisfy predetermined statistical conditions, thereby engaging directly with the structure of these measures. The original version relied on illustrated monster cards whose licensing conditions did not allow their reproduction in new academic and dissemination contexts. To ensure legal compliance while preserving pedagogical integrity, Generative Artificial Intelligence tools were used to create a new set of visual assets. The paper describes how the new images were created with the support of AI, detailing the formulation of prompts, the successive cycles of refinement, and the need to ensure coherence with the mathematical structure of the game. Maintaining statistical variability across visual features was essential in order to preserve both the gameplay and the intended learning outcomes. The process also exposed clear limitations of Generative AI. In particular, generating monsters with more than three eyes consistently proved challenging, requiring repeated corrections and highlighting the difference between producing visually convincing images and ensuring quantitative accuracy. The paper further discusses practical challenges, affordances, and ethical considerations related to authorship, transparency, and responsible AI use in educational design. By documenting both opportunities and limitations, it illustrates how Generative Artificial Intelligence can function as a practical design partner while requiring careful pedagogical and ethical oversight. The contribution offers a transferable example of AI-driven content development that supports sustainable innovation in mathematics game-based learning.

Keywords: GenAI, Responsible AI, Educational game design, Mathematics education, Statistics education, Game-based learning

1. Introduction

The rapid development of Generative Artificial Intelligence (GenAI) tools is increasingly influencing educational design practices across disciplines. Within game-based learning, AI-driven content generation opens new possibilities for creating visual assets, narratives, challenges and adaptive scenarios (Holmes et al., 2023; Kasneci et al., 2023; Lit et al., 2024). However, while innovation and efficiency are often emphasised, less attention has been paid to the ways in which generative AI may help educators respond to concrete practical and ethical constraints emerging in real educational contexts.

In mathematics education, visual design assumes a particularly significant role. Visual elements are not merely decorative components; they frequently encode quantitative information and directly support conceptual understanding. When visual attributes correspond to numerical variables, as in games involving classification, counting or statistical reasoning, the integrity of the learning experience depends on the precision and consistency of those representations. Redesigning visual assets is therefore not a neutral aesthetic operation, but a pedagogically sensitive process requiring careful attention to mathematical structure (Arcavi, 2003; Hlongwana et al., 2025; Rösken and Rolka, 2006).

At the same time, educators and researchers often encounter copyright and licensing constraints that restrict the reuse, adaptation and dissemination of educational materials beyond their original contexts. Such limitations may hinder academic sharing, publication and broader adoption of innovative game-based learning resources. Intellectual property issues thus become structural factors shaping the sustainability of educational innovation (Wiley and Hilton, 2018).

This paper explores how Generative Artificial Intelligence can function as a design partner in addressing these constraints while preserving pedagogical coherence. It presents the redesign of *Monster Samples*, a team-based

statistics game designed to support students' understanding of mean, median and variability through reverse reasoning tasks. The original version relied on illustrated monster cards that could not be reproduced in academic publications or dissemination contexts due to licensing restrictions. To ensure legal compliance and enable sustainable sharing, a new set of visual assets was generated using GenAI tools.

Rather than framing AI as an autonomous creator, this work positions it as a tool operating under deliberate pedagogical supervision. The redesign process required careful prompt formulation, iterative refinement and systematic verification of mathematically relevant attributes embedded in the images. Particular care was taken to preserve statistical variability across features such as number of eyes, limbs and colours, ensuring that gameplay dynamics and learning objectives remained unchanged.

By analysing this process, the paper contributes to ongoing discussions on responsible AI integration in education. It highlights both the affordances and the limitations of generative AI in educational game development, arguing that although GenAI expands creative and practical possibilities, it simultaneously requires critical oversight, transparency and ethical awareness (Holmes et al., 2022; Kasneci et al., 2023). In doing so, the paper offers a transferable example of how AI-supported redesign can promote sustainable innovation in mathematics game-based learning without compromising pedagogical rigour.

The following section situates this redesign within the literature on game-based learning, generative AI in educational design and responsible AI practices.

2. Theoretical Background

2.1 Game-based Learning in Mathematics Education

Game-based learning (GBL) has been widely recognised as a pedagogical approach capable of fostering engagement, motivation and deeper conceptual understanding (Duarte et al., 2026; Gee, 2003; Kapp, 2012; Plass et al., 2015). In mathematics education, games can create environments in which abstract ideas become operational and manipulable, allowing learners to experiment, test strategies and receive immediate feedback (Duarte et al., 2026; Hall et al., 2024; Morando and Turconi, 2022; Pais and Hall, 2024). Beyond engagement, carefully designed games can promote reasoning, collaboration and metacognitive reflection (Liat and Hayak, 2024).

Within statistics education, measures such as mean and median often present conceptual challenges. Students frequently approach them procedurally, applying formulas without fully understanding their structural meaning (Garfield and Ben-Zvi, 2008). Game-based approaches can support conceptual development by situating statistical reasoning within meaningful and constrained tasks. In particular, reverse reasoning tasks — where learners must construct a data set such that a given statistical measure is satisfied — encourage structural thinking about distribution, balance and the relationship between individual values and aggregate measures.

In this context, variability is not simply a topic addressed within the game; it becomes a structural condition of gameplay. The diversity of attributes embedded in game elements must allow multiple combinations and strategic decisions. Visual features that encode numerical attributes therefore function as mathematically operative components of the design rather than merely decorative elements. This perspective aligns with recent work on mathematically integrated game design, which argues that, in mathematically rich games, representations and game mechanics can become structurally embedded within the game space itself, directly supporting mathematical reasoning rather than serving only thematic or motivational purposes (Russo and Russo, 2025). Any redesign of these elements must therefore preserve their quantitative integrity in order to maintain pedagogical coherence.

2.2 Generative Artificial Intelligence in Educational Design

Generative Artificial Intelligence tools, particularly text-to-image models, have rapidly entered educational contexts as instruments for content creation. In educational design, GenAI can support the development of illustrations, scenarios and visual representations tailored to specific pedagogical purposes. This capacity introduces opportunities for rapid prototyping, localisation and iterative experimentation (Holmes et al., 2023; Kasneci et al., 2023).

However, integrating GenAI into mathematics-related design contexts raises important methodological considerations. Generative models operate through probabilistic pattern production rather than rule-based precision. While they can achieve high levels of visual plausibility, they may struggle with strict numerical

constraints or controlled attribute variation. In mathematics education, where visual elements may encode quantitative meaning, this distinction becomes pedagogically significant.

Effective use of GenAI therefore depends on intentional prompt construction, iterative refinement and systematic validation. The designer must articulate constraints clearly, evaluate outputs critically and verify alignment with learning objectives. In this sense, GenAI operates less as an autonomous creator and more as a co-designer whose outputs require human judgement and pedagogical responsibility.

2.3 Responsible AI and Intellectual Property in Game-Based Learning

As AI-generated content becomes increasingly present in education, questions of responsibility, authorship and intellectual property assume greater importance. Responsible AI in educational contexts encompasses concerns related to transparency, accountability, bias and legal compliance (Floridi et al., 2018).

Educational games often rely on licensed visual assets. Although such materials enhance aesthetic quality, licensing conditions may restrict reproduction in publications, conference proceedings or open-access formats. These limitations can hinder scalability and scholarly dissemination. Generative AI may offer a practical alternative by enabling the creation of original visual content not directly bound to prior licensing agreements.

Nevertheless, the use of AI-generated imagery does not remove ethical responsibility. Issues concerning transparency in declaring AI involvement, ownership of generated outputs and the necessity of human oversight remain central. Responsible integration of GenAI therefore requires deliberate design choices, critical evaluation of outputs and explicit acknowledgement of AI's role within the creative process.

Viewed through this lens, the redesign of *Monster Samples* is not merely a technical substitution of images, but a situated example of how mathematical precision, generative technologies and responsible innovation intersect in contemporary educational practice.

3. The Original Game: Pedagogical Structure and Mathematical Design

The “Monster Samples” game is an instructional activity developed to support students’ engagement with descriptive statistics, with particular emphasis on measures such as the mean and the median. The activity, analysed in Hall et al. (2025), adopts an interactive and game-based approach, encouraging students to explore statistical concepts through active participation. Students work in small groups of three to four and are given a set of 20 monster cards, each representing a fictional entity characterized by quantifiable attributes (e.g., number of eyes, colour, or size). In addition, the teacher uses a separate set of 36 instruction cards to structure the progression of the activity.

At the beginning, each group is required to remove five cards from their set, introducing a strategic decision-making component. This initial choice is consequential, as it may affect the group’s ability to successfully complete subsequent tasks. For example, eliminating all cards with a specific attribute—such as a particular colour—or those representing extreme values (e.g., monsters with a very high number of eyes) can limit the group’s flexibility when constructing samples that satisfy given statistical conditions. This stage highlights the role of variability in datasets and provides an opportunity to reflect on sampling bias and the importance of preserving diversity within a dataset.

In each round, the teacher selects and reads aloud an instruction card that defines the criteria for constructing a valid sample. These criteria may include, for instance, achieving a specified mean value for a given variable and ensuring a particular colour characteristic within the selected subset. Groups must then rapidly assemble a subset of their remaining 15 cards that meets the stated requirements. The first group to present a solution has their sample checked; a correct solution earns a point, whereas an incorrect one results in a penalty, allowing other groups to attempt the task. This structure fosters both competition and collaboration, promoting engagement while reinforcing statistical reasoning.

Pedagogically, the game inverts the traditional procedural approach to statistics. Rather than calculating measures from a given data set, students must construct a data set such that a predefined statistical measure is satisfied. This reversal encourages structural reasoning about how individual values influence aggregate measures and about how distribution and variability shape central tendency.

A core design principle of the game is the experiential understanding of variability. If a team discards all monsters with certain attributes — for example, those with many eyes — it may later be unable to construct samples requiring higher averages or specific configurations. Variability thus becomes both a conceptual focus and a structural condition of play.

The monsters' visual attributes encode quantitative variables, such as number of eyes or other features. These are mathematically functional components rather than decorative details. The integrity of the game depends on their accuracy and diversity. Any redesign must therefore preserve attribute variability, numerical precision and combinatorial richness to maintain the original pedagogical intent.

4. The Redesign Challenge: Copyright Constraints and Design Requirements

Although *Monster Samples* proved pedagogically robust, its broader dissemination was constrained by licensing limitations associated with the original illustrated cards. The images had been legally acquired for a specific context, but their licensing terms did not permit reproduction in academic publications or open dissemination formats. Consequently, sharing the game beyond its initial setting would have violated copyright agreements.

This situation reflects a broader tension in educational innovation. High-quality visual materials often depend on licensed or commissioned artwork, which may inadvertently restrict scalability and academic transparency. In research contexts, where sharing materials supports replication and critical discussion, such constraints become particularly significant (Wiley and Hilton, 2018).

The redesign therefore emerged from legal and ethical necessity rather than aesthetic preference. The objective was to generate a new set of visual assets that would:

1. Ensure legal independence from the original illustrations.
2. Preserve the mathematical and pedagogical structure of the game.
3. Enable dissemination without copyright restrictions.

Design requirements were clearly established:

- Mathematical fidelity – Quantitative attributes had to remain precise and clearly identifiable.
- Statistical variability – Attribute distribution across the deck needed to allow multiple valid sample constructions.
- Combinatorial richness – No attribute category could dominate or become structurally limiting.
- Visual clarity – Numerical and categorical features had to be immediately observable.
- Ethical transparency – The generation process needed to align with responsible AI practices (Floridi et al., 2018).

Traditional commissioning of new illustrations was considered but posed constraints related to cost, time and iterative flexibility. Generative AI offered an alternative, although one introducing new challenges concerning precision, control and authorship (Holmes et al., 2023).

5. AI-Supported Design Process

5.1 Design Strategy and Prompt Construction

The redesign began by identifying the mathematically meaningful attributes that required preservation. These included countable features (such as number of eyes), categorical variables (such as colour) and overall distributional diversity. Because these attributes functioned as quantitative variables within gameplay, they required explicit specification.

Text-to-image GenAI tools were used to generate original monster illustrations. Prompt construction was approached as a constrained design exercise, requiring explicit specification of features and iterative refinement, in line with emerging discussions on prompt engineering practices (Liu and Chilton, 2022). Prompts explicitly described required features, visibility conditions and stylistic coherence. Images were generated incrementally rather than in bulk, enabling ongoing monitoring of distribution and consistency.

Throughout the process, AI outputs were evaluated not only aesthetically but mathematically. The designer's role remained central in ensuring alignment with gameplay requirements.

5.2 Iterative Refinement and Attribute Verification

Systematic verification of numerical attributes became a critical stage of the process. Although the AI frequently produced visually appealing monsters, it did not consistently respect explicit numerical constraints.

A recurring challenge involved generating monsters with more than three clearly distinguishable eyes. Even when prompts specified four or five eyes, outputs often displayed ambiguous or partially merged features. Identical prompts could yield inconsistent results across iterations. Figure 1 shows one of these situations.

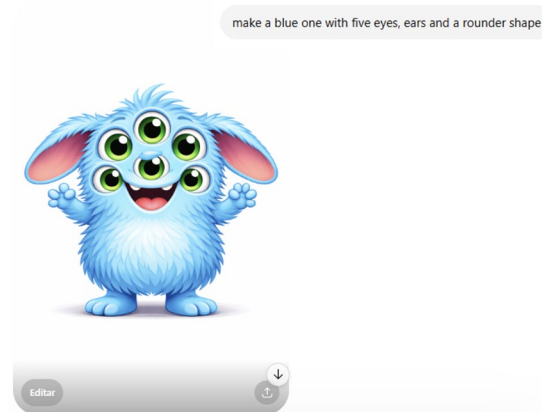


Figure 1: Example of a generated monster image with six eyes, despite the input prompt requesting five

For example, an initial prompt requesting “a friendly cartoon monster with five eyes” frequently resulted in images displaying only three or four clearly visible eyes, despite the visual plausibility of the output. Subsequent refinements introduced additional constraints such as “exactly five large, clearly separated eyes, all fully visible from the front”, which improved compliance but still required manual verification. This iterative process illustrates how mathematically meaningful constraints needed to be progressively stabilised through prompt refinement and human evaluation.

This highlighted a fundamental distinction between visual plausibility and quantitative precision. Generative models are optimised for realism rather than strict numerical compliance, a limitation that has been noted in recent discussions on AI-generated content (Kasneci et al., 2023). In a mathematics-based game, however, ambiguity undermines conceptual clarity. Each image therefore underwent manual validation before inclusion.

The iterative cycle involved prompt specification, generation, verification and refinement. This process continued until a deck satisfying requirements was achieved. Figure 2 illustrates the results.



Figure 2: Images created using AI

5.3 Affordances and Limitations

Generative AI enabled rapid prototyping, flexible experimentation and independence from licensed materials. It supported iterative adjustment of attribute distribution and facilitated sustainable redesign.

However, limitations were evident. Numerical control required human validation, prompt sensitivity reduced predictability and stylistic coherence required deliberate curation. These findings highlight the necessity of pedagogical oversight and human control in AI-assisted educational design processes (Holmes et al., 2023).

6. Ethical and Responsible AI Considerations

The adoption of GenAI extended beyond legal compliance. It raised broader questions concerning transparency, authorship and responsibility.

Although the generated images were legally independent from the original artwork, generative systems are trained on large-scale datasets whose provenance is not always transparent. Explicit acknowledgement of AI involvement therefore formed part of the ethical stance adopted in this project.

Human oversight proved structurally indispensable. In mathematics education, imprecision in visual representations may lead to conceptual misunderstanding (Duval, 2006). Responsible AI integration therefore requires validation rather than passive acceptance of outputs.

Transparency towards academic audiences and learners was also considered essential. Declaring AI-generated materials contributes to responsible digital literacy and models critical engagement with emerging technologies.

The redesign ultimately illustrates augmentation rather than automation. AI expanded creative and practical possibilities, but pedagogical responsibility remained firmly human.

7. Discussion and Conclusion

The redesign of *Monster Samples* demonstrates how Generative Artificial Intelligence can operate as a constrained design partner within mathematics game-based learning. Its contribution lies not in replacing human creativity, but in extending design possibilities under clearly defined pedagogical and ethical conditions.

The challenges encountered in achieving numerical precision highlight the limitations of generative systems in mathematically sensitive contexts. In games where representations are structurally integrated into mathematical activity (Russo and Russo, 2025), preserving the accuracy of those representations becomes pedagogically essential. At the same time, the capacity for rapid iteration and legal independence reveals meaningful practical advantages, particularly in addressing copyright-related constraints and supporting sustainable dissemination. More broadly, this suggests that GenAI may contribute to making visually rich non-digital mathematics games more accessible to educators by reducing dependence on commissioned or licensed artwork, thereby supporting wider dissemination and adaptation.

The process revealed that, in mathematics education, human oversight is not optional but essential. When visual elements encode quantitative meaning, imprecision may compromise conceptual understanding, reinforcing the need for systematic validation.

Overall, this case positions Generative Artificial Intelligence as a design partner operating under explicit pedagogical and ethical supervision. Responsible integration depends on pedagogical intentionality, critical evaluation of outputs and transparency in the use of AI-generated materials.

Future work may explore classroom implementation of the redesigned version and further develop structured frameworks for AI-supported educational game design grounded in principles of responsible AI.

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Ethics Declaration: This study does not involve human participants, personal data collection, or experiments involving humans or animals. Therefore, no formal ethical approval was required.

AI Declaration: Generative AI was used to improve the language in some paragraphs, as English is not the authors' first language. Specifically, the prompt "Check grammar and coherence without adding new sentences" was employed. This prompt provides only minimal suggestions related to grammar, clarity, and coherence, without reorganising the structure of the paragraphs or introducing new sentences

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