Article

How ChatGPT can inspire and improve serious board game design

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Abstract

This study explores the application of Large Language Models (LLMs), such as ChatGPT, in designing educational board games, and be deployed as objects-to-think-with It aims to guide educators through three pivotal design phases: ideation, where ChatGPT suggests themes and mechanisms aligned with learning goals; customization, providing templates for tailored games; and feedback on prototypes to enhance game components and mechanisms. We also compared the use of ChatGPT in a game ideation process, contrasting with a traditional game design approach. Although offering a dynamic platform blending computational prowess and creativity, ChatGPT and similar LLMs pose challenges. They can exhibit biases from training datasets, affecting game inclusivity. They may also generate inaccurate details, propose counter-intuitive rules, and misinterpret feedback, resulting in unintended dynamics. Addressing these challenges necessitates a designer critical evaluation of LLM suggestions and the infusion of human creativity and intuition. This research advances discussions on AI in education by highlighting both the potential and the challenges of employing such innovative tools in developing serious games, aiming to foster a balanced and informed approach to integrating LLMs in educational game design.

1. Introduction

Artificial Intelligence (AI) has catalyzed transformative shifts across industries, with Large Language Models (LLMs) emerging as one of its most promising applications [1]. LLMs have instigated a paradigm shift in natural language processing (NLP) and human-computer interaction, showcasing their capacity to handle intricate inquiries and undertake complex creative tasks. The efficiency of LLMs' responses hinges significantly on the clarity with which prompts articulate the desired objective [2]. Within NLP and machine learning framework, a 'prompt' is a precise directive or request provided to a language model to elicit a specific piece

of text. Typically comprising a few words or sentences, a prompt provides the context or topic upon which the language model generates its text. In essence, it forms the input to the language model, serving as a launchpad for the ensuing output.

Due to their adaptability, LLMs are finding applications across various domains, including game design [2]–[4]. Crafting serious games that successfully address students' diverse needs and interests presents a formidable challenge for educators [5]. LLMs, such as ChatGPT, carry the potential to aid educators in designing and evaluating game-based learning experiences. Developed by OpenAI, ChatGPT is a widely used NLP tool that leverages GPT (Generative Pre-trained Transformer) language model technology. This potent tool generates human-like responses and has found applications in answering questions, crafting narratives, summarizing documents, authoring essays, and even authoring with programming languages. On March 14, 2023, an enhanced version, GPT-4, was introduced [6], accessible via a monthly fee. However, in our commitment to greater accessibility, we will concentrate on the currently available free version: GPT-3.5.

This research explores the potential of educators utilizing ChatGPT as an ideation partner to design serious board games, particularly in scenarios where the formation of multidisciplinary teams for this purpose is not feasible [7]. These sophisticated LLMs, exemplified by ChatGPT, harness vast databases of knowledge, allowing them to provide insightful feedback, generate novel concepts, and even assist in thematic or narrative development. By seamlessly bridging computational capabilities with the creative process, LLMs offer designers a dynamic platform to test, refine, and expand their ideas. As designers engage with these models, they find not just a repository of information but an interactive partner, capable of both challenging and supporting the intricate journey from initial concept to polished game. To guide educators in the ideation process using ChatGPT, we propose prompts to create games or mod popular ones, such as Monopoly and Jeopardy, within specific classroom scenarios and target learning outcomes. Using the power of ChatGPT, educators can initiate serious game projects to boost student engagement and amplify the effectiveness of the learning process.

LLMs are a valuable resource for educators in board game design, as they act as interactive tools that facilitate creative thinking and problem-solving. These models serve as "*objects-to-think-with*" [8], [9], enabling educators to explore ideas, generate novel concepts, and refine game elements. By providing instant feedback, suggesting diverse narratives, and offering potential solutions, LLMs offer a dynamic resource that stimulates reflective thinking and fosters innovation in the design process. Their ability to blend computational analysis with creative ideation makes them ideal assets for educators in the multifaceted field of board game design.

The subsequent section will briefly examine the emerging literature concerning LLMs and games. We will then delve into the application of ChatGPT in the ideation process, illustrating how prompts can facilitate interactions between designers and the system. An example comparing traditional game design ideation with the use of ChatGPT will be provided. Subsequently, we explore our perspective on LLMs as *objects-to-think-with* and address the limitations of such systems. We conclude with our final thoughts and findings.

2. Large Language Models and Games

Previous studies analyzed the relationship between LLMs and games. Värtinen et al. [10] explored the use of GPT language models (GPT-2 and GPT-3) to procedurally generate quests for role-playing games (RPGs), as an alternative to hand-authored quests. Overall, the study highlights the promise of AI in generating game content but also points to the need for further improvements in the GPT language models. van Stegeren and Myśliwiec [11] examined the potential of ChatGPT-2, for generating text for video games. Specifically, the authors fine-

tuned ChatGPT-2 to generate dialogue lines for quest-giver NPCs (Non-Player Characters) in a role-playing game. van Stegeren and Myśliwiec [11] demonstrates the potential of ChatGPT-2 for generating game content and provides insights into the factors that influence the quality and creativity of the generated output.

LLMs are also studied in game design. Frans [4] analyzed the potential of language models for creating Language Model Games, which are games where players can manipulate the behavior of the language model through text input. Lanzi and Loiacono [2] presented a game design framework that uses both interactive evolution and LLMs. They proposed a cooperative game design framework that amalgamates interactive evolution and LLMs, aiming to emulate the typical human design process. Interactive evolution is deployed to leverage user feedback for identifying the most promising design concepts, while the LLMs are utilized to recombine and vary these ideas.

Our work was inspired by Lanzi and Loiacono's [2] proposal, attempting to address the specific need of educators who face difficulties and challenges in designing games for educational purposes. These challenges can be categorized into several key areas such as balancing fun and learning, aligning with curriculum and learning objectives, accessibility and inclusivity, and financial and technical constraints.

The delicate equilibrium between enjoyment and educational value in games is a primary challenge faced by designers [12]. The ideal educational game should captivate players while simultaneously fostering knowledge acquisition and skill development [13]. In order to achieve this balance, educators must carefully consider various game elements such as narrative, aesthetics, and mechanics, all while ensuring that learning outcomes remain at the forefront of the design process [14]. Striking the right balance is essential for maintaining player engagement, motivation, and ultimately, the effectiveness of the game as an educational tool.

Another significant challenge is creating games that align with specific curricular standards and learning objectives [15]. This requires educators to not only incorporate relevant educational content but also consider the diverse needs of learners to develop games that support learning objectives and facilitate meaningful learning experiences [16].

The affordability and accessibility of board games make them an effective learning tool to tackle inclusivity and financial and technical constraints while promoting students' engagement with the potential to enable cognitive and behavioural change [17]. Due to their straightforward mechanisms, board games serve as an effective tool for facilitating learning processes [17]. These games present unique design possibilities that rely on cost-effective resources, enabling their easy integration in classrooms where computers, internet access, or other high-tech devices may be lacking. Furthermore, board games eliminate the need for specific prerequisite knowledge, such as coding. By offering an immersive and engaging learning experience, board games also foster socialization opportunities within the classroom setting [18], [19]. Their use, therefore, promotes an inclusive learning environment, bridging the digital divide and fostering active, hands-on learning.

Even though most current literature on game-based learning emphasizes digital games, board games have persisted in homes and schools [20], [21]. Board games have been used to address many different topics such as Climate Policy [22], History [23], English, Math and Biology [24], Numerical Knowledge [25], E-commerce [26]; knowledge management [27]; accounting, finance, and marketing [28]; and entrepreneurship [29].

Board games have evolved beyond the basic approach of chance to designs that promote critical thinking opportunities [21]. The rise of board games that demand strategic thinking instead of chance during gameplay, often called eurogames [30], has also rekindled interest in the hobby.

3. Using ChatGPT in Serious Game Design

The endeavour to produce serious games is fraught with substantial challenges, especially when faced with restrictions in terms of time and resources allocated to their development [5]. The intricate design of serious games necessitates careful consideration of the complex and interrelated nature of diverse domains, such as education, psychology, technology (predominantly in digital games), art, business, and creativity [31]. This complexity underscores the essential demand for practical design instruments that can expedite the efficacious integration of educational elements into serious game designs. ChatGPT has the potential to facilitate this process and expedite its timeline. Nevertheless, the incorporation of ChatGPT must be cognizant of the broader context of the game design process.

A comprehensive literature review conducted by Ávila-Pesántez et al. [32] delineated a four-phase approach to serious game design. The phases—analysis, design, development, and evaluation—are primarily concerned with digital games, yet they can be adapted to suit the peculiarities of board game designs.

The analysis phase mandates an exhaustive study of the requirements, scenarios, pedagogical dimensions, learning content, and elements of fun. This phase discerns the indispensable elements for crafting a serious game. This phase corresponds to the generation of innovative ideas (ideation) for creating a game with engaging mechanisms that align with pedagogical objectives.

The design phase entails, in Ávila-Pesántez et al. [32]analysis, the creation of diverse digital resources to underpin the development of the serious game. These resources may include 2D and 3D illustrations, structured objects, and audio elements that echo the architectural specifications. In the context of board game design, this phase incorporates the conception of the game elements, such as the board, cards, and tokens.

Game designers employ a variety of tools and software resources to construct serious games throughout the development phase. In board game design, this crucial stage commences with the creation of a prototype, encapsulating the designers' ideas translated into the created elements, fundamental rules, and core mechanisms for playtesting [33]. Salen and Zimmerman [33] argued that prototyping and playtesting form the crux of the iterative design process. Iterative design constitutes a cycle of play, evaluation, modification, and subsequent playthroughs. This dynamic process empowers the designer or design team to base decisions on the continuously evolving iterations or versions of the game, thereby refining the final product.

Finally, the evaluation phase of a serious game incorporates playtesting, goal validation, and feedback collection. These evaluative stages play a pivotal role in measuring the alignment of the serious game with its predetermined objectives and corroborating its effectiveness as a pedagogical tool.

In this section, we have demarcated three primary ways educators can harness ChatGPT to enhance their game design experience. ChatGPT can assist educators involved in board game designs, particularly in the analysis, design, and evaluation phases. Moreover, ChatGPT can also support the development phase in the design of serious digital games.

Therefore, ChatGPT can be employed as a tool to facilitate the brainstorming process, suggesting game mechanisms and themes that harmonize with the curriculum and learning objectives. This analysis equips educators to create board games that are more likely to engage students, striking a balance between entertainment and learning. ChatGPT can also suggest templates or prototypes of game boards, cards, and other game components. Educators can utilize these materials to construct customized games tailored to the specific needs of their students, promoting accessibility and inclusivity while surmounting financial and technical limitations. Lastly, ChatGPT can provide support to educators in refining constructive feedback

received. In this role, ChatGPT may pinpoint areas for improvement and offer counsel on how to enhance the game's effectiveness and engagement as a teaching tool.

3.1   Ideation: Generating ideas for serious games

The first step in designing a serious game is to generate ideas that align with curriculum and learning objectives. Educators should begin by identifying the core concepts they wish to teach and exploring how these concepts can be incorporated into a game format. It is essential to consider the age group, skill level, and interests of the target audience while developing the game concept [13]. For example, a board game targeting elementary school children should be age-appropriate and focus on fundamental concepts, whereas a game for high school students may involve more complex ideas and advanced game mechanisms.

Educators can consult with ChatGPT to brainstorm ideas tailored to their teaching goals. By providing information about the target audience, age group, and learning objectives, educators can receive customized suggestions and insights from ChatGPT. For example, an educator looking to teach financial literacy can create a prompt with her educational goals and public such as:

Propose concepts for developing an educational board game for [define the public: e.g., mature learners or adult learners or young adults] specifically designed to promote and reinforce essential [curriculum and learning objectives: e.g., financial literacy] skills for this target audience.

> Prompt Example 1
> Propose concepts for developing an educational board game for [define the public: e.g., mature learners or adult learners or young adults] specifically designed to promote and reinforce essential [curriculum and learning objectives: e.g., financial literacy] skills for this target audience.

Once the learning outcomes, core concepts, and public have been identified, the next step is to translate these into game mechanisms. Educators should consider how the gameplay can be structured to facilitate the learning process, ensuring that players interact with the subject in meaningful and engaging ways. Some common game mechanisms include:

- Resource management: Players must collect, allocate, and manage limited resources to achieve specific goals, promoting strategic thinking and decision-making.
- Worker placement: This term refers to a strategic game mechanism where players use tokens or markers, often depicted as character-like figurines called "meeples," to select and carry out specific actions from a common selection pool.
- Deck building: This is a mechanism where players strategically play cards from their individual decks with two primary goals: acquiring new cards and continuously improving their decks over time. This strategy involves gaining new cards or strategically removing existing ones to optimize the deck's overall strength and functionality.
- Cooperative game: This term refers to gameplay where participants align their strategies and actions to meet shared victory criteria. The outcome is collective, meaning that all players either succeed together or face defeat as a group.
- Area movement: This game mechanism refers to a board game layout that utilizes uniquely shaped regions to dictate adjacency relationships and guide movement.
- Questions and answers: This gameplay structure involves players participating in a regulated exchange of questions and responses, adhering to specific rules and guidelines within the game's framework.

ChatGPT can offer examples and recommendations for game mechanisms. For example, by complementing the previous prompt with specific information about game mechanisms:

Prompt Example 2
The game should incorporate [level/type of game mechanisms: e.g., advanced game mechanisms] and [game mechanisms goals: e.g., encourage critical thinking and problem-solving]. Consider how the game can teach [learning objectives: e.g., practical financial skills and encourage players to make informed decisions about their personal finances].

Alternatively, ChatGPT can assist in modding classic commercial games, which can speed up the creation of a serious board game at a low cost [5], [22]. ChatGPT can proposed changes to enhance the gameplay experience. For example, deploying Monopoly [34] to teach financial literacy [35], [36], an educator can adapt the previous prompt, adding which mechanism they want to mod:

Prompt Example 3
Adapt the game [name of the game: e.g., Monopoly], incorporating [game mechanism: e.g., cooperative game] mechanisms. Consider how the game can teach [curriculum and learning objectives: e.g., practical financial skills] and encourage players to make informed decisions about [topic: e.g., their personal finances]. Ideas for game themes could include [themes: e.g., investing in the stock market, managing debt, and budgeting for retirement].

An engaging theme or narrative can significantly enhance the appeal of a serious game, capturing players' interest and imagination [37]. Educators should select themes and narratives that are relevant to the subject matter and resonate with their target audience. This can involve drawing inspiration from popular culture, history, or current events, or creating a fictional world that reflects the core concepts being taught. However, maintaining consistency in one's theme is paramount. The principal advantage of adopting a cohesive thematic approach in design lies in the synergistic reinforcement of all game elements, as their concerted efforts are directed towards a shared objective [38].

For example, a board game designed to teach history might be set during a specific historical period or event, whereas a game about biology could take place in a microscopic world. One example of a prompt can be:

Prompt Example 4
Create a fictional world that mirrors the core concepts of [theme: e.g., biology] for a board game. Provide [certain quantity: e.g., five] examples of how [curriculum and learning objectives: e.g., biological principles] could be integrated into the game mechanisms and rules.

An effective serious game should not only convey information but also promote critical thinking, problem-solving, and collaboration among players. Educators should consider incorporating game mechanisms and challenges that require players to analyze information, make decisions, and work together to succeed. This may involve designing puzzles, dilemmas, or scenarios that encourage players to think deeply about the subject matter, apply their knowledge in novel ways, and communicate their ideas to their peers. For instance, an educator who aims to teach students about environmental conservation can develop the following prompt:

Prompt Example 5

Design a game where players work together to [theme: e.g., clean up a polluted river]. Players could earn points by [game mechanism: e.g., removing pollution tokens from the game board and implementing sustainable practices, such as planting trees or recycling]. The game mechanisms could be designed to [learning objectives: e.g., encourage players to strategize and collaborate to maximize their impact on the environment].

By incorporating these elements into the prompt to initiate the ideation process, educators can lay the foundation for an engaging and effective serious game. AI helps enhancing this idea and may give suggestions to add new game elements and mechanisms. For instance, ChatGPT could suggest game mechanisms and tasks for a game adaptation, such as "Game of Life," with a theme like "Career Exploration".

Prompt Example 6

Adapt the game [name of the game: e.g., Game of Life] for [theme: e.g., Career Exploration]. Introducing a [topics: e.g., variety of career paths, each with unique pros and cons, incorporating real-world challenges like job market fluctuations, promotions, or layoffs]. Encourage players to [learning objectives: e.g., balance their work and personal life, considering factors such as family, hobbies, and self-care].

3.2   Providing templates: A starting point for serious game components

Once a general concept for the game has been established, the next step is to design the various game components. To facilitate this process, educators can utilize templates or examples of existing game components as a starting point for their own designs.

Game boards often serve as the central element of a board game, providing a visual representation of the game world and defining the spatial relationships between game elements. Some common game board templates include:

- Grid-based boards: These boards consist of a grid of squares or hexagons, which players navigate to achieve their objectives as in *Catan* [39]. Grid-based boards can be easily customized to accommodate various themes and subject matter.
- Point-to-point boards: These boards feature a series of connected points or nodes, representing locations that players can travel between as in *Pandemic* [40]. Point-to-point boards are well-suited for games that involve movement, exploration, or transportation.
- Modular boards: Modular boards consist of individual tiles or pieces that can be arranged in different configurations, providing a dynamic and adaptable game space as in *Gloomhaven* [41]. Modular boards are ideal for games that require variability or emphasize exploration and discovery.

When designing game components, educators can benefit from ChatGPT in creating game boards, cards, and tokens. ChatGPT can provide examples and recommendations for game board templates that best suit the game concept, considering factors such as layout, size, and aesthetics.

For example, an educator looking to create a geography-themed board game could consult with ChatGPT to receive suggestions on board layout can develop the following prompt:

Prompt Example 7

Create a [theme: e.g., geography-themed board game]. Give suggestions on [template: board layout, such as a world map with point-to-point connections between countries, or a modular board with interchangeable map sections representing continents or regions].

Cards are a versatile game component that can serve various purposes in educational board games, such as representing resources, events, or actions. When designing cards, educators

should consider the information and visual elements that need to be displayed and ensure that the card design is clear and easy to understand. Some common card templates include:

- Action cards: These cards grant players specific abilities or actions that they can perform during the game, such as moving their game piece, acquiring resources, or affecting other players. Action cards can be designed with icons, text, or a combination of both to convey their effects.
- Resource cards: Resource cards represent valuable assets or commodities that players can collect, trade, or spend to achieve their objectives. Resource cards should clearly indicate the type and quantity of the resource, as well as any relevant attributes or characteristics.
- Event cards: Event cards introduce random events or occurrences that can affect gameplay, adding an element of unpredictability and excitement. Event cards should describe the event and its effects in clear and concise language and may include illustrations to enhance their thematic appeal.

ChatGPT offers a valuable resource for educators seeking to improve the clarity and effectiveness of their game components. Specifically, educators can leverage ChatGPT's to design cards. To illustrate the potential benefits of this collaboration, consider the example of the educator who seeking to create a financial literacy-focused version of Monopoly. By partnering with ChatGPT, this educator could receive customized recommendations for card designs tailored to the specific learning objectives of the game. The educator could refine the card designs to ensure that they are clear, engaging, and effective in conveying financial concepts to players:

> Prompt Example 8
> In a game like-[name of the game: e.g., Monopoly] create [type of card: e.g., action cards] to introduce [topics: real-world financial events, like market fluctuations or unexpected expenses], to [learning objective: e.g., impact players' budgets and investments]. Give creative suggestions for visual elements to print on them.

In addition to cards, tokens can serve as valuable game components that enhance the aesthetics of a game. Tokens are tangible game pieces that can embody different game elements, including resources, characters, and objectives. Educators must account for a token's size, shape, and material when creating them, to ensure that they effectively align with the game's concept and are visually distinguishable while remaining easy to manipulate. Several commonly used token templates are:

- Resource tokens: These tokens represent tangible assets or commodities that players can collect, trade, or spend during the game. Resource tokens can be made from materials such as cardboard, wood, or plastic, and should be designed with clear symbols or icons to indicate their type and value.
- Character tokens: Character tokens represent the players' avatars or game pieces, which they use to navigate the game board and interact with other game elements. Character tokens can be designed as simple pawns, detailed miniatures, or custom-shaped pieces that reflect the theme and subject matter of the game.
- Objective tokens: Objective tokens represent goals or targets that players must achieve to win the game or score points. Objective tokens can take various forms, such as flags, markers, or cards, and should be designed with distinct colors or symbols to differentiate them from other game elements.

With the assistance of ChatGPT, educators can gain valuable insights for choosing suitable sizes, shapes, and materials that resonate with their design concept. Furthermore, ChatGPT can

offer many descriptive token designs, serving as a rich source of inspiration for educators. For example, in the game centered around cleaning up a polluted river, educators could create a prompt to facilitate the design of tokens, such as:

Prompt Example 9
Create [type of token: e.g., resource tokens] to represent [game element: e.g., pollution] to be [game mechanism: e.g., remove from the river]. Give ideas for shapes, materials, and images to print on them.

3.3   Feedback on prototypes: Refining the serious game

Once the game components have been designed, educators should create a prototype of the board game to playtest and gather feedback. A prototype can be a simple, low-fidelity version of the game, using materials such as paper, cardboard, or basic tokens. The primary purpose of the prototype is to facilitate playtesting and identify areas for improvement, rather than to produce a polished, finished product.

Playtesting is a crucial step in the game design process [42], as it allows educators to observe how the game functions in practice, identify any issues or imbalances, and gather feedback from players. To conduct effective playtests, educators should:

- Recruit a diverse group of playtesters, including individuals from the target audience, as well as those with different backgrounds, skill levels, and interests [42].
- Observe playtest sessions carefully (consider video recorder them), taking note of players' engagement, enjoyment, and understanding of the game mechanisms and subject matter.
- Encourage playtesters to provide honest and constructive feedback, asking questions about their experience, preferences, and suggestions for improvement.

After playtesting, educators can involve ChatGPT in the process by sharing observations and feedback from playtesters. ChatGPT can analyze this information and provide recommendations for addressing any identified issues or imbalances, helping the educator enhance the game's effectiveness as a teaching tool.

In the example of adapting Jeopardy for science education, an educator who playtests a Physics-themed version of Jeopardy might discover that some questions are too difficult for the target age group. By sharing this feedback with ChatGPT, the educator can receive suggestions for adjusting question difficulty, reorganizing categories, or providing hints to ensure the game remains engaging and accessible for all players.

Hence, based on the feedback gathered during playtesting, educators should iterate on their game design and adjust the game components, mechanisms, and rules as needed. This process may involve tweaking existing elements, introducing new features, or removing aspects that do not contribute to the learning objectives or player experience. Some questions to consider during this refinement process include:

- Is the game engaging and enjoyable for players? If not, what can be done to improve the experience?
- Do the game mechanisms effectively support the learning objectives and subject matter? If not, how can they be modified or enhanced?
- Are the game components clear, visually appealing, and easy to understand and manipulate? If not, what changes can be made to improve their design?
- Does the game balance challenge and accessibility, allowing players of different skill levels to participate and learn? If not, what adjustments can be made to accommodate diverse players?

For instance, during the playtesting phase of the clean-up polluted river game, players may discover that some actions are overly simplistic or monotonous, resulting in a lack of strategic decision-making. In response to this feedback, educators, with the assistance of ChatGPT, could integrate more intricate game mechanisms to elevate the level of challenge and foster more deliberate gameplay. An example of prompt could be:

> Prompt example 10
> During the playtesting of [name or topic of the game: e.g., the clean-up polluted river game], players found some actions to be [feedback received: e.g., overly simplistic and monotonous, leading to a lack of strategic decision-making]. Can you suggest [goal to be achieved: e.g., more intricate game mechanisms that could be integrated to elevate the level of challenge and foster more deliberate gameplay]?"

Educators should persistently playtest and refine their board game design through multiple iterations, gathering feedback, and correction until the game reaches their envisioned level of player engagement and pedagogical effectiveness. After the design has been meticulously tested and polished, the educator can collaborate with ChatGPT to finalize the game components design and rules. This ensures the serious game is well-equipped and perfectly tailored for classroom implementation.

3.4   Application example

The *Footprint Factor* (Figure 1) is an educational board game crafted over approximately 10 hours, excluding stages of prototyping, playtesting, and the finalization of game elements. The primary author collaboratively conceived the design in conjunction with two of his undergraduate students. The design trajectory integrated a holistic approach encompassing ideation of gameplay mechanisms, deliberative discussion on game rules, synthesis of game elements, and the design of cards and other pertinent visual components.

Figure 1. Game Footprint Factor

In this game, four players must select a corporate entity to represent. Each corporation seeks to extract resources and inaugurate production facilities, aiming to vend products in specific markets as objective cards dictate. Distinctively, each corporate entity possesses a unique competency, giving each player a distinctive competitive advantage. Essential resources, namely water, wood, oil, and minerals, are symbolized through tokens dispersed across various countries on the game board. Players can strategically acquire these resources upon landing in pertinent territories, subsequently establishing factories to facilitate product sales and accrue wealth. A pivotal element of the gameplay centers on the Footprint Scale; product sales contribute points to this scale. Upon amassing 30 points, the game culminates in a collective defeat. This element introduces an intriguing juxtaposition of competitive gameplay with cooperative undertones, as players can either finance reforestation initiatives to decrease the scale or invest in eco-friendly production facilities employing advanced (and more expensive) technologies.

The conceptual underpinnings of *Footprint Factor* are deeply rooted in the mechanics of established board games such as *Risk* [43], *Catan* [39], and *Pandemic* [40]. An intimate familiarity with these games was essential to adapt them to *Footprint Factor*. Due to the primary author's expertise in board game design and the undergraduate students' enthusiasm for the genre, the design process was executed seamlessly. Every facet of *Footprint Factor*, from its visual aesthetics to the nomenclature of corporate entities and the portrayal of global calamities through cards, was meticulously sculpted through collaborative brainstorming sessions.

In a parallel experiment, a similar conceptual output was replicated using ChatGPT 3.5 in a mere minute. For this simulation, we employed the prompt (example 1):

> Propose concepts for developing an educational board game for young adults at the undergraduate level specifically designed to promote and reinforce sustainability concepts for this target audience.

Six possibilities were presented: (1) *Eco-Quest Adventures* where players will have to manage resources, make ethical decisions, and collaborate with others to achieve common sustainability goals; (2) *Sustainability Tycoons* where players can choose from various industries (e.g., agriculture, technology, transportation) and must balance economic growth with environmental responsibility; (3) *Green City Builders* where players collaborate to design and build a sustainable city by making decisions about energy sources, transportation systems, waste management, and green spaces; (4) *Climate Change Chronicles* where players take on the roles of different stakeholders, such as scientists, policymakers, and activists, and navigate challenges related to climate change adaptation and mitigation; (5) *Sustainable Solutions Showcase* where players compete to design and present innovative solutions to real-world sustainability problems; and (6) *Eco-Crisis Classroom* where players work together to make decisions that balance short-term and long-term sustainability, considering social, economic, and environmental factors.

We decided to use the game *Sustainability Tycoons* as a basis for our project since it is similar to *Footprint Factor*. Thus, we continued the design in collaboration with ChatGPT through the following proposed prompt (example 2):

> Pick the game 2. The game should incorporate advanced game mechanisms and encourage critical thinking and problem-solving. Consider how the game can teach practical resource management skills and encourage players to make informed decisions about it.

In constructing our prompt, we specifically integrated the theme of resource management skills, given its centrality to the conceptual foundation of the *Footprint Factor*. ChatGPT's response was a comprehensive blueprint (detailed subsequently) reminiscent of the design elements inherent in the *Footprint Factor*. The blueprint encompassed not just facets of resource management, such as those requisites for factory construction analogous to our game, but also expanded to encompass ethical considerations reflective of our envisioned fair-trade market. It further delved into the intricate balance between economic proliferation and its consequential environmental footprint, an essence captured by our Footprint Scale. Remarkably, ChatGPT also postulated a parallel construct to *Footprint Factor* wherein diverse corporations are endowed with distinctive sustainability-oriented challenges and opportunities.

As we suggested in this paper, the proper prompts can spawn, in seconds, many game elements and mechanisms. These outputs, which were traditionally the domain of experienced game designers necessitating hours of deliberation, can now be instantaneously generated.

Game Concept: *Sustainability Tycoons*

Overview: *Sustainability Tycoons* is a strategic and immersive board game where players take on the roles of entrepreneurs striving to build and manage sustainable businesses in a competitive economy. The game aims to educate players about the intricacies of resource management, ethical decision-making, and the trade-offs between economic growth and environmental impact.

Game Mechanics:
1. Industry Selection: Players choose from a range of industries (e.g., renewable energy, eco-friendly consumer goods, sustainable agriculture) that they'll operate businesses in. Each industry presents unique challenges and opportunities related to sustainability.
2. Resource Management: Players must manage various resources, such as raw materials, energy, labour, and finances. Balancing these resources efficiently is crucial for their business success and sustainability.
3. Supply Chain Decisions: Players make decisions about sourcing materials, manufacturing processes, and distribution methods. They need to consider factors like carbon footprint, waste generation, and fair labour practices.
4. Technology Advancements: Research and development of sustainable technologies and practices can lead to competitive advantages. Players can invest in innovation to reduce resource consumption and environmental impact.
5. Market Dynamics: The in-game market responds to players' decisions. Consumer demand for eco-friendly products and services can drive profitability and reputation, while negative environmental impacts might result in consumer backlash and financial penalties.
6. Ethical Choices: Throughout the game, players face moral dilemmas that require them to choose between short-term profits and long-term sustainability. These choices affect their reputation and the overall sustainability of their business.
7. Collaboration and Competition: Players can collaborate on joint projects or engage in friendly competition. Collaboration can lead to shared benefits, while competition encourages players to differentiate their businesses through sustainability initiatives.

Educational Elements:
1. Resource Management: Players learn to optimize resource allocation, track energy consumption, manage waste, and prioritize sustainable practices to maximize business success and minimize environmental impact.

2. Critical Thinking: Players must analyze complex scenarios, weigh trade-offs, and anticipate the long-term consequences of their decisions on their business and the environment.
3. Problem-Solving: Players face challenges related to sustainable operations, requiring them to devise innovative solutions that balance profitability with environmental stewardship.
4. Informed Decision-Making: Players gain insights into real-world sustainability challenges and dilemmas, enabling them to make more informed decisions about ethical and eco-friendly business practices.
5. Strategic Planning: Players develop strategic plans to adapt to market shifts, technological advancements, and regulatory changes, while aligning their businesses with sustainable goals.

Teaching Practical Skills:

The game incorporates elements such as financial management, risk assessment, and market analysis, which mirror real-world business operations. By engaging with these aspects in a controlled gaming environment, players develop practical skills that can be applied to real-life business endeavours.

In our simulation, we observed that ChatGPT did not introduce a collaborative component to the game. Wanting to integrate this gameplay mechanic, we put forth the following prompt (example 3):

Adapt the game Sustainability Tycoons to include cooperative game mechanisms.

In response, ChatGPT offered a concept for *Co-op Sustainability Tycoons*. This game envisioned a cooperative board game where players unite as a team of entrepreneurs, striving to establish and oversee sustainable businesses in a competitive market. The game underscores collaboration, strategic foresight, and principled decision-making, all while tackling resource allocation and environmental considerations.

The game and certain mechanisms did not precisely match our expectations. For instance, the Collective Industry Choices (where players collectively choose industries based on sustainability challenges and prospects) and Shared Resource Pool (where players manage a communal resource pool encompassing materials, energy, labour, and finances) did not pique our interest. However, the proposed Market Response mechanic, where teams navigate market fluctuations based on their collective decisions and where the demand for green products and services shapes the team's reputation and profitability, caught our attention. This mechanism mirrors what we implemented in *Footprint Factor* and holds potential for further refinement.

Finally, we requested ChatGPT to generate tokens that would represent the raw materials in the game. These materials are a crucial aspect of the game as we intend to make players collect them and then face the challenge of their limited availability. We utilized the given prompt to achieve this (example 9).

Create resource tokens to represent the raw materials to be exploited by the players. Give ideas for shapes, materials, and images to print on them.

Their response presented a unique and innovative approach, combining token design and construction with the theme of the game.

Here are some ideas for shape, material, and images for the resource tokens:
Resource Tokens: Renewable and Non-Renewable Materials
1. Shape:

- o For a unique touch, consider using asymmetrical shapes that resemble organic or natural forms, promoting a connection to the environment.
- o Circular tokens with different patterns or notches could represent various types of resources.

2. Material:
   - o Sustainable options such as wooden tokens made from responsibly sourced wood can align with the game's theme.
   - o Recycled cardboard tokens can also be used, offering an eco-friendly and tactile feel.

3. Images:
   - o Renewable Materials:
     - ▪ Sun Symbol: Represent solar energy or solar-powered technologies.
     - ▪ Wind Turbine: Depict wind energy and clean energy generation.
     - ▪ Leaf or Tree: Symbolize sustainable forestry and natural resources.
     - ▪ Water Droplet: Represent hydropower and water-related resources.
   - o Non-Renewable Materials:
     - ▪ Oil Barrel: Signify fossil fuels and the extraction of non-renewable resources.
     - ▪ Coal Chunk: Depict coal mining and energy generation.
     - ▪ Metal Ingot: Represent metal extraction and manufacturing.
   - o Wildcard Tokens:
     - ▪ Recycling Symbol: Highlight the importance of recycling and waste reduction.
     - ▪ Green Energy Icon: Symbolize sustainable and eco-friendly practices.
     - ▪ Eco-friendly Building: Illustrate sustainable construction and infrastructure.
   - o Multi-Resource Tokens:
     - ▪ Tokens with two or more resource symbols can represent complex materials that require multiple resources for production.
     - ▪ These tokens can encourage players to think strategically about resource allocation.

4. Color Palette:
   - o Use a harmonious color palette that reflects natural elements, such as earthy greens, blues, and browns for renewable materials, and darker tones for non-renewable ones.

The advent of AI, exemplified by tools like ChatGPT, has revolutionized the traditional design processes in board game creation. As demonstrated by the development of *Footprint Factor* and the parallel game *Sustainability Tycoons*, it is evident that the synthesis of human creativity and machine efficiency can yield intricate, educational, and engaging game dynamics in significantly reduced timeframes. This blend not only expedites conceptualization but also introduces a wealth of diversified ideas, reinforcing the notion that human-AI collaboration can produce enhanced educational tools tailored to contemporary audiences. The future of board game design and many other domains will undoubtedly benefit from such synergistic approaches, balancing human expertise with the rapid ideation capabilities of advanced AI systems.

4. Discussion

Integrating an LLM as ChatGPT into the game design can be transformative for educational game creators. One of the standout strengths of an LLM is its wide-ranging knowledge. With the ability to tap into vast datasets, it provides insights across numerous domains. This feature proves invaluable when designers are tasked with creating games that bridge intricate educational concepts with engaging gameplay.

In the ideation phase, an LLM can serve as a rich resource. The model can suggest appropriate game mechanics, scenarios, or narratives when presented with a learning objective or theme. For example, if a designer is focusing on environmental science, the LLM might recommend mechanics revolving around ecosystem balance, resource conservation, and the impact of human actions. Additionally, the model's capability for comparative analysis is invaluable. Designers can receive feedback based on various educational games and concepts when they share their preliminary concepts or game mechanics with the LLM. Such insights help identify potential challenges, areas needing enhancement, and even predict potential user engagement and interactions.

The LLM's dexterity in distilling and translating theoretical concepts is another noteworthy advantage. Often, educational theories or principles can be abstract. The LLM aids in understanding and breaking down these concepts, subsequently transforming them into intuitive game mechanics that both educate and entertain. This ability is complemented by the model's skill in scenario generation. The LLM can craft or elaborate on scenarios for game designs rooted in real-world situations or problem-solving exercises, offering a compelling narrative backbone.

Tailoring content to the target audience is vital. Whether it is primary school children, high school students, or adult learners, the LLM can offer insights to calibrate the game's complexity or style to match the players' cognitive levels and interests. Furthermore, with education being a universal endeavour, games intended for diverse audiences benefit from cultural adaptability. The LLM can provide insights into varied cultural perspectives and learning methods, ensuring the game's resonance across different contexts.

Staying attuned to contemporary educational challenges and trends can make games more relevant. The LLM can inform designers of evolving pedagogical strategies, emerging global challenges, and novel learning paradigms, ensuring that the games are timely and resonate with contemporary learners. As the game design progresses towards finalization, the LLM continues to be instrumental, especially in drafting and refining game documentation, ensuring clarity and accessibility for users.

Given their comprehensive knowledge base and interactive capabilities, the LLMs can be viewed as a digital "object-to-think-with" [8], [9]. This perspective stems from several key attributes:

- Tangible Interaction: While LLMs are not physical objects, they serve as interactive tools for game designers. Designers can pose questions, test hypotheses, and garner feedback, making the act of typing and receiving textual responses akin to manipulating a tangible object.
- Experimentation: Analogous to the way one would manipulate a physical object to decipher its functionality, game designers can "play" with an LLM. They can probe its capabilities, iterate on its responses, and adapt their ideas based on the feedback they receive.
- Facilitating Construction: When brainstorming ideas, generating content, or attempting to fathom intricate concepts, LLMs serve as invaluable allies. They support the construction of knowledge by aiding designers in navigating the multifaceted landscape of game design.

- • Reflection and Refinement: Interaction with an LLM allows designers to introspect, reflecting upon the feedback they receive. This iterative process aligns seamlessly with the constructionist approach that emphasizes deepened learning through creation and reflection.

The application of LLMs presents both novel opportunities and unique challenges. It is imperative to note that LLMs are still under development despite their vast capabilities [44]. Their effectiveness can be task-specific and may differ depending on the environment in which they are employed.

One significant concern that arises with the use of LLMs is the issue of biased data [44]–[46]. When trained on biased datasets, LLMs might inadvertently reproduce these biases in their output. Such biases can be particularly detrimental in educational board game design, where inclusivity is often a primary objective. Games aim to cater to a diverse audience, and a biased LLM could inadvertently suggest game mechanics, narratives, or characters that alienate potential players. The key to navigating this challenge is awareness. Designers need to remain vigilant to potential biases in LLMs and critically evaluate their suggestions. Furthermore, it is of paramount importance to conduct playtests with diverse groups of players. Such tests can be instrumental in identifying and rectifying biases that might have otherwise gone unnoticed.

Another potential pitfall is the LLM's information hallucination [44]. LLMs might sometimes produce details not rooted in their training set, resulting in either factually wrong or purely imaginative outputs, resulting in wrong or deceptive outcomes, especially in critical situations. When LLMs hallucinate, it is usually because they are trying to bridge knowledge or contextual gaps, drawing from patterns they have recognized during training. There is a risk that they might hallucinate and introduce elements or nuances not intended by the game designer. This effect can cause confusion and unintended gameplay dynamics. Designers are, therefore, encouraged to meticulously analyze and check LLM-generated content for inconsistencies or inaccuracies introduced by the model. Moreover, continuously refine and adjust the use of LLMs based on feedback and observations. Multiple iterations can help in fine-tuning the integration of LLMs in game design. While LLMs can be a great starting point, the final refinement should always be infused with human creativity and intuition as well as vigilance to sound sources for information.

LLMs possess an extensive knowledge base, but they may sometimes display a lack of common sense [44]. This can mean that the board game rules or mechanics they suggested could be counter-intuitive or confusing to players. Therefore, it is crucial to conduct regular playtesting to overcome this issue. This iterative approach can help pinpoint areas of the game that might not resonate well with players. Moreover, feedback loops, where player feedback is actively incorporated into the design process, can be instrumental in refining the game.

Another concern is the LLM's capacity (or lack thereof) to reason and interpret feedback in the same way humans do [44]. Feedback is the lifeblood of game design, with designers often iterating based on insights garnered from playtesters. An LLM that misinterprets this feedback can inadvertently guide designers down an undesired path. It is essential, therefore, for designers to personally review and interpret feedback, using LLMs as supplementary tools.

Cultural nuances pose yet another challenge [44]. In an age where board games explore diverse cultures and settings, LLMs that miss these nuances might inadvertently lead to misrepresentation and produce harmful suggestions. It is recommended that designers engage cultural consultants or sensitivity readers. Collaborating with a diverse team or community also ensures accurate and respectful representation.

5. Conclusions

The use of AI tools as assistants in creating serious games has significant implications for educators, offering a cost-effective and time-efficient way of creating engaging and practical learning experiences. This study contributes to the ongoing discussion [1], [47]–[49] on the use of AI in education, offering insights into the potential of AI tools for scholars and educators interested in game-based learning, and the use of board games as alternative learning spaces [17].

While the development of serious games requires careful consideration and iteration [33], the potential benefits of this approach make it a valuable addition to any educator's toolkit. By leveraging the power of LLMs, educators can design and refine board games that effectively support their teaching objectives and offer a fun and engaging learning experience for students.

The aim of this project was to help educators in three key stages of design, as suggested by Ávila-Pesántez et al. [30], using ChatGPT-3.5 as an object-to-think-with. In the first stage, ideation, ChatGPT provided ideas and mechanisms that were in line with the educational goals. In the second stage, customization, templates were provided to create personalized games. Finally, feedback was given on prototypes to improve the game components and mechanisms. Table 1 summarizes the key points about the use of ChatGPT in each stage of the design process.

Table 1. Intersection between game design stages and LLMs prompts

Design Stage	Design Goals	Prompt Action Verbs	Prompt Key Concepts	Examples
	Generate innovative ideas to initiate a serious game project	Propose, Generate, Brainstorm, Initiate, Develop	Define the public	1
			Curriculum and learning objectives	
	Propose game mechanisms to enhance player experience	Incorporate, Propose, Design, Enhance, Improve	Level or type of game mechanisms	2
			Learning objectives	
	Modify commercial games to meet educational objectives	Adapt, Modify, Align, Tailor	Name of the game	
			Game mechanism	
Analysis (Ideation)			Curriculum and learning objectives	3 and 6
			Learning topics and themes	
	Suggest diverse narratives	Create, Suggest Develop, Formulate	Game theme	4
			Curriculum and learning objectives	
	Introduce game mechanisms to foster specific competencies, including critical thinking, problem-solving, and collaboration	Design, Introduce, Implement, Foster, Develop, Encourage	Game theme	5
			Game mechanism	
			Learning objectives	
Design (Providing templates for game components)	Provide suggestions for primary game elements, including game boards	Create, Provide, Suggest, Design, Develop	Game theme	7
			Template needed	
	Offer recommendations for complementary game	Create, Recommend, Suggest	Type of game element (e.g., card)	8

Design Stage	Design Goals	Prompt Action Verbs	Prompt Key Concepts	Examples
	components, such as cards and tokens		Learning objectives	
			Visual elements	
	Generate design ideas to enhance the aesthetic appeal of cards and tokens	Create, Give, Generate, Design, Enhance, Improve	Type of game element (e.g., token)	9
			Representation	
Evaluation (Feedback on prototypes)	Refine the game prototype by considering various elements such as mechanisms, player experiences, and game components	Refine, Evaluate, Assess, Improve, Consider, Analyze, Review, Enhance	Name of the game	10
			Game theme	
			Feedback received	
			Game element to be improved	
			Goal to be achieved	

The utilization of AI tools such ChatGPT presents a promising solution for adapting popular games such as Monopoly and Jeopardy to specific classroom scenarios and intended learning outcomes, while simultaneously promoting inclusivity and fun within cost-effective possibilities [5], [22]. However, it is essential to acknowledge that the primary role of AI is to enhance, rather than replace, human creativity and sensibility. Thus, educators must remain actively involved in the design and modding process. In the role of a game designer, educators must position themselves as the representative for the students/players [42]. Educators are obliged to interpret games from the students' viewpoint, integrating their perspective as an essential component of the design process to ensure that the games meet the diverse needs and interests of their students. Furthermore, there is a need for further research to explore the potential of AI tools in co-designing games for learning alongside students, which can offer novel possibilities for increasing student engagement and participation in the learning process.

Future research can examine the intersection between design, LLMs and game-based learning in different directions. The first idea revolves around applying LLMs to gamify learning materials. The central premise is to investigate how traditional learning materials can be transformed into engaging, game-like experiences. For instance, the LLMs can be deployed to adapt traditional textbooks into interactive, game-based learning modules. The LLMs can identify key concepts and learning objectives within the text and create engaging, gamified content such as quizzes, puzzles, and challenges. The research would assess the impact of this gamified content on student engagement, motivation, and learning outcomes compared to traditional learning materials. The research would assess the impact on learner motivation, engagement, and knowledge retention by incorporating gamification elements such as points, badges, and leaderboards. The potential impact of this research is significant, offering enhanced learner engagement and motivation, improved learning outcomes, and increased accessibility and appeal of educational content to a diverse learner population.

The second idea investigates the intersection of AI and game design, focusing specifically on both educational and modern board games called eurogames. Explore the development of a eurogame that utilizes LLMs to dynamically adapt game scenarios and challenges based on the player's learning progress and preferences. The game would focus on teaching historical events, with LLMs generating contextually relevant narratives and scenarios. The research would evaluate the educational effectiveness of the game and how LLMs-enhanced design contributes to learning and engagement. The implications of this research are far-reaching, contributing to developing more sophisticated and engaging games, improving learning experiences, and advancing the game design and development field.

A third research stream could explore specific evaluation metrics for assessing the success of AI-generated game ideas. The use of clear, standardized guidelines for measuring elements such as creativity, engagement, player satisfaction, and educational value would enhance the practical relevance and applicability of AI in board game design. A potential research project in this domain could involve the development and validation of a comprehensive set of evaluation metrics through empirical studies, comparing AI-generated board games with those designed through traditional methods. Participants from diverse backgrounds, including game designers, educators, and players, could provide valuable insights into the effectiveness and appeal of AI-generated games based on the proposed metrics. The outcomes of such research are anticipated to provide a robust framework for evaluating AI-assisted game design, thereby contributing significantly to the field and ensuring the objective assessment of the creative and educational merits of AI-generated board games.

A fourth stream can explore the ethical and sociocultural considerations in applying LLMs to serious game design, which is a pivotal area of research. This exploration delves into addressing critical issues such as bias, inclusivity, cultural representation, and the ethical dilemmas that may arise within game scenarios. The investigation could aim to uncover the multifaceted implications of integrating LLMs into the game design process, focusing on how these models might inadvertently perpetuate biases or misrepresent diverse cultures and societies. By scrutinizing these aspects, the research would seek to develop comprehensive frameworks and guidelines that will pave the way for responsible and inclusive serious game design using LLMs. These guidelines would serve as a beacon, ensuring that serious games are not only engaging and educational but also respectful of diversity and ethically sound.

Lastly, while the incorporation of such advanced tools undeniably opens up avenues for innovation and efficiency, it simultaneously raises pertinent questions about its impact on human creativity. The dependency on AI for generating content and ideas could potentially lead to a diminution of original thought and a homogenization of design concepts, given that AI models are trained on existing data and may inherently lean towards patterns already prevalent in the field. Future research should explore whether and how the use of AI in game design might inadvertently stifle creativity and seek to establish a balanced symbiosis where AI acts as a catalyst for human imagination rather than a substitute. This exploration is essential to ensuring that the intersection of AI and game design continues to be a fertile ground for innovation, fostering a rich diversity of thought and maintaining the intrinsic human touch that underpins truly impactful and resonant game experiences.

As LLMs continue to evolve and improve, we can expect to see even greater collaboration between educators and these powerful tools in the development of serious games and other innovative teaching methods. Through continued research and experimentation, we can unlock the full potential of games as a powerful tool for learning and educational development.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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