Exploring Sustainability Through Board Game Design as a Learning Approach in Schools

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Abstract: Sustainability and environmental education aiming to foster a nuanced understanding of environmental sustainability is receiving growing attention in schools. Simultaneously, board games have gained popularity as a pedagogical tool in primary and lower secondary education, especially in design-based approaches where students engage in iterative prototyping and developing games with various mechanics. This study explores the potentials and pitfalls of integrating board game design processes into sustainability education, focusing on how students engage with environmental issues through various game mechanics. The study uses principles from Education for Sustainable Development (ESD) as a framework to understand students' development of systems thinking, anticipatory thinking and problem-solving. The paper is based on a pilot study conducted in 2024 at a school in Copenhagen, using a Design-Based Research approach. The study involved students aged 12-15 redesigning board games to explore oceanic climate challenges. Through a six-weeks iterative process inspired by design thinking processes, students analysed games to develop game literacy while progressing through phases of inquiry, interpretation, ideation, prototyping and testing. The empirical data consists of field notes and photos from observations of the students' design processes. Furthermore, we conducted workshops and interviews with selected teachers. The theoretical framework draws on game theory, design-oriented approaches and creativity. The analysis highlights potentials and challenges in students' engagement with board game prototyping, particularly in balancing educational content, aesthetic expression, and functional game mechanics. The three redesigned game: Pictionary, Dixit, and Ego, each demonstrated specific affordances for supporting sustainability-related learning, including perspective-taking, emotional engagement, and values-based reflection. However, the process also revealed a need to explicitly support iterative work, as many students struggled with revisiting and refining their prototypes, often aiming for polished products rather than engaging in open-ended experimentation. Based on the analysis, the paper presents a series of design principles aimed at using board game design as an approach to working with ESD in schools.

Keywords: Sustainability, Environmental education, Education for sustainable development, Board games, Design processes, Learning

1. Introduction

Board games are becoming increasingly popular in primary and lower secondary schools for teaching sustainable development (Tan and Nurul-Asna 2023; Fjællingsdal 2025). This includes uses of many different types of games, for example the use of learning games and commercial board games, as well as design-based approaches where students modify or create games to explore environmental themes. There are various reasons for using "green games" as a tool for sustainability education. One reason is that sustainability can be difficult for students to comprehend as a concept as it often involves complex and interconnected challenges. Board games can help make abstract environmental issues more tangible by revealing systemic aspects and allowing students to interact with them in a structured way. Furthermore, board games can provide immersive and engaging learning experiences by allowing students to take an active role in problem-solving, creative design, and collaboration. By playing and designing games, students can develop an understanding of sustainability topics while using strategic and analytical skills. However, there is also a risk of oversimplifying sustainability issues.

In sustainability education, the goal for students is to understand and engage with environmental challenges. This can evoke feelings of climate fatigue (Thystrup Mehlsen et al. 2023). Education for Sustainable Development (ESD) seeks to address this fatigue and feelings of powerlessness by providing students with the competencies to navigate and address sustainability issues. A systematic review of sustainability competences in primary education highlights five core competences: systems thinking, futures thinking, action-oriented competence, values thinking, and collaboration (Vesterinen and Ratinen 2023). Laugesen and Elf (2023) further emphasize that ESD should be integrated within individual subjects as well as across disciplines. A central point in their

approach is the inclusion of an aesthetic-affective dimension alongside cognitive, moral, and psychological aspects. This dimension emphasizes the importance of considering students' emotions, sensory experiences, and more embodied engagement when teaching in sustainability. They argue that teachers should invite students to connect with sustainability issues through visual expression, hands-on experiences, and more direct experiences with nature. In this way, the aesthetic-affective dimension in sustainability teaching should focus "on embodiment, sensations, and emotions – in other words, what sustainability teaching feels like" (Laugesen and Elf 2023, p.168). Their understanding of teaching quality builds on pragmatism inspired by Dewey, which emphasizes that quality in teaching emerges through experiments and experiences, is context-dependent and must relate to a particular content or topic.

Similarly, Lene Tanggaard (2020) argues from a creativity perspective that education plays a vital role in making students feel that they are a part of life in their society and culture and have the ability and responsibility to contribute to it. Tanggaard's perspectives also build on a pragmatic approach to creativity, emphasizing that students' contribution depends on their sense of creative agency and social responsibility, which should be taught and cultivated within the subject areas. When we work with ESD perspectives, we aim to support the students' experiences of being part of society having the agency to act together with others. Thus, we build on an understanding of "collective creativity" (Tanggaard 2020, p. 4) where students collaborate to design games that tackle the complex aspects of sustainability.

In this study we explore creative approaches to ESD by investigating secondary students' design and redesign of board games with a focus on complex sustainability issues. We understand board game design in learning situations as an inquiry process that involves navigating various framings and choices regarding aspects such as the target group, subject-matter integration, and the balance between gaming and learning — what Hanghøj (2023) refers to as design dilemmas. This brings us to the following research question: What design dilemmas arise when secondary students design board games addressing environmental challenges, particularly in relation to perspective-taking and aesthetic aspects?

2. Board Games and Game Design in Education

Board games have a long history in education. They represent appealing spaces for learning because of the simplicity and hands-on quality of many game mechanics, which are often fairly easy to understand and change (Bayeck 2020). Moreover, games enable focused face to face communication across the board and shared bodily orientations. In this way, the affordability and accessibility of board games make them ideal for providing social and playful learning experiences (Ruberg and Shaw 2017). Moreover, board games allow for various interactions that result in students engaging in problem-solving, teamwork, and creativity (Zagal et al. 2006; Hanghøj and Karnøe 2024).

There exists a growing body of research on the educational use of board games for teaching environmental education (Tan and Nurul-Asna 2023; Fjællingsdal 2025). Most of these studies focus on the use of existing board games, either educational games or commercial games, for teaching. However, other studies have investigated design approaches to board games, i.e. where students learn by designing or redesigning board games in relation to specific educational aims (Hanghøj 2023; Hautopp et al. 2023; Bernier et al. 2024). In contrast to using existing board games, design approaches focus on developing students' creative competencies, e.g. by learning how to recreate board games through a design processes - often inspired by the various phases of design thinking (Rusmann and Ejsing-Duun 2022).

To understand how the students worked with game design processes, we draw on the MDA framework, which has been developed by game designers as a tool to analyse games (Hunicke et al. 2004). The MDA framework formalises the properties of games by breaking them down into three components: *mechanics* (the base components of the game involving rules and every basic action the player can take in the game), *dynamics* (how players respond and enact the mechanics, e.g. through tactics or collaboration), and *aesthetics* (the desired emotional responses evoked in the player). For example, the creative word association game Dixit iuses game mechanics such as drawing cards, taking turns giving ambiguous clues, and trying to vote on the right card. Playing the game enact game dynamics such as guessing relations between the given word and the cards and trying to follow the perspective of the assumed card holder. This involves aesthetic experiences related to the visual perception of the ambiguous cards, using the imagination, and engaging in collaborative storytelling around different meanings of words and cards.

3. Collective Creativity from a Pragmatic Perspective

Creativity is often misunderstood as an expression of artistic talent that is only carried out by especially talented people (Brinkmann and Tanggaard 2013; Tanggaard 2020). Contrary to this belief, Tanggaard (2020) argues that creativity is a craft that can be learned, and what is perceived as new and creative work can vary across different domains. Tanggaard (2020) emphasizes that creativity in education "requires that students are taught to share perspectives, to get things done, to take risks, to not always ask for permission and to understand the roles of others in relation to their own creativity" (p. 12). This calls for a we-paradigm where “collective creativity” is a focal point of students group work addressing subject areas and not seen as a detached meta-competence (p.13).

Brinkmann and Tanggaard (2013) advocate for the establishment of 'creative communities' in education that focus on the epistemology of the hand. They emphasize craftsmanship and pragmatic inquiry processes, which involve 'grasping' the world through hands-on activities. This approach contrasts with the traditional understanding of learning based on the epistemology of the eye, where students are merely presented with knowledge in lectures by omniscient teachers. According to the epistemology of the hand, learning through practical activities and experimentation is emphasized, aligning with John Dewey's pragmatic approach to inquiry. Dewey argues against the traditional separation of theory and practice, stating that the "so-called separation of theory and practice means in fact the separation of two kinds of practice" (p. 69). Thus, the process of inquiry is central to testing ideas and actions that lead to reflections on solutions. In a pragmatic approach to learning, theories and methods are viewed as 'tools' to be applied and reflected upon in relation to practical experiences in the world (Brinkmann and Tanggaard 2013).

In our study, this means providing students with a variety of materials and game mechanics as tools to develop games and reflect upon ESD issues. Moreover, our analysis will identify changes in students' perspectives as they redesign and play their games. As Tanggaard (2020) argues, "The creative capacity concerns the ability to imagine the perspective of another person and thus put oneself in their shoes” (p. 8).

4. Method and Data

Our methodological approach builds on Design-Based Reseach (DBR), which is a participatory and interventionistic research approach to developing educational designs, creating changes in the specific contexts as well as generating knowledge for the research field (Anderson and Shattuck 2012). The empirical data in this study is based on a pilot study conducted in 2024 at a project-oriented school in Copenhagen involving approx. 30 students aged 12-15 spanning 6 weeks. The intervention was part of a cross-disciplinary project-based course with learning goals from science, mathematics, cultural studies, L1(Danish), and practical subject competencies. The guiding question that framed the project was how climate change affects the oceans. The course organisation was familiar to both the teachers and students. As part of this course, the intervention aimed to redesign commercial board games (Pictionary, Dixit, and Ego) that involved expressing or interpreting ideas, emotions, or intentions to communicate oceanic climate challenges to potential players. The empirical data consists of field notes and photos from observations of the students’ design processes, prototype testing, and presentation of game designs. Six researchers were involved in gathering data. Furthermore, we conducted *in situ* interviews with students and teachers as part of classroom observations. In line with the DBR participatory methodology, we involved the teachers in the planning phase of the study. Based on our DBR interventions, we developed design principles aimed at providing guidance for researchers and practitioners conducting similar studies (Hanghøj et al. 2022). The principles developed here is a continuation of the principles concerning teacher redesign of board games presented by Hautopp et al. (2023).

5. Analysis

In the following analysis, we explore the empirical data through two themes that reflect different orientations and dilemmas in students’ board game design processes. The themes do not reflect fixed binary oppositions but represent continua of different configurations found in the data. The first theme focuses on the role of aesthetics in supporting or complicating sustainability learning, while the second theme explores how game design can support or constrain students’ ability to adapt new perspectives and engage with sustainability from different viewpoints. Across both themes, we draw on theoretical perspectives from creativity (Tanggaard 2020), aesthetic-affective (Laugesen and Elf 2023), and the MDA (Hunicke et al. 2004).

5.1 Theme 1: Balancing Game Design and Aesthetic Dimensions

This theme explores the tension between the aesthetic dimensions of game design and the ESD learning goals. The students worked with visual and material design by sketching, drawing, and using digital tools like Canva, which revealed both potentials and challenges. In summary, the aesthetic dimension worked as a hook to engage students but there was also a risk of overshadowing the sustainability learning goals.

5.1.1 Visual creation as a motivational entry into the game design

In several cases, the graphic design of the game board and components served as a motivational entry into the project. One group of students, Alicia, Allan and Lena, redesiged Pictionary and created a game board with a "trash island" and cards to play with. The group's redesign featured a game board with spaces to move a meeple on, (fig. 1) and playing cards with three colors (fig. 1) matching the spaces. Each color on the card had a word or phrase. So, when a player landed on an orange space the player took a card and drew the phrase for the orange color and the team should guess what it was.

Figure 1: The playing board is shown on the right. On the left is an example of a game card with the phrases: "dried out sea", "factory" and "suffocated turtle"

Initially, the group had approached the task with a detached attitude, but their engagement shifted once they began working on the visual layout. Alicia was skilled in Canva and engaged with the overall design of the board, the colors of the spaces and particularly how they could make an aesthetically pleasing trash island in the middle of the board. She first used Google searches to look for images of trash islands, finding out that they were called rubbish patches. However, none were deemed to fit the theme she aimed for. So, she ended up using the Canva AI tool to work with a lot of templates for bottles, plastic cups and other kinds of waste to create their own image of a trash island. During this, Allan used a considerable amount of time to design a dock-theme on the upper left corner of the board. As the group worked on their design, they began humming and singing which can indicate a sense of comfort and engagement in their creative process.

There are several examples that point to aesthetic competence as a valuable form of expertise in the classroom which resonates with Tanggaard's (2020) notion of "collective creativity," where students contribute to the shared culture of the classroom. One example is the student, Samira, from another group, who was impressed by the design by Alicia and asked Alicia for help with the design of her own group's board.

5.1.2 Translating knowledge into playable games

Although the sustainability content was not always explicit, there were indications that students used visual design to explore and express complex ideas. This process required students to make decisions about how to represent environmental issues in ways that were meaningful and playable. One example comes from a group of two girls working on a Pictionary-style game. They searched the internet for information about environmental issues and discussed how to translate this information into game content. Their goal was to create cards that

were not only grounded in facts but also open to interpretation—a feature of this game's mechanics. In this way, the group tried to get initial insight into the environmental phenomenon before they could visualise it and then abstract it into a term or image that would work in the game. Their reflections indicate an awareness of the need for ambiguity in game design, and how this ambiguity must be grounded in elements that can mean different things. This example highlights how the process of designing for ambiguity potentially can support learning. The students were not just copying information—they were striving to interpret, transform, and recontextualize information within a creative framework. One could argue that these students undertook an inquiry and experimental process where their knowledge is tested and reshaped through practical activity.

In the testing phase, students had the opportunity to observe how others interacted with their games and whether their game was playable. One group noted that the visiting students were engaged and entertained by the gameplay. This indicates that the mechanics of scoring points captured the players' attention and limited the opportunity for a dialogue or reflection on the sustainability themes in the game. This highlights the importance of balancing these elements in educational game design.

Several students encountered new knowledge during the design process as they searched the internet for information about environmental issues. This often sparked emotional reactions. One student exclaimed, "I didn't know a coral reef could die before this project," while another, upon seeing images of the Pacific garbage patch, simply said, "ew!". These moments illustrate a shift from vague awareness to more concrete understanding. However, they also highlight a pedagogical dilemma: as the students gained insight into environmental problems, they might experience discomfort or apathy.

5.1.3 When "pretty" becomes the main goal

The strong focus on visual design among the students also had a downside. In several cases, students became absorbed in wanting to perfect the look of their games, which backgrounded the sustainability content that remained underdeveloped or was rather vague. One student questioned this directly by saying: "But maybe it is not the point that it should be pretty?".

One group of students redesigned *Dixit* with a marine theme but struggled to link the visuals to environmental issues. When the teacher encouraged them to brainstorm using post-its, one of the students wrote: "The game should look nice." The atmosphere remained disengaged until they began using computers and Canva, which improved their engagement. Although their collaboration improved, their focus remained on visuals rather than sustainability. This was also evident when a student remarked: "I just need to use flames" while designing a card about forest fires, illustrating how visual appeal and expression, often overshadowed the educational goals.

In several cases the teachers also drew attention to this focus as they explicitly praised the visual quality of the games. One teacher commented: "Wow, the games are pretty in here." This contains the risk to further support a norm where pretty aesthetics is related to successful game design. The risk is that students base design choices solely on what looks good and pretty, and not on what supports the game mechanics or the ESD learning goals. From the perspective of the MDA framework, the goal is not to prioritize one aspect but to balance the aesthetics (the emotional and sensory experience) with the mechanics (rules and actions) and dynamics (player interaction) to support meaningful learning.

5.1.4 The difficulty of unfinished work and redesigning a prototype

Another recurring challenge was the students' struggle with the iterative manner of prototyping which they were not familiar with. Many students expected to produce a finished product at an early stage in the process and found it difficult to work with incomplete or continuously evolving designs. As one teacher observed: "They [the students] really had a hard time with the idea that it didn't have to be completely finished." This resistance among the students towards working iteratively and with more sketchy prototypes indicate a norm where more "polished" and finished products sometimes are preferred and valued over the process of design and continuously revisiting a prototype. Tanggaard (2020) emphasizes the importance of working with more open-ended processes, where students learn through experimentation and revisions. However, in this case, some students struggled to hold their motivation when their work remained in a sketching or prototyping phase.

One group had completed a prototype of their Dixit redesign, and they were not particularly interested in continuing the development. The teacher encouraged them to explore new ideas, but the students were resistant. In their first version of the game, the students used hand-drawn cards and mostly copied the playful style of Dixit—just with an ocean theme. When playing the game, the environmental problems were simplified into short phrases like 'plastic in the ocean,' which made the complex issues seem too simplified.

5.2 Theme 2: Balancing Game Design and Perspective-Taking

This theme explores how game mechanics and design processes can foster the shift of perspectives among students, while also highlighting the risk that such reflections can remain superficial and fail to support the ESD learning goals.

5.2.1 Imagining "the other" in design processes

In the design process, students had to imagine "the other" and consider how future players might play their game or how they would navigate the sustainability themes. This process of designing with someone else in mind required students to step outside their own perspective and imagine how others would make meaning through their game mechanics and the visual design.

One group emphasised that their target group were 9-30 year old, "who have grown up with climate issues". They aimed to design figurative cards that could be interpreted in multiple ways, reflecting on how technology can both solve and contribute to environmental problems. They strived to express this duality visually. It can be argued that these students were aware about different perspectives (Tanggaard 2020) on technology's influence on the environment which they wanted to adress in their game. However, these students had a hard time illustrating this ambiguous dimension through their analogue drawings. The introduction of Canva allowed them to better realise their intentions and refine their message for the imagined player. Another group preferred to draw their cards by hand and resisted using digital tools. For them, analogue drawing was a meaningful way to engage with the topic and imagine how others might experience the game.

This act of designing for someone else can be seen as a form of perspective-taking, where students try to see the topic from another person's point of view. From an aesthetic-affective perspective (Laugesen and Elf 2023), this way of working helped the students feel more emotionally connected to the theme, while also developing their creative capacity to consider different viewpoints and imagine the perspective of others (Tanggaard 2020).

This was also noticeable in another group where a student reflected on a card about second-hand clothes: "I think the card is good… it makes you think, for example, about second-hand clothes. I like wearing second-hand... it's much cheaper and you can get more expensive brands. And it has already been bought, so less clothes need to be produced." Here, the student connects personal values to broader sustainability themes, while also considering how the card might prompt others to reflect.

In one example, the students wrote in their reflection paper that their game should create a "good atmosphere" for players, but they also expressed a concern that it might become "too sad". This indicates an early shift of perspective, where the imagined player becomes part of the group's design considerations where students tried to imagine how others would experience their game and how they tried to balance various emotional responses to their design and game mechanics.

5.2.2 Game mechanics based on dilemmas

A group of students designed games that included dilemmas and voting mechanics, which created dialogues on ethical dilemmas. They drew inspiration from the game called Ego, which is a party game where players respond to personal or ethical questions and others guess their answers. This game mechanic can prompt reflections on values and assumptions about the other players. In their redesign, students discussed whether they would pick up trash in public. One student said, "You would just look at it and do nothing, Amanda," to which Amanda replied, "Yeah, I am a terrible person," followed by, "I thought you were better than that!". In another dialogue, the dilemma of choosing between plane, train, or car travel sparked discussion about environmental impacts. One student said, "You don't like flying, it gives you a headache," implying the choice was driven by personal discomfort rather than environmental concerns. The dialogue nevertheless also included pro and con arguments on the various types of travel. Even though the tone in these dialogues was often humorous, the examples show that the students started to reflect on social norms and personal responsibility. This aligns with Tanggaard's (2020) concept of collective creativity, where learning involves negotiating values and imagining others' perspectives. On could argue that the game format showed potentials to support the students to talk about difficult topics in a playful way and a space where they could express their opinions and guess what others might think or do. In this way, the game mechanics supported perspective-taking and somewhat value-based dialogue.

5.2.3 Shifting perspectives through narratives and everyday experiences

Some groups used storytelling to connect abstract environmental issues to familiar experiences. One group created a game titled "Gaia", which represented: "Mother Earth who gets angry, when we as humans do not

treat her nice". The students further elaborated: "Just like our parents, who can get angry and say that we are not allowed to watch TV or use our mobile phones. Gaia gets angry when we don't behave properly, for example, it causes landslides and floods. And when we treat the Earth well, it also becomes happy". One could argue that the students in this example connected the climate crisis to an everyday conflict they have experienced with their parents. The analogy potentially helped the students to make sense of complex issue through everyday family dynamics.

From an educational perspective, this can be seen as a form of perspective-taking, where the students attempted to imagine the Earth having emotions and reactions. In line with Tanggaard's (2020) notion of creative capacity, the students engaged in a process of imagining the perspective of others and relating it to their own lived experiences. This narrative move reflected a shift from abstract complex global problems to a more embodied and emotionally resonant understanding, which aligns with the aesthetic-affective dimension of ESD (Laugesen and Elf 2023). However, while the narrative made the issue more relatable, it also risks oversimplifying the causes and consequences of environmental challenges, reducing complex and more systemic issues to individual moral behaviour. Another group also used narrative elements to make their games emotionally involving for their future game players. They designed a card with forest fires. Even though forest fires can be linked to environmental challenges, the students did not articulate this connection. Instead, they focused on creating a dramatic scene. As one student explained, "there needs to be a story," indicating that this student imagined that this would stimulate emotional engagement and maybe open for multiple interpretations. The students seemed to imagine how future players might respond to the visual and emotional cues in the game. However, the environmental meaning behind these elements remained vague in this example.

6. Discussion

In this study we have explored how students in school can work with sustainability topics by designing and redesigning board games. We found that many students became highly engaged in the visual and creative parts of the design processes. Especially the aesthetic part was important for motivation but also contributed to a shared culture of collective creativity in the classroom. Sometimes however, focusing on making the game "look nice" backgrounded the focus on the sustainability content. This can be a problem if the learning goals from one aspect overshadow learning goals form other aspects. In this context, the teacher's role was to facilitate the making of meaningful connections between aspects. Connected to this was challenges in the prototyping process. Many students were not used to working with unfinished products and found it difficult to change their ideas repeatedly. Thus continuing to work on their first prototype had more appeal than discarding it and starting on a new iteration. Early on, some students perceived their games as being finished and did not like to change them, as it felt like going backwards. This shows how important it is to support students in understanding that design is also a process and not only a final product. Furthermore, we saw that some students started to think in new ways about sustainability. For example, they tried to imagine how other people would play their game or how others would feel about the environmental topics. This kind of perspective-taking is important in Education for Sustainable Development (ESD). But not all students had the language or knowledge to engage deeply with the topics. Some seemed to just search random things on the internet and uncritically use what they found. This shows that students need help to build knowledge both about ESD and about game design, and that the design process should incorporate more explicit opportunities for this. In the examples above Canva was involved as the turning point for many of the groups, however this was not always the case and other groups also found Canva a limiting factor. The role of digital vs analogue drawing tools in the design process would be interesting to explore further. Based on our findings, we identified the following design principles that can help teachers when using board game design in sustainability education:

- Design for compound creation between aesthetics and learning: support opportunities for students to make meaningful connections where creativity, sustainability and game mechanics complement each other.
- Consider being explicit about how the learning design supports iterative work: Students who are not familiar with iterations need support to learn the value of changing and improving their ideas and design.
- Consider using specific game mechanics to support the learning goal: If the learning is perspective-taking, games with dilemmas, voting or storytelling can help students think about other people's views and values.
- Consider using emotional and narrative engagement: support opportunities to use stories and emotions to make abstract environmental issues more relatable while avoiding oversimplification.

- Support a classroom culture of shared and collective creativity where student groups can be inspired by each other.

7. Conclusion

This study shows that board game design can be a useful method to involve students in learning about sustainability, especially when it includes creative work, collaboration, and trying to see things from different perspectives. However, it is important to pay attention to how the visual and playful elements of the game are balanced with the educational content. Also, students need support during the process, and they should be encouraged to work with their ideas in an open and iterative way. The design principles proposed in this paper may serve as a framework for other educators and researchers seeking to use game design and integrate it into sustainability education.

Ethics declaration: The research follows the ethical research guidelines from the *Danish Code of Conduct for Research Integrity*.

AI declaration: We have used AI as thesaurus and for proofreading.

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