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Serious game design to reveal delta ENIGMAs for shifting to more flexible and adaptive flood risk management

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Introduction

ΔENIGMA is a national research infrastructure with various work packages (WP) studying the water and sediment dynamics for nature-based, flexible, and adaptive flood risk management in the Dutch Delta's river-estuary-coast continuum. WP6 joins efforts between TUDelft, Wageningen, Twente, and Deltares Labs to study and facilitate interactions bridging related knowledge-communication-action gaps. The WP6 designs various tools, such as serious games, using digital and physical interfaces to facilitate collaborations between societal and academic actors while joining efforts within, across, and beyond WPs. Collaborative interactions are considered productive when achieving individual, group, and societal learning about the problem and proposed solutions, the norms and values behind, and the necessary (collective) action f (Barth et al., 2023). This paper presents the TU Delft Game Lab+'s prototype, developed with ΔENIGMA WP2 and TU Delft Serious Game Design students (Kontaxopoulou et al., 2024).

Collaborative design framework for productive interactions

Serious games simulate climate adaptation scenarios that are otherwise difficult to experience and are increasingly used to facilitate productive interactions that inspire sustainable collective actions. When well-designed, games change attitudes toward the problem or solution, increase related knowledge, and allow practicing necessary skills. However, effective games must balance complexity, learning goals, and enjoyment. To address this design dilemma, we used established collaborative frameworks (Kip et al., 2025) and bring together considerations for designing interactive games for learning (Jaccard et al., 2021), collaboration, and policy-decision-making processes (Djenontin & Meadow, 2018). We follow the **Figure 1** framework by involving relevant stakeholders as informants or co-designers at different stages according to the value they can get and give from their involvement (De Jans et al., 2017).

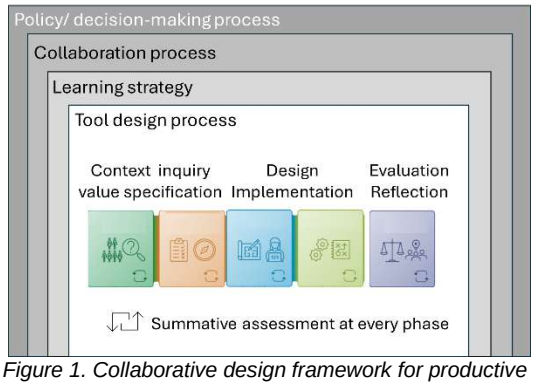

Figure 1. Collaborative design framework for productive interactions. (Adapted from Kip et al., 2025).

Preliminary prototype and results

Inspired by WP2 research in the Dutch Schelde estuary, brainstorming sessions between the (co-authoring) team led to the following game elements:

Game context

Delta communities and management actors have historically chosen a flood protection approach that reclaims land for development via hard or soft measures such as dikes, sand nourishment, or coastal wetlands. The short-term benefits of delta flood safety kept wetlands dry for developing urban, agricultural, and industrial activities, leading to economic prosperity. This protection approach has increased delta communities' development and flood exposure in the long term. A closed protection approach has also led to the degradation of delta ecosystems and land subsidence, ultimately increasing the flood risk. In turn, short-term effects in the long run are reduced by an inability to reverse past choices. However, in the past, the delta land flooded at high levels; the free water and sediment dynamics allowed sediment and vegetation that contributed to flood protection. The free dynamics enriched soils, supported diverse ecosystems, and improved water quality. Today's rising sea threatens the delta's sustainability. Combining dikes with wetlands that can flood strategically can enhance flood safety and nature.

Policy-making value specification
A combined approach requires space from land that may already be developed for implementation. Moreover, management actors should make collective management agreements, such as continuously assessing the development and flood maintenance needs. The benefits of land use changes for combined flood protection may take years to decades to become visible as ecological benefits. Economic gains required additional efforts, such as creating recreation and tourism opportunities. Altogether, there is a need to communicate to all generations how the management of the past contributed to the undesired effects of today. A sustainable future requires collective action and considering the benefits and challenges.

Learning goals
The serious game to design aims at:
(1) Learning about the role of water-sediment dynamics in the short and long-term sustainability,
(2) Showcasing the benefits and challenges of combining protection and
(3) Fostering collective reflection and responsibility on past management to enable flexible and adaptive futures.

Target audience and game setting
Intended players are last-year high school students. The game serves as an icebreaker for discussions on flood protection agreements among (future) managers or experts. We expect the game to be played in educational and collaboration activities, science days, or museum visits at the location. Initially paper-based, the game may move online for broader reach or integrate elements of other interactive tools. Playing the whole game should take a limited time.

Game Outline
Four players own each region in the delta game board (**Figure 2**). Each region has different land uses represented by tokens related to four interests (villages, agriculture, nature, and industry). Players work collaboratively to achieve flood safety, ecosystem value, and economic prosperity for the region to ensure a future-proof delta. Players make protection choices in three rounds, representing the past, present, and future. Protection choices are doing nothing, building a dike, or a dike with a wetland, each represented with Lego pieces on the board. Some options are locked out depending on the protection choices. A scorecard determines the area tokens and flood protection in the short term.

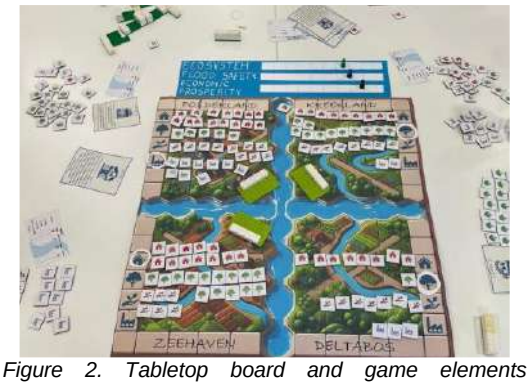

Figure 2. Tabletop board and game elements impressions as prototyped by Kontaxopoulou (2024).

After making choices in the past and current rounds, a flood event may take some tokens away from each region according to its protection level. In the future and last round, players realize and discuss the long-term scorecard of their decisions. Every round, players learn of the choice effects through interactive stories.

Feedback & next steps
Game design students suggested enhancing engagement, interactivity, and interconnectedness of effects. Next is to validate the prototype context, choices, and expected use with academics, educators, policymakers, and professionals.

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