Earthquake Rebuild: Math Learning through Modeling and Design

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Research Question

Focusing on the design conceptualizations, prototypes, and design-based functional specifications of the game: How does participating in architectural design and modeling in Earthquake Rebuild help with middle school students' learning of math?

Project Overview

- Earthquake Rebuild: A 3D architecture game that promotes versatile representations and epistemic practices of mathematics in architectural design and building quests.
- A longitudinal design-based research project:
  - Exploring key features of play-learning integration and stealth assessment in our game-based learning environment.
  - Examining how qualitative, informal math conjectures evolve into formal math knowledge in simulated practice of architectural design, modeling, and critique.

Playful, Constructionism Learning

- Motivation and persistence
- Experimentation and experience – discovery and situated learning
- Modeling – conversion between concrete/associative and abstract/symbolic representation
- Learning through design and building

Design-Based Research

Guided prototyping

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Experimenting with design propositions extracted

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Prototype refining

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Evaluating with refined design propositions

Learning and Game Mechanics

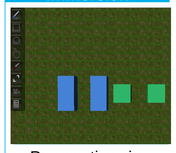
Learning Actions	Game Mechanics
Identification and representation (e.g., of prisms)	Collection and selection (of construction elements)
Measurement and calculation (e.g., of distance, perimeter, or area)	Construction site survey and plan
Create	Building – positioning, stacking, rotating, joining
Analyze	Management (of the inventory, design cost, and need)
Evaluate	Design critique: Thrifty in materials and time, Sturdiness to survive the next earthquake hit, Addresses living needs

Preliminary Meta-Generalizations

Content Integration

- Mechanics driven (what you can do) vs.
- Narrative driven (what it is about)

Perspective and Immersion

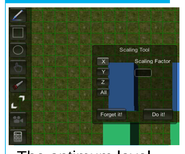


- Perspective view vs. Orthographic view
- Plan view vs. Elevation view
- Adventure mode vs. Construction Mode

Granularity

Granularity level for the construction elements: Bricks vs. Prefabricated container houses

Mathematizing



The optimum level and tools of scaffolding for math learning and engagement

Observations

Preliminary findings of iterative expert reviews and user testing (with seven middle school students) during the past 9 months suggest that the current prototype (compared to the prior four versions) is an obvious improvement in terms of usability, playability, and learning affordance. The findings have also provided the following meta-generalizations, or preliminary speculations, to be further examined via future design experiments:

- A *medium granularity level* (e.g., a prefabricated container vs. a whole house or bricks/planks) should be selected for the initial building action, which can then be scaled either up or down depending on learners' needs.
- The *perspective view*, compared to the third-person, orthographic view, fosters a stronger sense of immersion/presence.
- The *flying view* (i.e., fly-through mode in virtual reality), compared with the elevation view, provides more intuitive object maneuvering and stacking.
- Providing both *adventure* and *construction play* in a 3D game helps integrate the actions of 'building,' 'decision making,' and experiential, self-reflective 'critique' to engage diverse players or learners.
- The use of *scaffolding* should be applied via explicit game rewards and should work as an intermediary interface between the player and the game (e.g., in the current prototype, the player has to enter the numerical input or value of the x, y, and z coordinates in the cutting and scaling tools to cut and scale an object).

Other Preliminary Findings

- Interdisciplinary language in design communication:
  - "What do you mean by 'Plan' and 'Elevation' views?"
  - "What is a 'task' for architectural design, for math learning, for the stealth assessment model, and for gaming?"
- Negotiation of design perspectives and disciplinary cultures:
  - "How do you evaluate and reward architectural design for math learning?"

Future Design and Research

- Continue developing/refining functional specifications
- Design experiments varying the ratios of content-specific and content-generic play across game levels
- Finalize the stealth assessment models (competency, evidence, and task models) – establishing statistical links between actions taken in the game and inferences about math competencies
- Conduct pilot study on the usability, learning effectiveness, and playability of key design elements related to game mechanics and the stealth assessment models

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