Mathstation: A Serious Game for Mathematics

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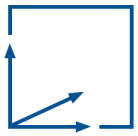

Final: Master Informatics: Games Engineering

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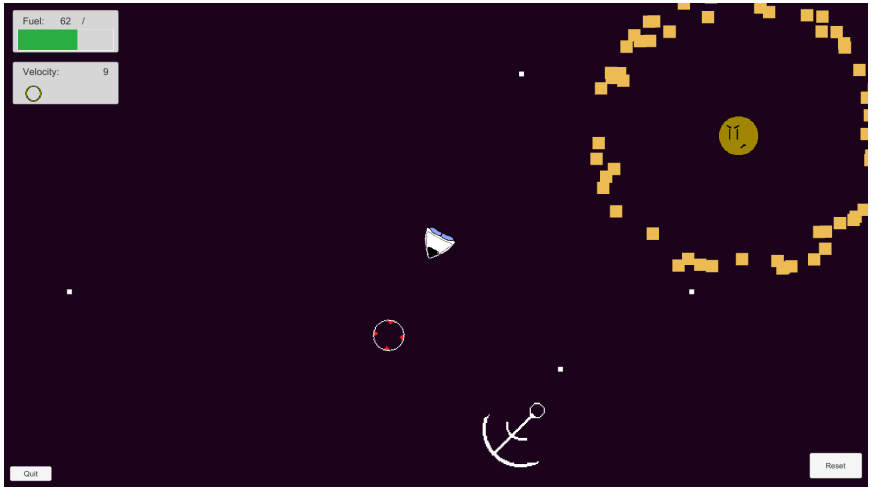
Advisor: Dr. David A. Plecher

Overview

- Introduction and motivation
- Critical issues, related work
- Proposed approach
- Implementation
  - Math editor, game modes
- Evaluation
- Future work
- Conclusion

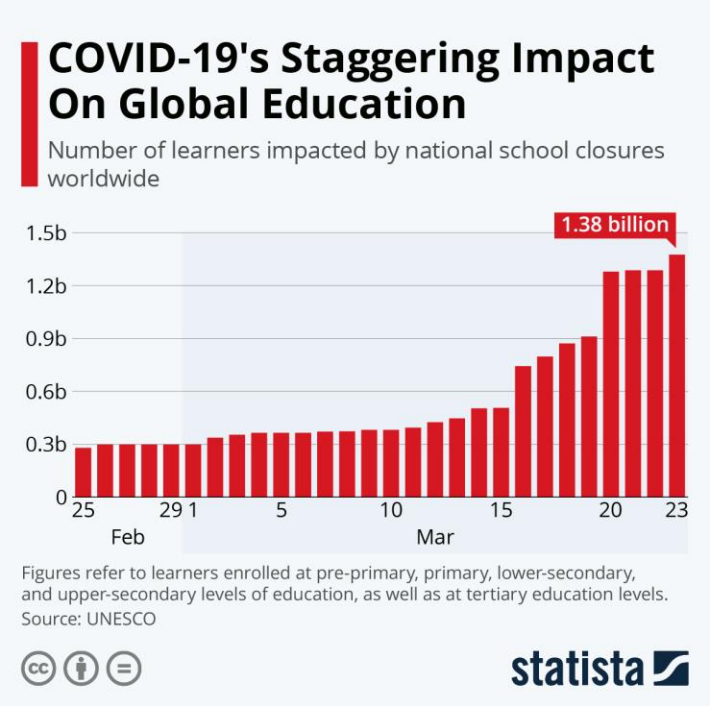
Introduction / Motivation

- *Mathstation* is a math based serious game
- Offers a supplemental learning activity
- Serious games are valuable learning tools
- Recent pandemic related restrictions



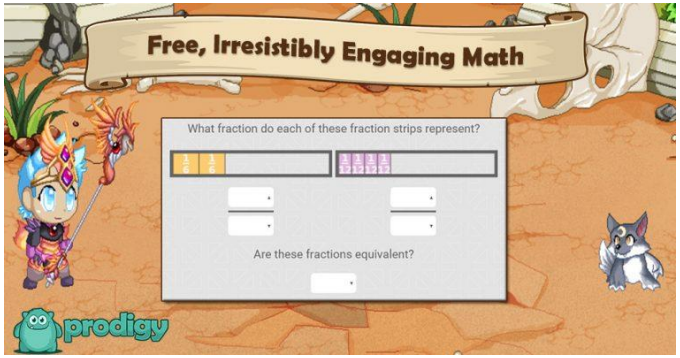
Problem Description: Issues

- COVID-19 Pandemic
- School outages
- Inconsistent education [1]
- Remote learning is suboptimal
- Long term implications



Existing Solutions / Related Work

- Existing Math games, e.g. Prodigy
- Math text books
- Serious games in other educational fields
  - HieroQuest
- Serious Games as teaching tools
  - Meta analysis[2], Mapping of Learning Mechanics to Game Mechanics[3]



[4]

Goals of this Thesis

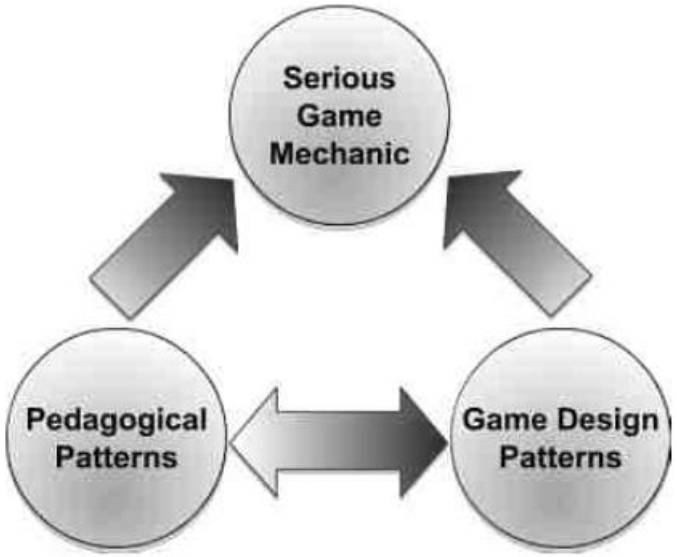
- Create a math game that is available and accessible
- Practice math skills through play
- Cater to a wide audience (within elementary school)
- Generate math problems
- Present math in a text book similar environment
- **Increase learning yields**

Critical Research Issues

- Critical attributes of educational serious games
- Math Syllabus
- Longevity and retention
- **Learning mechanics game mechanics map**

The LM-GM Model

- Serious Game Mechanic – from learning practice to mechanical game-play element
- LM-GM Model – relates pedagogy and ludic elements

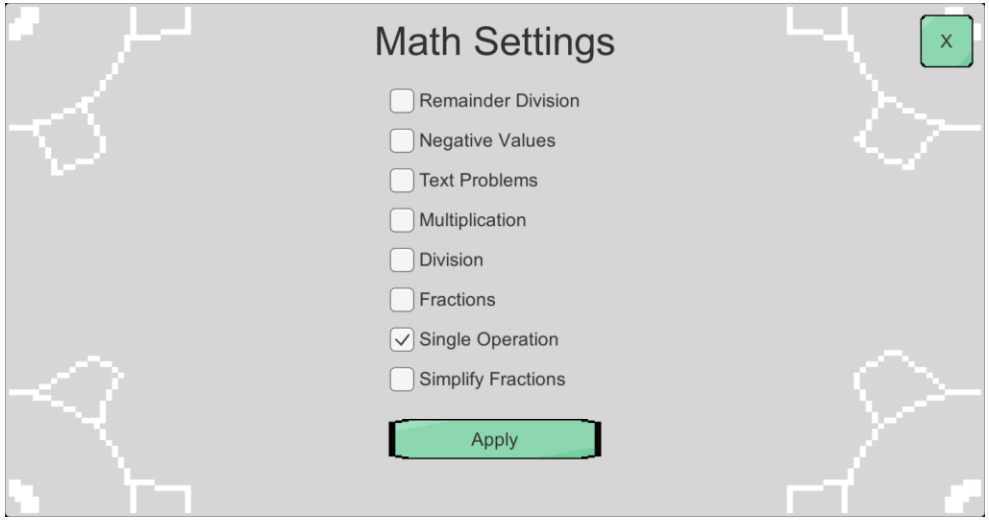


Proposed Work / Approach

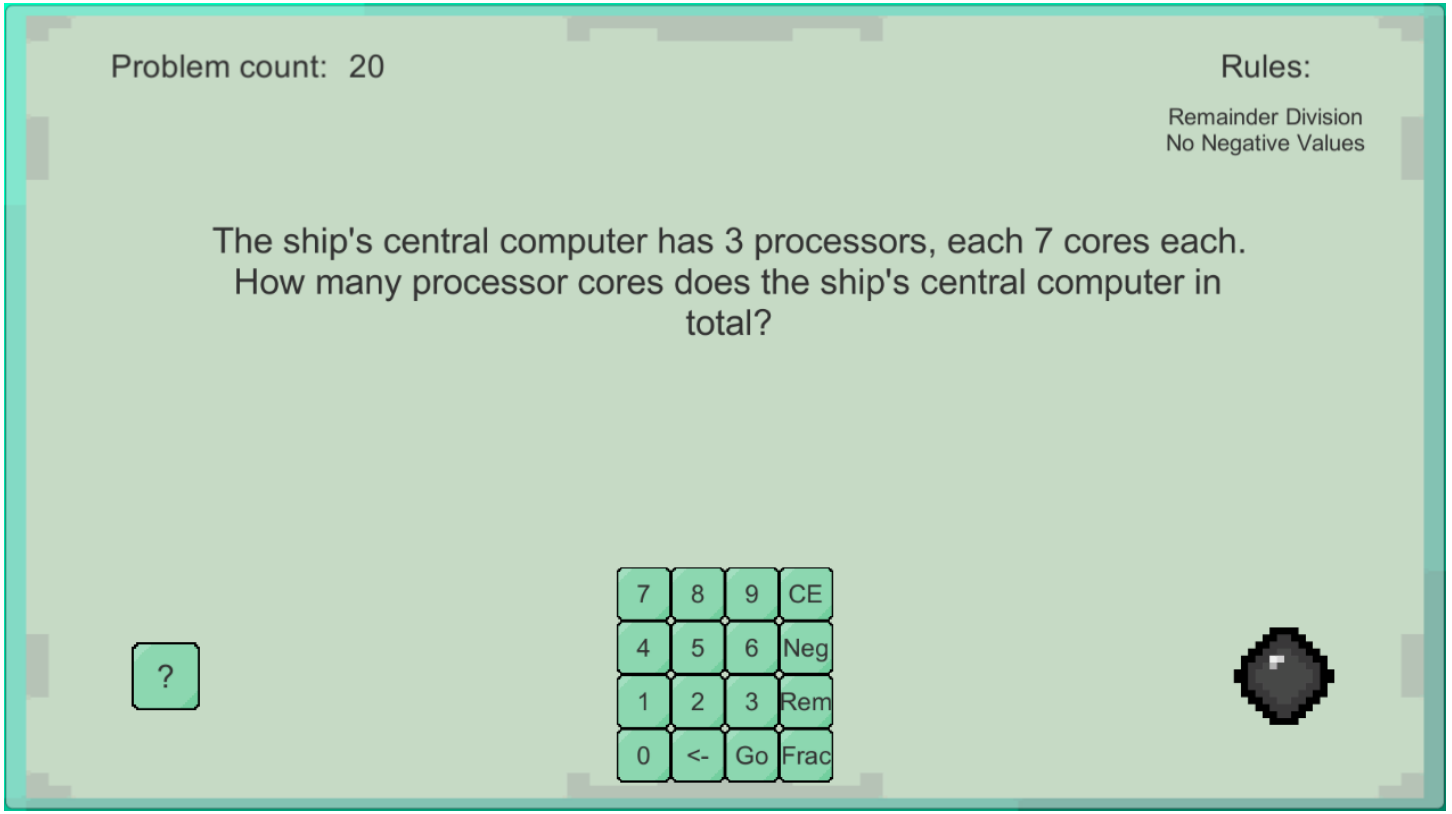
- Math themed mini game collection
- Offers games derived of different genres [5]
  - Action, Strategy and Adventure / "Collecathon"
- Include math solving as part of the game loop
- Configurable math problem generation

Implementation

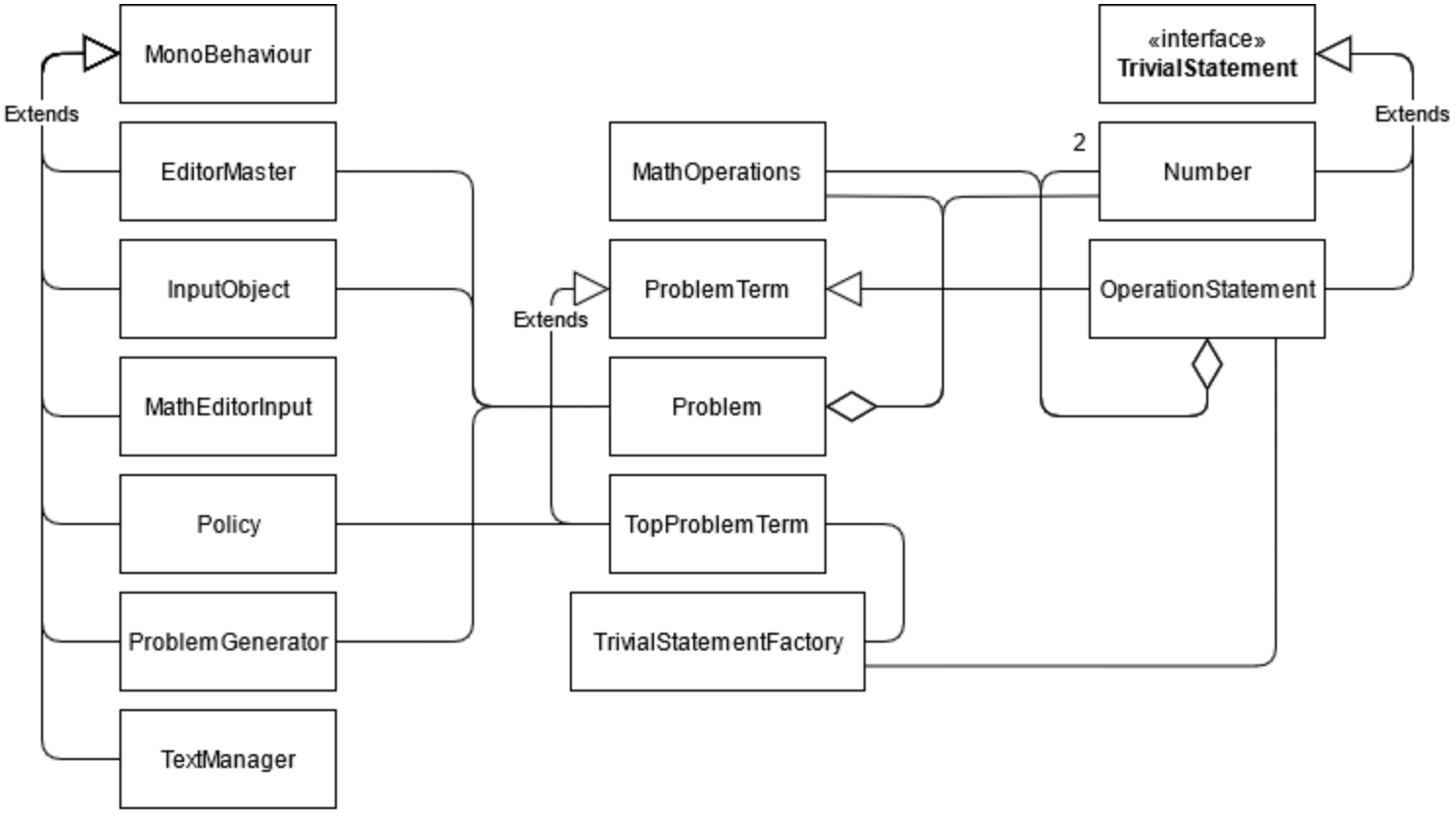
- Unity mini game collection
- Math editor: Problem generation, Interface
- Levels, tutorials, game mechanics
- Minimalistic art style
- **Configurable math**



Math Editor


Problem count: 20
Rules:
Remainder Division
No Negative Values
The ship's central computer has 3 processors, each 7 cores each. How many processor cores does the ship's central computer in total?
7 8 9 CE
4 5 6 Neg
1 2 3 Rem
0 <- Go Frac
?

Math Editor Insight



The Game Modes

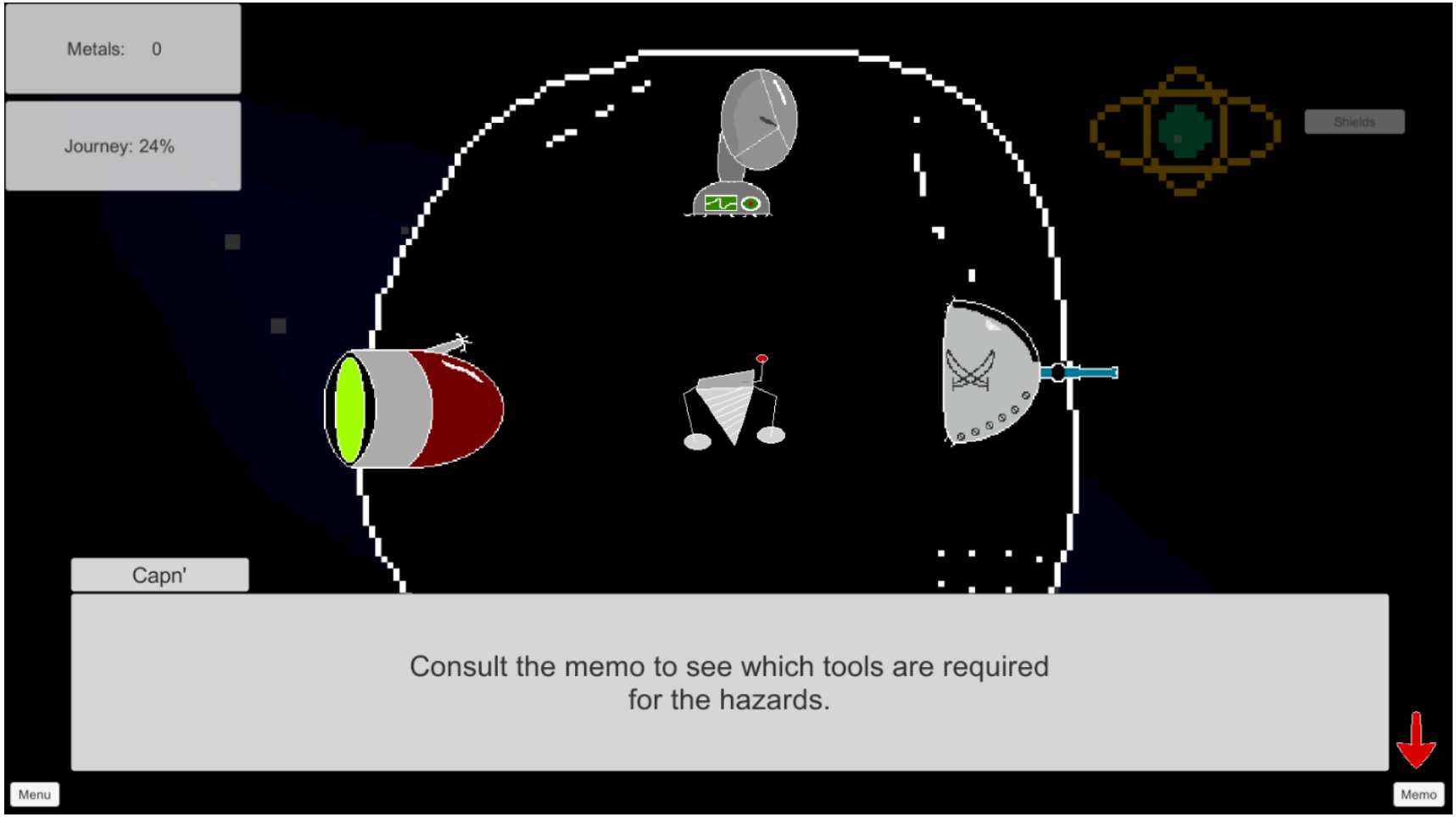
- Action game – Fight
- Strategy Game – Mine
- Adventure / Collectathon – Explore

Action Game - Fight

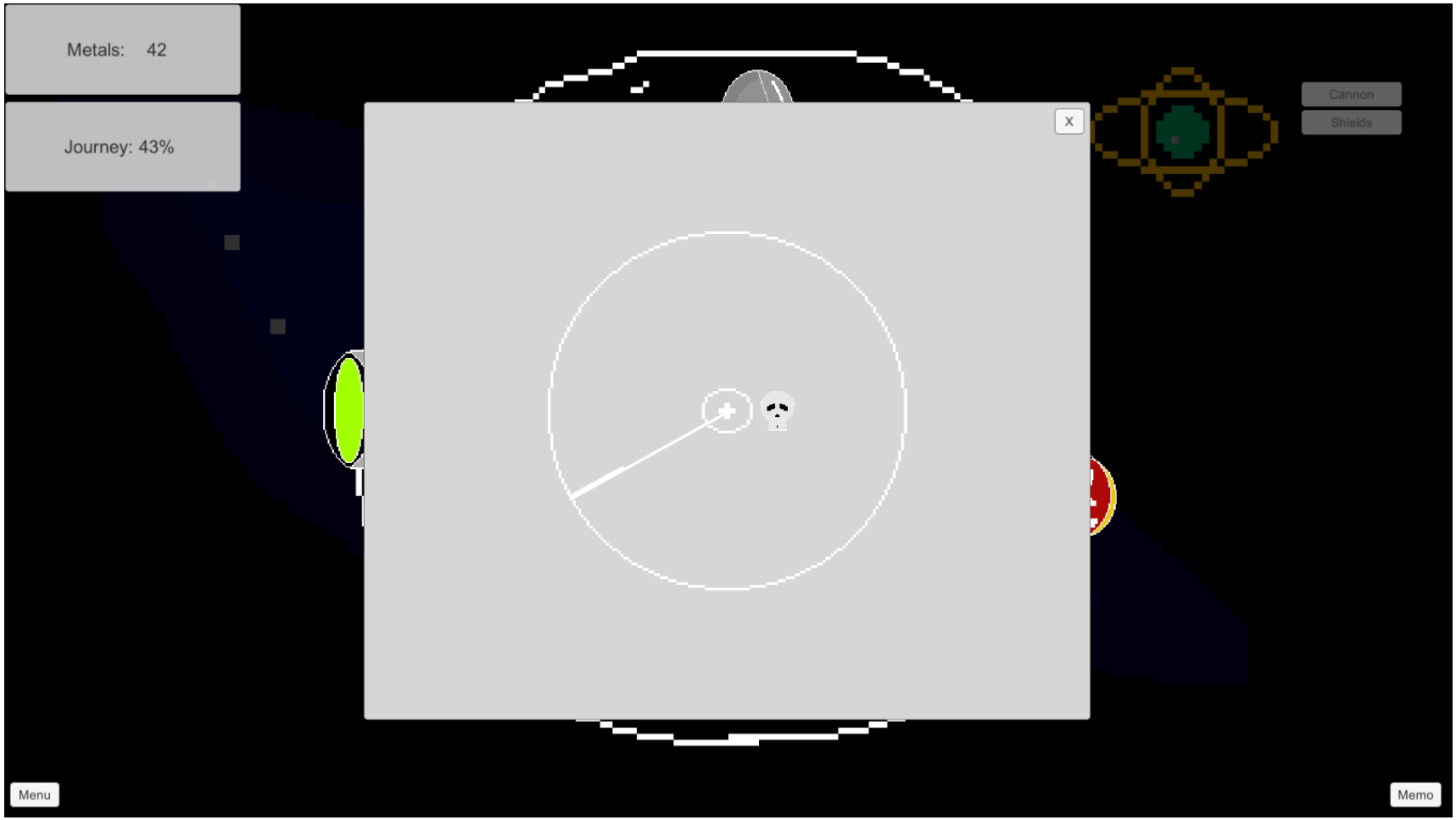
Action Game - Fight

- Based on action games and on rail shooters
- Highlight LM-GMs:
  - Elimination – Action / Repetition
  - Action Points – Feedback

Strategy Game - Mine



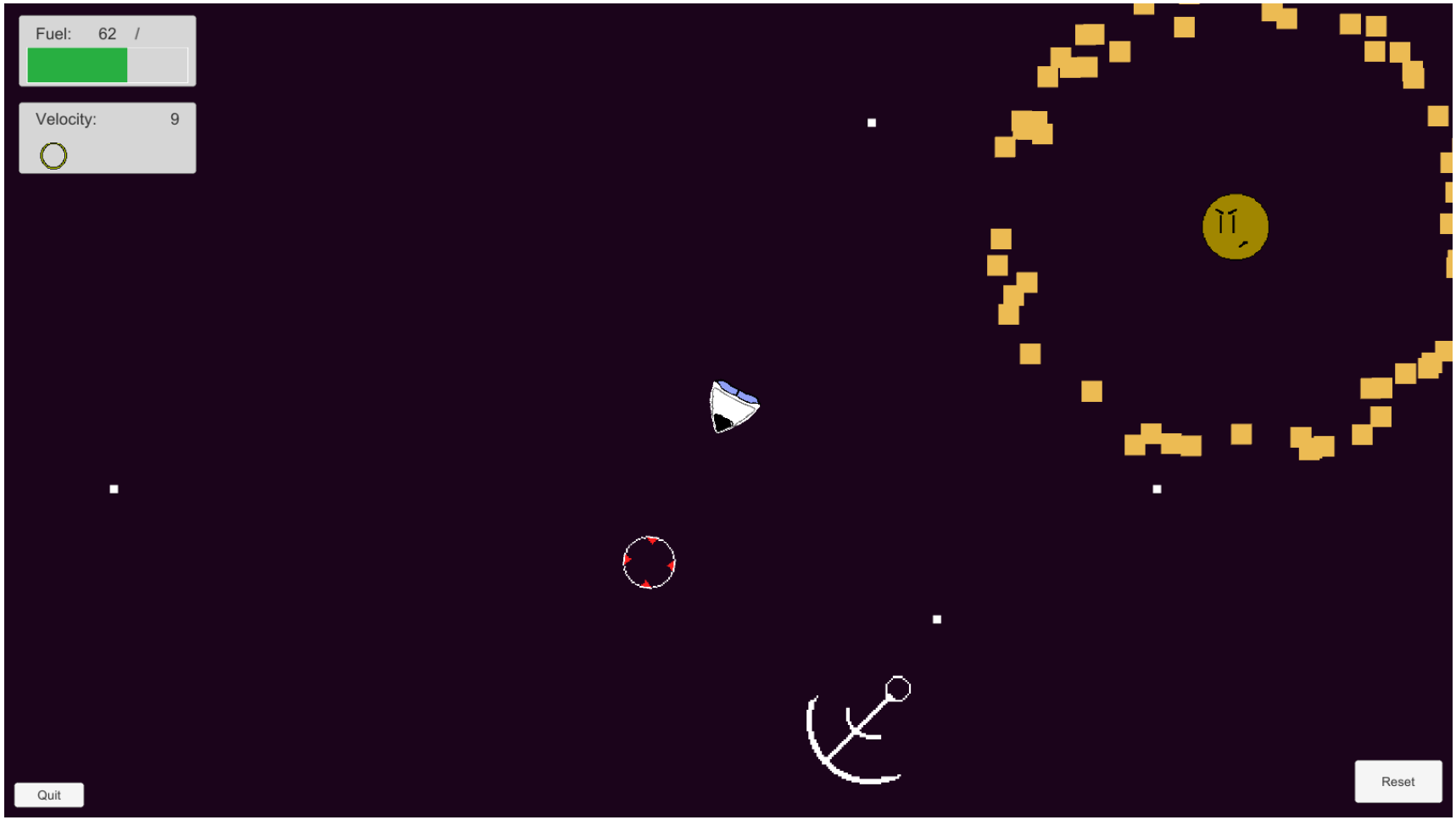
Strategy Game - Mine



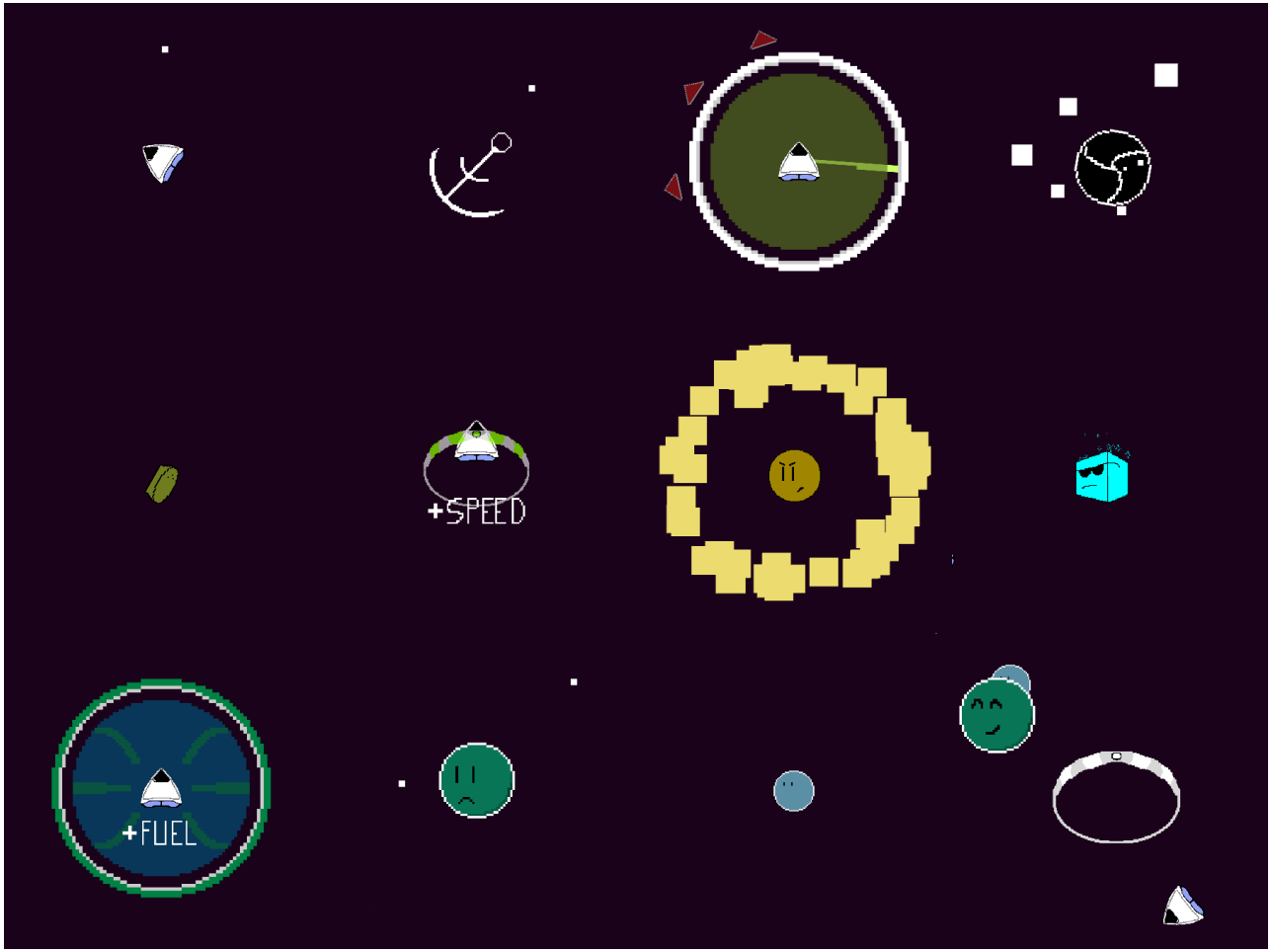
Strategy Game - Mine

- Based on real time strategy games
- Highlight LM-GMs:
  - Resource Management – Plan
  - Time pressure – Simulation
  - Cascading Information – Identify

Adventure / Collectathon - Explore



Adventure / Collectathon - Explore



Adventure / Collectathon - Explore

- Based on action adventure games and collectathons
- Highlight LM-GMs:
  - Collection – Discovery / Incentive
  - Movement – Action / Feedback, Repetition
  - Resource Management – Limitation / Plan

Overarching LM-GMs

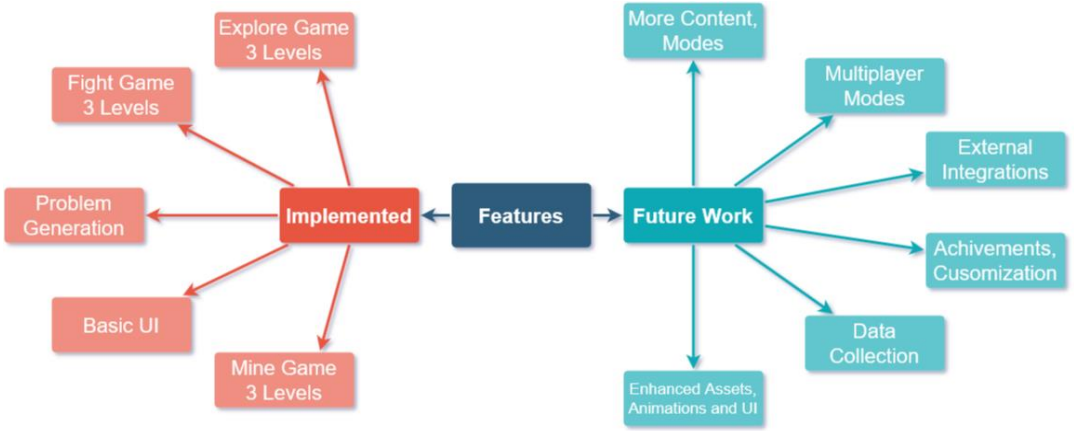
- The following LM-GMs are common to all game modes:
  - Feedback – Feedback, Assessment
  - Questions and answers – Repetition, Simulation
  - Levels – Motivation / Incentive
  - Tutorial / Story – Guidance, Demonstration

Evaluation (User Studies, Test Runs)

- User study unavailable due to the pandemic
- Tools and methods prepared for future use
  - Player experience inventory (PXI) for game qualities
  - Math pre- and post-test, common core standards

Discussion / Suggested Future Work

- More modes, features
- Community features, multiplayer games
- External integrations
- Data collection for long term study
- Publish on digital distribution stores
- New demographics



IEEE Publication

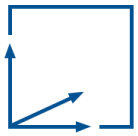
A work-in-progress paper of *Mathstation* has been submitted to the Immersive Learning Research Network (iLRN) and presented at the poster session.

Link to IEEE publication.

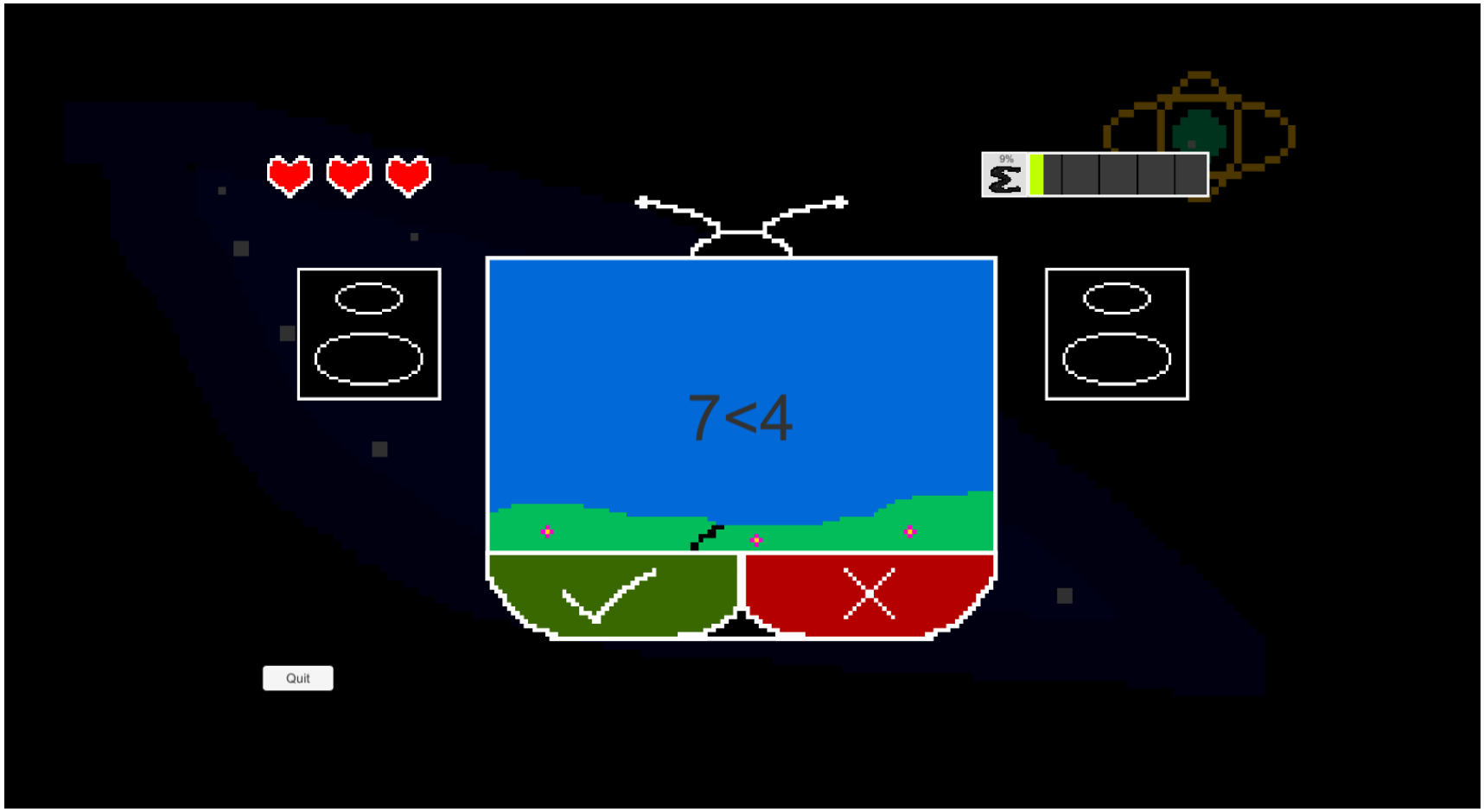
Conclusion

- *Mathstation* offers three distinct game modes
- Has an extendible math problem generator
- Requires a study in the future

Questions



Game Footage



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1. N. McCarthy. *COVID-19's Staggering Impact On Global Education.* https://www.statista.com/chart/21224/learners-impacted-by-national-school-closures/, visited: 20.7.21
2. M. Riopel et al. *Impact of serious games on science learning achievement compared with more conventional instruction: an overview and a meta-analysis.* In: *Studies in Science and Education* 55.2 (2019) pp. 169-214.
3. S. Arnab et al. *Mapping Learning and Game Mechanics for Serious Games Analysis.* In: *British Journal of Educational Technology* 46.2 (2015), pp. 391-411.
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5. T.H. Apperley. *Genre and Game Studies: Toward a Critical Approach to Video Game Genres.* In: *Simulation & Gaming 37.1 (2006),* pp. 6-23.