Introduction

- Challenge: create games that support both an intended aesthetic experience and an intended set of educational objectives
- Help with that challenge: a framework for analysis and design
  - An attempt to "marry" game design and instructional design
- Framework has been used by students in the course Design of Educational Games
  - Taught at Carnegie Mellon Univ.

Overview of the framework

Examples of student work
What the framework is not

- Development methodology or process
- Set of design patterns
- Prescription for how to integrate learning and game play

Overview of the framework

MDA

Educational Objectives

Instructional Design Principles

Zombie Division

- Created by Jacob Habgood and Shaaron Ainsworth at the University of Nottingham
- 3D action-adventure game that supports learning of whole number division
- Mission: Matrices must rid the dungeon of zombies
- Zombies succumb when attacked with weapon whose number divides the Zombie’s number evenly
- Evaluation studies show that ZD supports learning and enhances motivation
Specifying educational objectives

Helps make sure that game fully addresses a intended, coherent set of educational goals

Prior knowledge: What knowledge or skills will students need before playing the game?

Learning and retention: What knowledge or skills will students learn from the game?

Potential transfer: How far are these knowledge and skills likely to transfer?

Provide for each:
(a) Written description
(b) Examples of tasks
(c) Place in Bloom’s Revised Taxonomy of Educational Objectives

What will the student/player learn from Zombie Division?

- Skill and fluency with divisibility judgments with dividends < 100 and divisors < 10
  - Example: By which of these divisors can you divide 42: 3, 5, or 6? Or none of the above?
- Conceptual understanding of division as “making equal groups”
  - Example: 12 is divisible by 3, because if you can make 3 equal groups out of 12
- Conceptual understanding of division as the inverse of multiplication
  - Example: Understanding that 56 ÷ 7 = 8 because 7 x 8 = 56

What prior knowledge is needed for Zombie Division?

- Notion of whole numbers up to 100
- Understanding of whole-number multiplication
  - Example: what it means to say 7 x 8 = 56
- Basic notion of division
  - Example problem: 6 ÷ 3 = ?

How far will skills and knowledge learned with ZD transfer?

- Transfer means improvement on tasks or skills that are related to but different from the original learning content
- In general, making predictions about transfer is difficult.
- Skill and fluency with division?
  - Example: What is 42 ÷ 3?
- Will students learn to recognize prime numbers?
  - Example: Can 41 be divided evenly by any number?
Overview of the framework

MDA

Educational Objectives

Instructional Design Principles

MDA: Definitions

- Mechanics: The rules and concepts that formally specify the game-as-system
- Dynamics: The run-time behavior of the game-as-system
- Aesthetics: The desirable emotional responses evoked by the game dynamics


http://algorithmancy.8kindsoffun.com/MDAintu.ppt

The Designer and The Player

Mechanics → Dynamics → Aesthetics

Designer → Player

Zombie Division Core Mechanics

- Player gathers points by defeating zombies
- Zombie succumbs if the weapon’s number is a divisor of the zombie’s number
- Zombie can fend off the attack if it has the same weapon with which it is attacked
- Players loses health if the attack is with the wrong weapon (not a divisor), or if zombie strikes first

Relation with ZD learning objectives:
- Learning content is tightly integrated in the game’s core mechanic
**Zombie Division Dynamics**

- Game supports a “deliberate style of suspenseful hunting”
  - Combat? Zombies not very combative ...
- Need to apply math skills under mild time pressure
  - But can avoid pressure by walking out the room, or by stopping when seeing zombie in the distance
- Occasionally, greater time pressure
  - Hectic situations with multiple zombies
  - Levels with fast-appearing zombies
- Some parts are very slow moving
  - Bone-dragging exercise on the help screen is very slow

- Appropriate choice of dynamics, given the educational objectives?

**Aesthetics**

- LeBlanc’s (non-exhaustive) Taxonomy of Game Pleasures
  - Sensation
  - Fantasy
  - Narrative
  - Challenge
  - Fellowship
  - Discovery
  - Expression
  - Submission

**Overview of the framework**

- Educational Objectives
- Instructional Design Principles
- MDA

**Zombie Division Aesthetics**

**Challenge: Attacking Zombies**

The math adds to the challenge. (The math is the challenge?)

**Fantasy:** Greek warrior identity, kill monsters in a dungeon

**Discovery:** Explore the maze, find keys

- Relation with learning objectives
  - Aesthetics mainly function to raise interest?
  - Challenge of doing math (which gives rise to the challenge aesthetic) helps learning
  - Tedium of the bone-dragging exercise may have an educational purpose: Division as an operator avoids the tedium of dragging items one-by-one into piles
What are instructional design principles?

- Principles are prescriptions for how to support learning effectively. Statements of the form: “all else being equal, instruction that has feature X leads to more robust learning and/or greater interest than instruction that does not have feature X”
- Ideally, backed up by (e.g., Mayer & Moreno, 2003):
  - A theoretical rationale (linking the principle to a theory of cognition and learning)
  - Empirical evidence
- Key way in which educational researchers communicate the results of their research to practitioners
- Likely, but unproven, that instructional principles can be applied to educational game design

To illustrate

Example:
“11. Multiple Examples. An understanding of an abstract concept improves with multiple and varied examples.”
http://www.psyc.memphis.edu/learning/whatweknow/index.shtml

Non-example:
“Curriculum A for 6th-grade math is better than curriculum B.”

Lots of Lists of Principles

- Cognitive Tutor (CT) Principles
- Multimedia & eLearning (MM) Principles
- Life-Long Learning Principles (LLL)
- Jim Gee’s principles of learning embedded in video games (Gee)
Principles supported in *Zombie Division*

Gee #12: “Learners get lots and lots of practice in a context where the practice is not boring.”
CT #6: “Provide immediate feedback on errors”
LLL #13: “Learning wrong information can be reduced when feedback is immediate.”
LLL #11: “An understanding of an abstract concept improves with multiple and varied examples.”
Gee # 27 “The learner is given explicit information both on-demand and just-in-time. ...”
LLL #21 “Assignments should ... be ... at the right level of difficulty for the student’s level of skill or prior knowledge.”

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Summary: Use of framework for analysis

- Viewed the game from 3 analytical angles, considering relations between them
- Yields rich description (and appreciation) of the thoughtful design of the game
  - “Deliberate hunting” dynamic
  - Fact that time pressure is varied throughout the game and ways that seem consistent with the learning objectives
  - Use of the tedium aesthetic to reinforce educational objectives (risky, to be sure)
  - Rich coverage of learning principles

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Use of the framework to generate re-design ideas

Focus on one component to generate ideas
Then check if the ideas work well with the other framework components

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Use of the framework to generate re-design ideas
Use of the framework to generate re-design ideas

Generating redesign ideas: Focus on MDA

• How could we enhance the game’s discovery aesthetic?
  – Something hidden in the maze? Captive Greek mathematicians?
  – Fits well with the narrative aesthetic?

• Add educational objective? divisibility rules
  – E.g., a number is divisible by 5 when it ends in 0 or 5

• What game mechanic could help make this happen?
  – Will the mathematicians accompany Matrices and offer advice proactively?

• Instructional Principles: Gee #27 “Explicit Information On-Demand and Just-in-Time Principle.”

Generating redesign ideas: Focus on educational objectives

• What topics are closely related to the game’s educational objectives?
  – Prime numbers, factoring, dividing, divisibility rules

• What mechanic could support learning prime numbers?
  – Weapon to use against prime numbers only: a hammer that smashes the skeleton into all its individual pieces

• Fits nicely with the game’s dynamics and aesthetics
  – Deliberate hunting, challenge

• Relation with learning principles?
  – Student must get sufficient practice with prime numbers (Gee #12) and must encounter appropriately challenging prime numbers (LLL #21)

Discussion

• General framework
  • Helps make sure important angles are considered during analysis and redesign
    – Does not replace the creativity normally involved in game design or instructional design
    – Helps a designer coordinate the different levels at which an educational game must succeed

• Ideas for extending the framework
  – Theory about how to integrate learning and game play
  – Educational game design patterns
  – Supported by scientific studies
Epilogue

• Can environments explicitly designed to meet both educational and aesthetic goals succeed?

• LeBlanc’s (non-exhaustive) Taxonomy of Game Pleasures
  - Sensation
  - Fantasy
  - Narrative
  - Challenge
  - Fellowship
  - Discovery
  - Expression
  - Submission
  - Learning

The End

No, really.