Mathematical Thinking in Turn-based Strategy Games

Background

“Victory Ratio” is an educational game being developed that is trying to capture what makes turn based strategy games fun, while mechanically utilizing common mathematical functions from a standard high school curriculum. It is to be played before beginning a unit studying probability or ratio math. Games require a steep investment of time, and so making educated design decisions is important to ensuring the time, and therefore the budget, is well spent. In this case, the game will be developed as part of a Creative Component for the Spring 2021 semester at Iowa State University, and the findings of this research will influence the direction of the project.
Game-based Learning is a field of great interest that is still in its infancy. Educational, or “serious”, games are being adopted in the classroom, but oftentimes amount to a lightly interactive quiz. Engagement has been shown to increase retention of learning, meaning that an educational game can be more effective if it is perceived by the students as fun, rather than simply touching the topics needed. This, along with digital games’ potential to provide students with a tangible frame of reference to relate their classroom lessons to are confirmed by Yu-Hao Lee in “Are Good Games also Good Problems” (2013).
Sabaté, Albarracín, Calvo, and Gorgorió (2016) found that students engage in geometrical thinking when engaging in real-time-strategy (RTS) games. Through the use of eye-tracking software, they were able to identify the thought process of students while making decisions on the fly, including resource management and looking ahead to evaluate risks.

Statement of Positionality

I am a Human-Computer Interaction Master’s student with a background in software development, experience making games using the Unity3D game engine, and an interest in game-based learning. I am a firm believer that games are a powerful tool to pass on messages and skills, and that they have their place in the classroom. I remember having some difficulty studying math that just felt like magic numbers to me without a real-world application or goal to show why I’m using these numbers the way that I’m expected to. Having games that provide a context for the lesson plan will give students something to connect their lessons to, and therefore enhance their comprehension and information retention, or at least this is what I seek to prove.

Scope

The goal of this study is to test the waters for going forward with this project. This will be done with a brief literature review to find cases where the principle goal of the project held, such as

studies on the transferability of skills from games to the real world, and studies of serious games in the classroom enhancing test scores. A paper prototype of the game using known mechanics will be created and tested with a few willing participants who will be interviewed about their decision-making process while playing the game. Qualitative data from this can indicate that the players make calculated decisions based on the math used in the game, which should be a transferable skill to the classroom.
Success in this study would greenlight the creation of the digital game, with perhaps some usability testing along the way. After completion, ideally this game would be tested in high school classrooms with a test group and a control group completing pre-tests and post-tests and comparing the resulting improvements at the end of the school unit, but that is outside of the scope of this study.

Method

Due to COVID and being on the budget of a student, this test will only be completed with a sample size of 2 acquaintances with no exposure to the project. They are adult-age Information Technology undergrad students, and so not strictly representative of the target, but the play behaviours should be similar enough, even if they are more advanced from the perspective of mathematics education. Or so at least we hope.
The original plan was to test a strategy game that was a partial form of inspiration for “Victory Ratio” to see if a player took time to assess statistical risks in it while playing the game. The game in question was “Fire Emblem: Three Houses”. During a short interview with a player of the game some important insight came up. The principle of assessing someone’s mathematical reasoning while playing the game was met with what was intended to be a joke about putting two characters together to fight because she wanted them to date. This put forth a huge problem in this method, as while I still hold that math is a major decision factor in “Fire Emblem”, the game has incentives that will distract the player from making what is strictly the best strategic decision. While risk factors would still be weighed, and there would likely be some long term benefit to playing the game, this could also introduce noise into qualitative data collected from the user study. Because of this, the paper prototype of “Victory Ratio” would need to be developed and played to have a game with more focused objectives.
A grid sheet like the kind that a “Dungeon and Dragons” player would use to keep track of a map would be used along with placeholders to represent the units. The tester will sit across from the player, explain the rules and how damage is calculated, and control the “AI” opponent through set behaviors. A short “tutorial” session would be played with fewer units, followed by a full simulated “battle”. The battle will be recorded, and then played back for the player with pauses to ask about the player’s logic at the time of noteworthy decisions being made. This semi-structured interview will provide qualitative data of how the player makes their decisions.

Results

Key words and behaviours will be sought out in the semi-structured interview with the player. How they refer to their decisions, such as come to the conclusion their unit will be able to come

out victorious if it engages with another unit, will be compared to how this is calculated in game. The in-game calculations will be reflective of the mathematics lessons it is intended to supplement, and so if the player uses those game mechanics in their decisions, the result can be assumed to be a success, and the project can go forward.

Discussion

The study by Sabaté et al. (2016) confirms the utilization of mathematical thinking in RTS games. We are attempting to use statistics instead of spatial reasoning and resource management, but doing so in a turn-based setting where the player has little reason to not take their time and calculate their decisions.

The short interview with a player was much more insightful than expected, especially with the casual nature of the interview. I had great worry about educational games often being dry if designed for a purely educational purpose, but the complexity of “Fire Emblem” does show the benefit of designing a more focused experience. While it is important to me still that “Victory Ratio” not be a quiz game, designing the game within the constraint that it should engage very specific rationales in player decisions should be viewed as an asset to the game, rather than education being the by-product.

Failure to get the desired results in user tests does not necessarily mean the concept of the game is a failure, but could indicate that the current design is ineffective. If this is the case, it is my intent to gather what is lacking in order to provide the player with that experience when time to construct the digital game arrives.

Works Cited

Hernández-Sabaté, Aura, Albarracín, Lluís, Calvo, Daniel, & Gorgorió, Núria. (2016). EyeMath: Identifying Mathematics Problem Solving Processes in a RTS Video Game. Games and Learning Alliance, 10056, 50-59.

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