

Exploring In-Game Scaffolds for Higher-Order Learning in a Case-Based RPG Learning Game

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Abstract: As active learning tools, digital games often focus on including interface and design features to scaffold progression. However, little emphasis on the use of such in-game scaffolds for higher-order learning exists in the literature. We focused this study on the second interaction of a working prototype game called Stories of a GeoFarmer. The study evaluates the importance of in-game scaffolds for engaging learners in higher-order thinking in undergraduate Geography education. Stories of a GeoFarmer is a case-based role-playing game where players take on the role of a farmer in different countries. The game utilizes documented case studies of different environmental issues relating to cultural geography to place players into the role of the individuals impacted by the various situations. The situations are ill-structured presenting interesting arguments for no-win situations meant to engage more thinking about geographic implications. We incorporated several in-game scaffold types that connected to the learning objectives including metacognitive, conceptual, and procedural. We use a mixed methods exploratory design approach consisting of thematic analysis and correlation of post-game survey responses. Our research question asks how does in-game scaffolding in the geography game Stories of GeoFarmer affect the adult learners' experience? Results from 63 undergraduates indicate that students can regularly recall and extrapolate how their in-game actions affect the environment. However, fewer students are able to evaluate why no singular solution exists to the game's problem despite all the provided in-game scaffolds. Metacognitive scaffolds play the largest role in prompting students to recognize cause and effect but also highlight the necessity of making multiple scaffold types more prominent in order to reach higher-order thinking. This study holds implications for serious game designers to consider how in-game scaffolds can be presented to support high-order learning in adults.

Keywords: Games-Based learning, Role-Playing games, Case-Based learning, Scaffolding, Adult learning

1. Background

In education, there is a need to utilize academic curricula, lesson plans, activities, experiences, discussion topics, etc., that challenge students to solve complex and irregular problems due to their prevalence in the 21st-century professional landscape. Providing students more opportunities to encounter situations where higher-order thinking is necessary to resolve these problems is a challenge for almost every academic professional, and many have started implementing Game-Based Learning (GBL) to meet this need. GBL is a transformative pragmatic approach that can create unique digital learning environments that support higher-order thinking skill development (Jan and Gaydos, 2016, p. 6). Specifically, GBL defines games that situate players in purposely designed environments, in which the player must become a proactive learner who gains the higher-order problem-solving skills necessary to overcome the game's built-in challenges (Jan and Gaydos, 2016, p. 10). GBL environments, if properly designed, have been viewed as a potential way to provide student's consistent experiences where they interact with problems that prompt continual growth of their problem-solving skills throughout the entire game that can be transferred inside or outside their original gameplay experience (Gee, 2005, p. 9).

1.1 Active Learning and Andragogy

To understand the needs of adult learners and how active learning can and should be applied within a game context, we look to Knowles theory of andragogy. The investigation into adult learning with serious games primarily focuses on the understanding that the design of the game can be made to align with adult learning

theory (Symborski et al, 2014). In an active learning environment, learners engage problem-solving through activity (Lewis and Bryan, 2021). This active engagement with higher-order problems connects with the ability to explore while assuming responsibility for one's own learning – the foundation of adult learning (El-Amin, 2020). The focus on active learning within andragogy within our study examines the principles presented by Knowles and how we combine them with GBL principles from Gee (2005). Gee's principles of good game design dovetail with active learning, providing overlap with Knowles' andragogy. Specifically, problem-solving in games where the presentation of information and the structure of a larger problem can be scaffolded for players to associate to the larger game goal. This type of connection between active learning in games connecting to goal-driven needs of adult learners illustrates a need for understanding how scaffolding assists with adult learning.

1.2 Scaffolding in Games

GBL treats games as whole learning systems, meaning that learning can and often is scaffolded in a similar manner to other learning systems to support feedback (Melero, Hernández-Leo and Blat, 2011). Scaffolding offers information that can be *just in time* (Gee, 2005) or structured following performance in an activity. In GBL, the nature of scaffolding can vary from clues to reflections external to the game (Melero, Hernández-Leo and Blat, 2011). However, when learning must happen within the closed system of a game, there is a need to categorize different game elements into aligning scaffolds. Cai et al (2022) noted that more work needs to be done understanding scaffolding mechanisms and the nature of the influence they have on both behavior and learning, especially in adult learners who need to connect learning to a problem (El-Amin, 2020).

We explored several scaffolding types in a working prototype of the digital learning game, *Stories of a GeoFarmer*. There were three main scaffolding types we used in this study. The first type is conceptual scaffolding. This specific scaffold uses concept mapping and/or specific tools to help students engage in visualization depicting concepts so they can identify what to think about when solving a problem (Kim, Belland and Walker, 2018, p. 402). Metacognitive scaffolding has students reflect on what they are learning along with how they learned it and encourages them to think deeper about the problem at hand in order to find solutions (Kim, Belland and Walker, 2018, p. 402). Procedural scaffolding helps learners understand specific rules to the game/activity, steps to take, and the progress the student has made up to a given point (Chen, Hou and Wu, 2023, p. 5). We included elements of strategic scaffolds in our procedural scaffold as well. Strategic scaffolds help students identify and process information presented to them and help them develop a solution to the presented problem (Kim, Belland and Walker, 2018, p. 402). Procedural scaffolds fit into our game much more effectively than strategic did, though elements of strategic scaffolds were still applicable to the scaffold we implemented. The focus on these specific scaffold types connecting to active learning among adult learners led us to ask two research questions: 1) how does in-game scaffolding in the geography game *Stories of GeoFarmer* affect adult learners' experience? And, 2) how does in-game scaffolding in the geography game *Stories of GeoFarmer* affect the adult learners' perception of learning?

2. Methods

This study used an exploratory mixed methods design approach (Creswell and Plano Clark, 2017) to better understand the adult learner's experience with in-game scaffolding in a GBL environment. Such a design, we believed, would allow for stronger correlations to be made between the adult learners' experience with the implemented scaffolds and the attainment of the higher-order learning objectives of the GBL environment. The study's qualitative research question was how does in-game scaffolding in the geography game *Stories of GeoFarmer* affect adult learners' experience? Which was supported by the quantitative research question of how does in-game scaffolding in the geography game *Stories of GeoFarmer* affect the adult learners' perception of learning?

2.1 Game Description

Stories of a GeoFarmer is a role-playing game (RPG) focused on teaching undergraduate geography students about sustainable agroforestry and its socioeconomic impact in south and east Asia (Figure 1). The game was created using the RPG Maker MV game engine and utilized built-in assets, third-party graphics, and custom-made sprites. Players progress through levels by completing a series of quests from non-playable characters (NPCs) and are forced to make decisions that balance the economic, environmental, and social impact on the region. As players complete quests, they obtain the in-game currency, Ringgits, as well as items that help them advance through levels faster. This iteration of the game includes a significantly updated tutorial, brand-new farming, and logging mechanics, a heads-up display (HUD) for quest and progress tracking, and a revised story

with new maps. The tutorial begins with the basic movement and selection mechanics of the game and returns throughout the game as more advanced mechanics are introduced. An NPC provides dialogue instructions and even demonstrates some of the actions the player will need to complete within the tutorial. Regarding new features, the farming and logging mechanics utilize advanced event scripting and JavaScript to include collision tracking that registers player tool collision per farm plot or per tree. The heads-up display shows the progress of quests in each area, keyboard controls for the logging and farming mechanics, and two meters that track progress. The envirometer measures the player's effect on the environment and the populameter measures the player's popularity with the in-game characters based on the choices made in the game. Along with the mechanics and user interface updates, the story and maps were updated to align with these changes. The story follows a farmer whose property was destroyed due to climate change and who is trying to work to secure a new homestead and source of income. These updates were implemented over the course of a semester and were made with assistance from a number of contributors that helped with the story, dialogue, learning objectives, and overall game design.



Figure 1: Scenes from Stories of a GeoFarmer, including the title screen, tutorial, and NPC interactions

Three primary scaffold types were selected: metacognitive, procedural, and conceptual, see Figure 2. Each scaffold type was represented through an aspect of the game. The metacognitive scaffold was the combined user interface meters, envirometer and populameter. The procedural scaffolds were based on NPC guidance along with the tutorial (Chen, Law and Huang, 2019). Lastly, the conceptual scaffold was Wong Enterprise signage that appeared in areas taken over by the company. This final scaffold would multiply across the game environment as the player sided with the company over the indigenous people.



Figure 2: Scaffolds represented in the game with the metacognitive scaffold on the far left, the conceptual signage to the right of the metacognitive meters, and the procedural scaffold as NPC interaction

2.2 Participants

Participants in the study were recruited from the 124 students enrolled in the Regions and Nations course. Twenty-one (21) students were enrolled in the Honors section, and 103 in the regular section. The Honors and regular sections meet for lecture twice a week, and Stories of a GeoFarmer was implemented and tested in lecture during week 5 of the 15-week semester. Apart from the midterm and final, each week in lecture culminates in a timed 5-point quiz the students take on the Canvas LMS. For week five, students were given the option to “play-test” Stories of a GeoFarmer or take the scheduled quiz for the week.

Sixty-three (63) of the 124 students opted to play-test the game: 10 freshmen, 20 sophomores, 13 juniors, and 20 seniors. For point of comparison, total enrollment in the course consisted of 18 freshmen, 33 sophomores, 36 juniors, and 37 seniors. Of the 63 participants, ten were enrolled in the Honors section, and 53 in the regular section. For point of comparison, total enrollment in the course consisted of 21 Honors students and 103 students in the regular section.

2.3 Procedure

The course instructor created an ungraded Survey in Canvas with the Institutional Review Board (IRB) informed consent along with instructions asking the students who volunteered to play the game all the way through

until receiving their “score card” in the treasure chest at the “final farm,” which marks the end of the game in the prototype. Clicking “play” constituted agreement to participate in the study and linked them directly to the game’s start screen. Once the students completed the game, they were required to take and upload a screenshot of their scorecard and complete the feedback survey to earn five points. All 63 participants successfully completed the requirements. The survey consisted of 15 Likert-scale questions about Enjoyment (adapted from Davis, 1989), Usefulness, Guidance, and Perceived Learning. Additionally, there were six open-ended questions to follow up on in-game performance and opinions towards the use of the game in the course (e.g. Review your environmeter and populameter scores, what is your opinion on the results of your scorecard?).

To analyze the study's qualitative research question, thematic analysis (Braun and Clarke, 2006) was conducted on the responses collected from the surveys submitted after participants finished their run-through of *Stories of GeoFarmer*. Specifically, we adopted the Collaborative Qualitative Analysis approach (Richards and Hemphill, 2018) where we utilized a consensus coding approach through six group meetings across three weeks. The first two rounds of coding focused on a combination of inductive and deductive coding to form and test our codebook (Fereday and Muir-Cochrane, 2006). The final round of coding consisted of a group axial coding conducted by the same three coders in a singular collaborative session to further develop potential combinations between the data (Williams and Moser, 2019). The aim of the consensus coding was to add trustworthiness to the independent coding conducted outside of the group meetings. All coding was performed using Delve’s qualitative data analysis software. We then conducted a correlation analysis using JASP across the themes using Fisher’s Exact Test to identify relationships among the themes. Significant themes were then related to four variables from the survey: Enjoyment, Usefulness, Guidance, and Perceived Learning.

3. Results

After conducting the thematic analysis of the survey data and holding a collaborative discussion, five themes were derived from the data; NPC, environment, ethics, conforming, and game dilemma. These themes will be defined and given in-game context in the following paragraphs.

Table 1: Thematic Code Book with Code Count Results.

Theme name	Code count	Theme description
NPC	24	Participants list and/or describe in-game interactions with the game's NPCs and how those interactions made them realize their actions impacted the environment.
Environment	75	Participants list and/or describe in-game actions they did that impacted the environment, whether positive or negative.
Ethics	38	Participants list and/or describe in-game actions that could be perceived as immoral or based on ethics that led to environmentally harmful events.
Conforming	14	Participants recognized and/or described in-game moments where they conformed to the demands of Wong Enterprise, which negatively impacted the environment.
Game Dilemma	12	Participants recognized and/or described how their in-game situation was challenging, specifically how their characters faced an ill-structured problem with no clear solution.

The theme “NPC” (standing for non-playable character) was used to identify when students noted the procedural scaffold in the game. Specifically, it was used when the student noted an NPC interaction made them realize their effect on the environment. This could be both a positive or negative effect on the environment. For example, one student talked about how someone working for Wong Enterprises asked them to burn down a section of the forest to clear it. Another student mentioned that negotiating on behalf of the

locals with Wong Enterprises at the end of the game opened their eyes to the environmental implications of the deal they were negotiating.

The theme of "environment" is made up of two significant observations of the data. First, students across the dataset could consistently list or describe in-game actions that harmed the environment. I.E., burning a section of forest, cutting down trees, or planting palm oil trees. Specifically, students were able to correlate how these negative actions impacted their envirometer and populameter. The second observation within this theme was that students could also list or describe in-game actions that supported the environment. I.E., planting the correct tree or refusing to burn a forest section down. Specifically, students also correlated how said actions impacted their envirometer and populameter. Moreover, the implemented metacognitive meter scaffolds and their connection to in-game actions were present throughout the entire dataset.

When coding for the theme "Ethics", we were looking for any mention of a poor ethics or actions that could be perceived as immoral that led to a negative environmental impact. Examples of these actions would be taking bribes from Wong Enterprises, lying for them to cover their tracks, or anything that seems morally wrong to do. One student wrote "I really realized that the decisions I was making were wrong at the end when the elders and family members were speaking and the corporation was trying to bribe me." Students connected these poor ethics with both the metacognitive (meters) and the procedural (NPC interactions) scaffolds. They noted that the specific interactions with multiple NPC's assisted them in realizing these morally wrong actions they were taking. Furthermore, the changes of the meter scores after they took the morally wrong actions aided in them realizing the actions effects on the environment and the people surrounding them.

The theme "Conforming" was used to identify when students took actions in the game to align themselves with Wong Enterprises, whether they knew it was morally wrong or not. An example of this would be when one student said, "If I folded to the big business and their greediness my populameter would have risen while the environmeter would of gone down." Students most often associated the metacognitive scaffold with this theme. They noted that conforming to the desires of Wong Enterprises (such as exploiting the environment, brokering one-sided deals, etc.) would increase their popularity score, but decrease their environmental score. Additionally, NPC interactions (the procedural scaffold) with people such as Wong Enterprise representatives and village leaders showed the students the effects of their actions when they conformed. This means the students were able to recognize their actions when conforming to the interest of Wong Enterprise directly effected both the metacognitive and procedural scaffolds. However, they were not able to correlate these actions with the overall learning goal of the game.

The theme "game dilemma" is centered around the instances in which students identified the main high-order learning objective of the game, which is that their in-game situation was challenging and was an ill-structured problem with no clear solution. An example of a student response coded in this theme was, "I did not like how it felt like there was no way to win because both of my meters kept going down until about halfway through the game." This particular student was able to recognize the main learning objective of the game due in part to their interaction with implemented metacognitive meters and the procedural NPC scaffolds. The conclusion was drawn after analyzing these students' survey responses that connect their experience with the scaffolds and their understanding of the main learning objective, a pattern shared amongst the other codes in this theme.

Based on the qualitative themes, we conducted a correlational analysis of the themes. Using Fishers Exact Test, we found that Game Dilemma related to several of the other codes based on students who identified aspects related to NPC interactions, Environmental Impacts, and Conforming to Wong Enterprises, see Table 2.

Table 2: Fishers Exact Test Results Showing Relationships amongst Theme to Game Dilemma. **significant

	Log Odds Ratio	P
NPC	-1.120	<0.001**
Environment	0.417	0.008**
Ethics	-0.067	0.651
Conforming	0.828	<0.001**

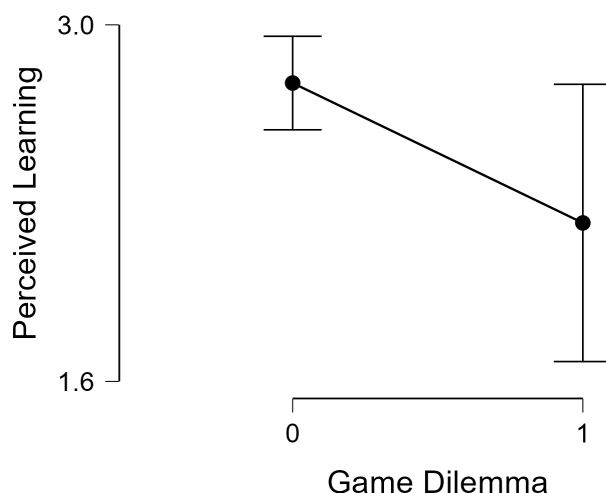


Figure 3: Plot showing relationship between student self-efficacy (through Perceived Learning) to identifying the Game Dilemma

Lastly, we completed a Mann-Whitney U Test on students who identified the Game Dilemma to see if there was a relationship to their perception of learning within the game. A significant difference ($U=348.000$, $p<0.05$) was found between students who identified the Game Dilemma and those who did not when they rated their self-efficacy towards learning. Additional tests were checked for Enjoyment, Perceived Guidance, and Perceived Usefulness, however, none were significant.

4. Discussion

4.1 Metacognitive Scaffolds

The importance of in-game scaffolding for learning also reveals the issues with different types of scaffolds. Learner attention in an exploratory space can easily shift focus to where feedback is most prominent, or with adult learners focusing on what appears most relevant. With metacognitive scaffolds built into the user interface of the game, students fixated on the scaffold, forcing it to become the primary goal of playing. This led to fewer students achieving the learning objective, to realize the ill-structured nature of the problem, the *Game Dilemma*. The intention of the metacognitive scaffold was to indicate player performance through each action. At the level of actions carried out by the players, the relationship was partially well understood. However, without attention being directed towards other features within the game, the nature of the problem became less evident. This idea that scaffolding distracted from the game, or another aspect of the game was similarly found in the study conducted by Charsky and Ressler (2011). In their study, the use of an external concept map to play the game took precedent over playing the game, resulting in lower posttest scores.

4.2 Conceptual Scaffolds

Conceptual knowledge is the foundation to generating higher-order activities, yet scaffolds representing such changes should be more overt to avoid being overshadowed within a game environment. The singular conceptual scaffold of signage proved to be too passive for learners to recall in their reporting. While in the gameplay session, the scaffold may have been used to indicate based on player actions involving Wong Industries that the company was slowly taking over. However, students were unable to recognize this scaffold in their recall of the complex situation they faced. Passive scaffolding serves many purposes to provide simple yet visual cues like signs for navigation. However, within a system like a game, players may lose the need for simple cues (Ding et al, 2009) while they are directed to complete quests and explore with purpose.

4.3 Procedural Scaffolds

Learning the rules of a system through procedural guidance is necessary in any learning system. While very prominent, procedural scaffolds became supports for the metacognitive scaffolds. The direction from NPCs and pop-up indicators along with a tutorial level that embedded the narrative goals created a unique challenge for the students. In switching focus to filling out the two meters, the actions guided by different NPCs within the game became more important in establishing an individual way to progress in the game. Strategic or procedural scaffolds are important in assisting metacognitive scaffolds with learner guidance and self-planning

within board games (Hou, 2022) which suggests that the reduced role the procedural scaffolds had within the data may follow a similar need in digital games.

4.4 Achieving Learning

Learning with the various scaffolds designed into the game was achieved in parts. The larger learning objective, to develop an understanding of the ill-structured nature of the problem faced by farmers, was not solvable with a single solution. While fewer students were able to identify this dilemma, the ones who did scored their perception of learning lower than their peers who were not successful in recognizing the learning objective. This suggests that engaging with the problem presented in game may be dependent on the scaffolds. Specifically, the choice of scaffolding types to incorporate could play a large role as passive or static type scaffolds have indicated mixed results over the more adaptable scaffold types (Chen and Law, 2016). The decision to select scaffolds associated with knowledge types (e.g. metacognitive, conceptual, and procedural) provided potentially too many similar options for the problem. Though Chen and Law (2016) were successful in blending the more adaptable to static scaffolds, the type of game and learner age group may also be a consideration when the focus is on engagement with a higher-order problem.

5. Conclusion

Scaffolding is fundamental to active learning environments and comes in many forms. For GBL, it is necessary to consider the type of scaffolds incorporated to avoid confusion and keeping students from feeling outside of the structuring of their learning. The second iteration of Stories of GeoFarmer illustrated unique challenges in the use of in-game scaffolds. Learner attention as well as meaningfully situating when a game occurs play a large role in the success of performance for higher-order objectives. Future work needs to be done on better understanding the nuances of different in-game scaffold types and what external factors may play a role in diminishing the intended effect.

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