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Baba is Hint - Designing a Scaffolding Guidebook for Game-Based Learning

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Abstract: Providing guidance to learners navigating a game-based learning environment requires walking a fine line between encouraging progression toward learning goals without disrupting playful engagement in the game. In this paper, we present a scaffolding guidebook developed for tutors to provide guidance in game-based learning environments that encourages exploration of the problem space and solving puzzles without disrupting engagement. Scaffolding strategies were coded and categorized from *Baba is You* gameplay recordings of 13 middle school and 12 undergraduate students and then situated based on guiding principles from relevant literature into a scaffolding guide. Here, we describe this guidebook and its development, which could provide educators with important tools that can help their students progress through game-based learning environments without interfering with engagement.

Introduction

Traditional Scaffolding

Scaffolding in traditional learning environments helps learners develop skills just outside their current independent ability level, provides just-in-time support that is tailored to the individual learner, is faded as the learner becomes competent (Belland, 2014; Wood et al., 1976), and can be distributed across people and material tutors (Puntambekar & Kolodner, 2005). Scaffolding is most effective when the task is in the learner's zone of proximal development (ZPD), or just outside of their current ability to accomplish independently (Vygotsky, 1978; Wertsch, 1985). As such, scaffolding can be ineffective when below the ZPD because those skills are already developed, or when above the ZPD as the learner doesn't have the prerequisites to engage in a more difficult task.

Scaffolding in Game-Based Learning

In game-based learning environments, scaffolding is often embedded into the game itself. Progression is supported by game design techniques that effectively scaffold the player through the game - the first few levels of the game are typically easier, walk the player through how to use their abilities, and give safe spaces for the player to practice. Further, throughout the game, players are given constant and immediate feedback, and can often look up relevant information just-in-time and on demand (Gee, 2003). The affordances of the digital environments are a further source of scaffolding by constraining the environments and guiding learners' attention and progress (Bumbacher, Salehi, Wieman & Blinkstein, 2018; Salehi, Keil, Luo & Wieman, 2015). Some game-based learning environments are also administered with a teacher or tutor nearby to help further scaffold (Melero, Fabra, & Blat, 2011). Barzilai and Blau argue that this can often take the form of helping the student through the game when they're stuck or helping to evoke transfer of the embedded learning goals through supplementary materials. However, they find that while increasing transfer and overall learning gains, these materials have been shown to detract from the engagement of the game if given prior to play (2014). This sequence may frame the game as more of a school activity than a play activity, taking away from the player's natural playful engagement. This demonstrates how scaffolding during game-based learning is a useful, albeit delicate tool to use; educators must walk a fine line between letting the student experience the engagement of the game while ensuring that they are productive in their learning goals.

Productive Failure

One strategy employed in the learning sciences that can shed some light on this problem has been coined as "productive failure" (Kapur, 2008). In traditional instruction, students are given direct guidance concerning a novel problem and then asked to practice the newly acquired skill until it's mastered (i.e., productive success). In productive failure learning spaces, students are initially asked to solve a novel problem with little guidance before an instructor then builds on the strengths of students' approaches to articulate the solution. During initial problem solving, students encounter many impasses and failed attempts, but are also encouraged to reflect on the deep features of the problem. After directed instruction, productive failure students exhibit stronger near and far transfer compared to students in a traditional instruction sequence (Kapur, 2008). However, little research has been done on how to keep students engaged as they encounter these impasses and experience this failure. This model of learning is a good theoretical model for how to create a game-based learning scaffolding guide as it encourages students to explore the problem space naturalistically to come to a robust understanding of the underlying embedded concepts.

Flow

A well-discussed aspect of games is how developers strive to balance game content between challenge and skill level. Often seen through the lens of Csikszentmihalyi's concept of flow (1990), the game must be challenging enough that the player is not bored and simultaneously not too difficult so that the player becomes anxious or frustrated. While this has not always been taken to mean that the player is kept in an actual state of flow, it still rings true for how game developers attempt to generally balance the difficulty of their games to keep the player engaged, interested, and not overly frustrated from this anxiety. However, it is extremely difficult to create a difficulty curve in a game that all players will follow identically. Some players will find some areas of the game more challenging than others, effectively increasing the relative difficulty for that player. This can result in the individual player experiencing frustration as they move out of the "flow channel" towards anxiety. This points to how scaffold in game-based learning could be developed: assisting in keeping the player within a good balance between being challenged yet not frustrated. Well-designed games do a good job of increasing the difficulty level of the game as the player's skill progresses, however, assistance may be needed to prevent the player from getting so frustrated that their desire to continue is disrupted. This presents an opportunity to help guide players when this point of frustration approaches while still pushing and developing their abilities.

Hints

One of the tools that game developers use to alleviate frustration is through hint systems. Hints have been defined as information designed to stimulate recall or inference by conveying information, pointing to information, or providing a directed line of reasoning (Hume et al., 1996). However, O'Rourke et al. (2014) found that hints were associated with a *decrease* in performance in an educational game, suggesting that providing hints during play can disrupt player engagement. This shows the difficulty of providing hints in a way that doesn't detract from the enjoyment of the game (by making it too easy and thereby boring) and keeping the player from getting too frustrated when stuck (Drey et al., 2021). However, Drey et al. also argue that these hint systems, provided at the right frequency, can help maintain player flow through challenging content. Games provide a unique medium that affords players to explore and experience failure, and a good hint system should support this exploration.

Need for Scaffolding Guidance in Game-Based Learning Environments

Scaffolding is an important tool to help students overcome challenges in their learning and should be designed to encourage the student to develop the tools they need to solve the problem themselves in the future (Cazden, 1991). Video games are often designed with natural scaffolding that helps the player understand how to progress through the game and keep players engaged. However, as this in-game scaffolding cannot be consistently tailored to the individual, we argue that it can miss the mark of when the player is in real need of guidance - providing too little when they're frustrated, or too much, resulting in boredom. Game-based learning environments are often part of distributed scaffolding systems, through both embedded game-design scaffolding as the player progresses, and supplementary personalized guidance from a tutor when individual players feel frustration from getting stuck. However, when and how to present this guidance remains under-investigated.

Research Context

Data for this project was generated during a larger line of inquiry intended to investigate how youth solve puzzles in video games. During this work we recruited 13 middle school and 12 undergraduate students via online fliers to play the popular puzzle game *Baba is You* (Teikari, 2019). For one hour per week for three weeks, participants were asked to join a Zoom meeting with a researcher while they played so that sessions could be recorded for later analysis, and so that the researcher could answer any questions they had or help the participant when required. This resulted in 39 play sessions and approximately 50 hours of video-recorded data. Participants were also asked to verbalize their thinking as they played so that researchers could understand better how they were attempting to solve the game's puzzles. Researchers were instructed to primarily remind the participant to verbalize their thinking while playing and to help the participant only when needed. As the researchers were not told how to provide support, these interactions highlighted the different naturalistic ways tutors approached providing players with guidance.

Current Study

The purpose of this study is to (a) investigate how tutors naturally provided scaffolding to individuals navigating a puzzle game, (b) categorize these scaffolding strategies, and (c) inform these categories with principles of productive scaffolding from the existing literature to begin to lay the groundwork for a guidebook of effective game-based learning scaffolding techniques. Here, we provide the rationale for the development of these scaffolding strategies and how they were situated in the guidebook.

Methods

To identify naturally occurring scaffolding strategies in *Baba is You* gameplay, two of the authors randomly chose times to begin watching each play session video until a moment the tutor provided guidance was identified. Each moment was descriptively annotated relative to context, perceived intent, and impact of tutor support. These descriptive annotations were member-checked (Lincoln & Guba, 1985) with the tutor who provided the support to ensure accurate description and identification of scaffolding. Next, we categorized scaffolding based on the perceived aims of the guidance. This was done until saturation was achieved and no new categories of scaffolding were identified. Initial categories were discussed and refined until a consensus was reached, resulting in four distinct scaffolding strategies and six scaffolding tools that were used throughout our data. To situate these categories, we consulted relevant literature on scaffolding best practices in classrooms, game-based learning environments, and providing hints. From this literature review, we identified core principles that helped align the scaffolding approaches - encouraging problem space exploration, alleviating frustration, encouraging players to be inside their zone of proximal development, and stimulating inferences.

Results

Context

This guidebook aims to help tutors who are supporting students navigating through a game that is being used for educational purposes. This does not mean these principles should not be used for games designed for entertainment, as such games can also be used for educational purposes to teach students about concepts inherent to those games for entertainment. In fact, this guidebook was created from gameplay created from tutors helping players navigate through a puzzle game designed for entertainment, Baba is You. However, the principles of the guidebook are relevant to any scenario in which a tutor aims to help a player progress through a game being used for educational purposes. To be effective, the tutor must understand the mechanics of the game, but does not need to know the solution to every puzzle the game presents, as they will be focused more on nudging players to find those solutions themselves. This will require that the tutor understand the context in which the player might need help, so they will need to watch what the player is doing, and importantly the goals they are attempting to complete to give effective scaffolding. While it would be most effective for a tutor to give a single player all of their attention to ensure they understand the context that the player is in when they require scaffolding, this is not always possible as tutors likely have other students to guide. As such, we recommend that the tutor be able to pop into the student's gameplay to see where they are and what they are attempting from time to time, and to ask the player what they're trying to do before giving advice.

Distal goals

We define the player's distal goal as the overarching goal that the player is attempting to accomplish to complete the level. This is the goal that they are consistently moving towards through their actions. While this could be considered to be "to win", we shift this focus to what the player must do to win as this is the highest level the tutor can intervene. Importantly, this goal does not need to be the intended solution of the level - while the player may not be initially successful in completing the level, if they are exploring the mechanics of the game, they are developing an understanding of those mechanics which can lead them to the puzzle's solution autonomously. It is also important to note that a player can be acting in the world without an explicitly stated distal goal. For example, the player can be exploring the mechanics without the intent of solving the puzzle. In this case, as the player is still exploring even without a distal goal, they are still progressing their knowledge of the game's mechanics and should be encouraged to do so autonomously.

For example, a player might be in a level that has a river of lava separating baba from the flag. The player's distal goal might be to get past the river of lava to touch the flag and win. The steps they take to do so would be their proximal goals.

Proximal goals

The player's proximal goals are the smaller goals that progresses the player closer to their distal goal (i.e., the steps the player needs to take to complete their distal goal). As previously mentioned, a player can pursue proximal goals without having a distal in mind. In these cases, the player is exploring the mechanics of the level often just to see how they interact, and as such we would consider their distal goal to be to understand the mechanics available in the level. This approach is also useful in allowing the player to determine the possible actions available to them within a problem space. In both of these scenarios, the player is actively exploring the mechanics and the problem space but are not directed to any distal goal of completing the level.

In our example, to get past the lava the player might make a plan to push the lava out of the way. To be able to do so, they have to change the property of the lava so that it can be pushed. They might also have to get to an area that allows them to do so. Each of these would be their proximal goals on the way to their distal goal of getting past the river of lava.

Strategy

Strategy refers to how the player is attempting to use the mechanics of the game to achieve their proximal goal.

In our example, the player might be trying to create a rule that states LAVA IS PUSH. This strategy would be using the game mechanics that allows you to affix properties to objects by creating rules and the push mechanic that allows you to move objects.

Mechanics
Mechanics refer to a particular game object of importance (i.e., how an individual mechanic can be used to create a strategy).

In our example, some of the mechanics that the player is using are lava, push, and creating rules.

Guidelines
To ensure players are allowing the game to create an engaging experience, these strategies are designed to be used only when the player no longer has any identified avenues to explore, and not as prescribed activities or prompts to ensure their progression. As such, these strategies should be used at the tutor's discretion under the following guidelines:

1) Scaffolding should enable exploration of the problem space
These strategies were designed to follow a "productive failure" approach to learning. As such, they are designed to enable players to explore the problem space with little initial support. Scaffolding should not be introduced if the tutor deems that the player is actively exploring the mechanics of the level to develop an understanding of how they work and interact, even if the player's strategy will not be ultimately successful in completing the level. This allows the player to come to a robust understanding of how the problem space is constructed and how all its elements interact without detracting from the engagement that the game experience provides. Additionally, allowing exploration of the problem space enables the tutor to understand the player's current ability in the game, a necessary step in producing scaffolds contingent on the player's ZPD.

2) Scaffolding is only provided when the player is no longer exploring the problem space
These scaffolding strategies are intended to be introduced only when a player begins to show signs of running out of ideas to explore. The signs the tutor should look for include the player verbalizing that they don't know what to do, the player is not taking actions in the game that show exploration of a mechanic, and their body language suggests they are not actively engaged in thinking about the level's mechanics. For example, if the player is performing the same actions repeatedly, has verbalized that they don't know how to complete their goal, and does not appear to be actively thinking about the mechanics they are using, then the tutor should intervene at the appropriate level to encourage further exploration. Players should be permitted to explore the problem space without interference, if possible, so that they can come to the solution by their own volition. This design aims to allow the player to navigate the game in an open and playful way, letting the game-based scaffolding guide the player as much as possible, thereby allowing players to navigate and experience the game without interference. Even when the tutor has identified that scaffolding intervention is warranted, waiting until the player has had sufficient time to think is crucial. Tutor scaffolding should be used only when the player is showing signs of being stuck and that the challenge of the level is starting to push the player out of the "flow channel" and into anxiety/frustration that may hamper engagement.

3) Sequentially increase the focus of scaffolding to promote agency
Scaffolding should also provide the lightest touch required to alleviate player frustration (O'Rourke et al., 2014; Wauck & Fu. 2017). While use of these strategies is contextual and at the tutor's

discretion, it is recommended that strategies are considered sequentially to avoid providing a hint that detracts from the player's enjoyment of completing the puzzle themselves. By considering scaffolding that encourages the player to switch their distal goal first, they are more likely to figure out how to accomplish that goal themselves. If the player has a promising distal goal but is out of ideas to pursue it, then providing scaffolding that encourages the player to switch their proximal goal will allow them to figure out the steps they need to take themselves. If the tutor provides a hint that is too specific, they can spoil the engagement that comes from solving the puzzle. Presenting the scaffolding with the lowest amount of specificity that encourages the player to think about the elements of the puzzle in a new way can effectively lead them towards solving the puzzle themselves and maintain this engagement.

Scaffolding Strategies

Here we lay out four broad scaffolding strategies that emerged during our coding of the data, including an example of each strategy. Paired with each, we draw on guiding principles from the literature to recommend when these strategies should be used and what general aim each affords.

Re-approach distal goal: tutor encourages the player to think about the overarching goal they need to achieve to complete the level.
Use: If the player is not progressing because their distal goal is misaligned with the solution.
Aims: Encourage the player to think about and change their distal goal.
Examples: "What are you trying to do in this level?"

Re-approach proximal goal**:** tutor encourages the player to think about the steps they need to take to progress in the level.
Use: If the player is not progressing because their proximal goal does not align with how they are progressing through the level.
Aims: Encourage the player to think about and change their proximal goal.
Example: "What steps do you need to take to complete the level?"

Re-approach strategy: tutor encourages player to think about the mechanics they need to interact with to achieve their proximal goal.
Use: If the player is not progressing because their strategy does not align with their proximal goal.
Aims: Encourage player to think about and change their strategy.
Example: "What else could you do with those blocks?"

Focus on a mechanic: tutor encourages player to think about a specific mechanic of importance.
Use: If the player is not progressing because of a misunderstanding of a specific mechanic important to their strategy.
Aims: Encourage player to think more deeply about a mechanic they are using in their strategy.
Example: "What does that block do?"

Soft Scaffolding Tools

We also identified six general tools that tutors used that could help alleviate frustration across a range of situations. We include these as "soft scaffolding" tools that can be used generally to help alleviate frustration and progress throughout play.

Think aloud: Tutor asks the player to verbalize their thinking.
Use: If the player is getting frustrated thinking through the puzzle they are currently trying to solve.
Aim: Encourage the player to talk through their thinking to focus on the logic of their strategy.
Example: "Tell me how you think this is going to work."

Comradery: Tutor positions themselves as a peer to relieve player frustration. Use: If the player is generally frustrated with the problem-solving process.
Aim: Encourage the player to feel like you are working together to lessen frustration. Example: "What do you think we need to do in this level?"

Reinforcement: Tutor encourages the player to think deeply about an action after they've progressed in the level.
Use: If the player has made progress but does not seem to understand how the mechanics interacted to produce the result.
Aim: Encourage the player to think more deeply about the mechanics they used to progress. Example: "Tell me how you solved that."

Emotional regulation*:* Tutor acknowledges and normalizes the player's failure.
Use: If the player is expressing frustration after failing their task.
Aim: Increase player motivation through acknowledgement of difficulty.
Example: "Don't worry, this one is really hard. Keep working at it!"

Co-play: Tutor actively contributes ideas or strategies as if they were playing.
Use: If the player is struggling to come up with ideas to test out.
Aim: Suggest ideas for what the player could work on as if you were playing the game. Example: "What if we tried putting this block over with those ones?"

Reminder**:** Tutor reminds player of something they may have forgotten.
Use: If the player has seemingly forgotten an interaction that they have already used in a previous part of the game.
Aim: Remind the player about the tools that they have previously identified.
Example: "Don't forget, you can undo your move."

Discussion

This study presents the development of a guidebook of scaffolding strategies to be used to help guide players through game-based learning environments. We designed this guidebook through observing the natural scaffolding that took place throughout 39 play sessions of *Baba Is You*. Categorizing this scaffolding illuminated common strategies used to encourage players to focus on different levels of thinking including distal goals, proximal goals, and specific mechanics. Consulting the literature across scaffolding in classrooms, in game-based learning environments, and hints, we found that the strategies could be aligned in a way that could alleviate frustration and still allow players to maintain the excitement of completing a puzzle on their own. This scaffolding guide approaches helping players navigate through a puzzle game through the lens of a productive failure environment. This approach encourages players to explore the problem space and try new strategies even if they will not succeed. This allows the player to come to a more robust understanding of the mechanics that create the puzzle that will help the player progress and solve the puzzle. This allows the player to navigate the intrinsic scaffolding built into the game and figure out the puzzles as well as they can independently. If this built-in scaffolding proves insufficient and leads to frustration, the player can then receive scaffolding from a tutor.

This scaffolding approach can be seen in relation to Csikszentmihalyi's (1990) theory of flow and how it relates to video games. Game developers consistently aim to encourage players to stay at a level of challenge that matches their increasing skill level as they progress through the game (Juul, 2013). Developers employ game design techniques that can be considered as game-based scaffolding to guide the player through the game. However, developers cannot create puzzles that work equally well for all players - some players will inevitably get stuck at times others figure out the solution with ease. This scaffolding guidebook provides a way for tutors to help alleviate the frustration that comes with these spikes in difficulty by providing scaffolding techniques that keep players in the "flow channel", encouraging players to focus on their distal goals, proximal goals, and specific mechanics. In effect, this provides a tool which helps push players back down into the flow channel if they start to feel the challenge level pushing them into the anxiety zone, while allowing the natural game scaffolding to progressively increase the challenge of the game, keeping them from falling into the boredom zone (Figure 1).

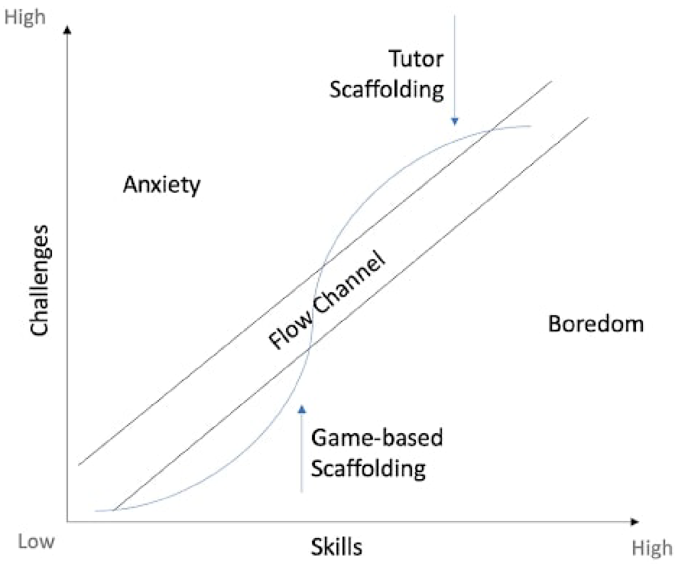

Figure 1
Effects of Scaffolding in Relation to Flow (adapted from Csikszentmihalyi, 1990)

Limitations
This paper shows the rationale behind the development of this guidebook but does not present its efficacy. The next steps we plan to take include training researchers with this guidebook to use the scaffolding tools with participants navigating through a puzzle game. This will allow us to evaluate the strengths of these scaffolding strategies and tools, giving further insights into how we can best present scaffolding in a game-based environment.

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