Decoding Player Behavior: Analyzing Reasons for Player Quitting Using Log Data from Puzzle Game Baba Is You

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Abstract. In this paper, we study the reasons for unsuccessful level completion in *Baba is You*, a puzzle-based video game, using Epistemic Network Analysis (ENA). The study focuses on student cognition, which can be inferred through an in-depth examination of in-game actions and decisions recorded in log data from complex, contextualized game levels. To build epistemic networks around video game log data, chronological log records of player levels were set as codes. Epistemic networks of player actions paired with interpretive examinations of the context of each level offer insights into why students may quit levels in *Baba is You*. Findings suggest that (1) inadequate acquisition of knowledge from the previous level, (2) premature focus on winning at the earlier stage without engaging in distributed exploration and experimentation, and (3) over-reliance on undoing actions may all play a role in unsuccessful level completion. The goal of this work is to support the design of future game-based interventions that can address context-specific quitting and foster student engagement within the game.

Keywords: Digital Game · Quitting Behavior · Epistemic Network Analysis · Automated Codes · Interaction Log

1 Introduction

In the field of education, digital games, whether commercial or serious, have emerged as useful tools for creating engaging learning experiences for students [23, 29]. However, to support persistence and learning, game designers often face the challenge of creating a level of difficulty that is "pleasantly frustrating" - challenging players without discouraging them [10]. When the difficulty level is high, some players may encounter setbacks and manage them in productive ways [4], while other players may quit due to inadequate understanding of the concepts or mechanics, ineffective puzzle-solving strategies, or lower levels of academic achievement [8, 15, 24]. Given this context, a comprehensive understanding of the drivers of player quitting is crucial for promoting more universally effective and engaging learning environments in games, informing timely interventions, and preventing frustration-induced stopout.

In this paper, we investigate what patterns of in-game decisions and actions precede unsuccessful completions within the syntax-based problem-solving game *Baba is You*.

Specifically, we focus on players' spatial reasoning decisions through game log data, with cognition inferred from their interactions within the complex, contextualized game levels. To achieve this objective, we visualize player interactions using Epistemic Network Analysis (ENA) [21], a quantitative ethnographic technique that can visualize patterns of connections between concepts or behaviors in large-scale, complex datasets. Our work builds on prior research that has used epistemic networks of in-game log data to explore players' in-game actions and understand how learning and decision-making emerge (e.g., [14]). Our work examines students' actions contextualized by the unique attributes of specific game levels, with the goal of examining specific reasons for players quitting related to that particular level.

The research questions guiding this study are: 1) How do patterns of game behaviors differ between students who quit and those who do not, and 2) What insights can these differences provide us regarding why students quit? Through this research, we hope to contribute to the understanding of how players interact with complex puzzle games and provide insights into how game designers and educators can create effective and engaging learning environments.

2 Literature Review

Digital games provide students with access to immersive and authentic learning experiences in specific content areas in STEM [26], offering opportunities for developing critical skills such as problem-solving [18], decision-making [5], and communication [3]. High-quality game design has been linked to the development of intrinsic motivation in players around targeted content areas. This, in turn, can be valuable to learning, as motivated learners are more likely to engage deeply with the content, persist through challenges, and seek out additional learning opportunities on their own [1, 9].

Given the learning benefits associated with games, understanding player cognition in games has become an increasingly popular research topic among scholars from diverse fields such as psychology [2], neuroscience [6], and computer science [27]. One specific area of interest revolves around inferring players' cognitive processes based on their in-game behaviors. For example, Hou [11] found that learners' behavior and exploration patterns while they are playing in the simulation game *Perfect PAPA II©* may often be influenced by cognitive processes such as memory retrieval and alignment. Owen and colleagues [20] constructed prediction models based on features of behavior patterns to detect both unproductive persistence and wheel spinning behaviors, which are often associated with frustration or reduced motivation, among students using the adaptive game-based learning system *Mastering Math*. Similarly, Leduc-McNiven et al. [17] utilized player action data to infer cognitive processes such as strategy learning, retention, and recall in a serious game *WarCAT*. These examples demonstrate the potential of game-based activities as a means of investigating cognitive processes.

Our work aims to contribute to the existing research by providing insight into students' cognition within the puzzle-based video game, *Baba is You*, leveraging the fine granularity of interaction logs. A growing body of work within the QE community has demonstrated the utility of interaction logs for studying fine-grained behaviors across different contexts and over time in human-computer interactions. For example, Karumbaiah et al. [14] used clickstream data from the educational game *Physics Playground* to analyze students' quitting behavior. Karumbaiah and Baker [13] extended applications of ENA to investigate affect dynamics when students solve problems on ASSISTments, while Wu and colleagues [28] used ENA to explore the metacognitive aspect of math learning in the context of self-regulated learning (SRL) in CueThink. Drawing on the insights gained from previous studies, we studied the relationships between the events logged by the game *Baba is You* to determine the possible reasons for quitting in learning games, as well as to provide insights into phenomena such as how learners apply concepts across levels and players' exploration patterns in the game between those who complete the game and those who quit.

3 Context

In this study, we explored and compared patterns of in-game actions and behaviors enacted by players who quit and complete levels in the commercial video game *Baba is You*. In the game, players complete levels by solving complex puzzles that involve manipulating push-able text objects on the game board to create, break, or modify rules [25]. The rules consist of three distinct types of text objects: nouns (e.g., BABA, WALL, and FLAG), operators (e.g., IS and AND), and properties (e.g., WIN and STOP). When the three text objects are aligned vertically or horizontally, the rule becomes activated, assigning the specified property to the noun associated with said rule. For example, as shown in Figure 1, the rule WALL IS STOP signifies that walls possess the property of obstructing players from traversing through them. However, if any of the three text objects constituting the rule are displaced from their original position, the rule becomes nullified, rendering walls ineffective in stopping players or possessing any properties.

The primary objective of each level is for players to create a winnable rule, i.e., [OBJECT] IS WIN, and guide the player-controlled character, typically Baba—a sheep-like avatar—to touch this winnable element. Across levels, the player is presented with unique combinations of obstacles and rule sets that can be manipulated in different ways to reach the win state. Participants have the option to 'undo' their actions or 'restart' the level entirely at any time, thereby reverting the puzzle to its original state.

Despite the absence of hints or scaffolding by design, the early levels of the game serve as a platform for players to familiarize themselves with the game mechanics as well as the conditions necessary to complete a level. For example, in level 1 (See Fig. 1), players can gradually deduce that pushing any text object within the rule WALL IS STOP would break the rule and render the walls permeable. Once the player passes through the previously blocked wall, they can establish the rule FLAG IS WIN and then touch the flag object in order to complete the level. At the onset of each level, players may not see viable paths to victory, necessitating exploration of each level's context to devise, test, and apply possible winning strategies.

Fig. 1. Design of the first level, *Where Do I Go?,* in *Baba is You*

For this study, we examined player quit behavior on two levels. *Lonely Flag* (level 02 in the sub-world Rocket Trip) was selected as a context in which players must apply iterative, cross-level knowledge to achieve success (and avoid quitting), while *Walls of Gold* (level 09 of the subworld Temple Ruins) serves as a later-game example of a level with a more complex win state, in which quitting is more common.

Level *Lonely Flag* and the preceding level *Empty* are purposefully linked together by the designer to challenge players to learn and apply the new concept in the game. In the first level (*Empty)*, players are introduced to the special noun referred to as EMPTY, which functions differently depending on its usage. Assigning an object with the property of EMPTY causes that object to permanently disappear from the game board. However, when EMPTY is used as a noun, such as in EMPTY IS FLAG, it transfers all unoccupied cells on the game board to the object that EMPTY represents (in this case, the FLAG). Players can use EMPTY as either a property or a noun to solve the level *Empty*. However, in the next level, *Lonely Flag*, players must use EMPTY as both a property and a noun in order to win. Given the relative rarity of multi-use nouns such as EMPTY in the game, player use of EMPTY as a noun in the prior level (though not required for success) may prime players for subsequent completion of *Lonely Flag.*

Fig. 2. Design of the level *Lonely Flag*. Players must first create DOOR IS EMPTY (property) to eliminate surrounding doors and then form EMPTY IS BABA (noun) to transform empty spaces into BABA entities that automatically reach and touch the FLAG object.

The level *Walls of Gold* (See Fig. 3) does not introduce new objects but is a game level with multi-stage win states designed to challenge players to demonstrate a comprehensive understanding of multiple game elements. Similar to other advanced levels in the game, *Walls of Gold* offers a more intricate challenge that requires players to explore and experiment with different strategies to find a solution.

Fig. 3. Design of the level *Walls of Gold.* Players must first create the rule WALL IS ROCK to transform the walls into pushable rocks to break free from the obstruction. Subsequently, they must configure the rules ROCK IS WIN and ROCK IS YOU, using the YOU text situated in the top-right corner of the screen, and complete the level through the transitive property.

4 Method

This work is part of a larger research project that seeks to improve our understanding of how players solve problems in *Baba is You*. Prior studies have examined how players notice deviations (situations when the outcomes of their goal-oriented actions deviate from their expectations), generate causal explanations, and adjust their problem-solving strategies accordingly during gameplay [7]. Participants in these studies were recruited through email advertisements circulated through local middle schools and around a large public university in the United States. Once individuals were enrolled, they installed a copy of the game on their device and were instructed to play for approximately one hour per week over a period of three weeks. As players completed their gameplay sessions, data was uploaded to a secure server and preprocessed for analysis. The complete dataset consisted of player interactions from 184 middle-school and college students, with ages ranging from 10-31. The sample consisted of 49% identifying as male, 43% as female, 5% as non-binary, and 3% preferring not to respond.

The log data was structured to provide (1) player ID, (2) keyboard inputs as the player navigated through game space, (3) the timestamp of each move, (4) any changes made to the game state (e.g., creation or breaking of a rule), and (5) location of each object in x:y coordinates. Using this data, our team was able to track player interactions with specific rules and objects of interest, which were relevant to measuring player behaviors. For this paper, we draw from the complete dataset, but sample 11 players who played *Lonely Flag* and 26 players who played *Walls of Gold* - the levels best suited for our analysis. Although we observe variation in player ages across both levels, our analysis using Pearson's correlation coefficient revealed no statistically significant correlation between age and performance (r = 0.12, p = 0.45). In other words, the findings provide no evidence to suggest that older players consistently outperform younger players or that younger players are more prone to quitting.

4.1 Participant Sampling

Out of the 11 players who attempted and passed the level *Empty*, 7 players applied EMPTY as a property in the prior level, while 4 players opted to use EMPTY as a noun in their win condition. Out of the 11 players, 8 were able to correctly apply EMPTY as both a noun and property in the subsequent level, *Lonely Flag*, while 3 quit before identifying a solution. It is possible that using EMPTY as a noun during the first level can ultimately assist players in completing the second level. Therefore, to examine the potential influence of players' prior learning on their subsequent performance, we analyzed the click-stream data in *Lonely Flag* and categorized the 11 participants into "Noun" and "Property" groups based on their strategies in completing Level *Empty*, and into "Quit" and "Complete" groups based on their success whether they succeeded in solving *Lonely Flag*. The outcome of the categorization yielded three exclusive groupings, specifically denoted as "Complete (Property)", "Complete (Noun)", and "Quit (Property)", with 4, 3, and 4 instances, respectively, in Figure. 4. These groups were used as unit variables to generate ENA visualizations.

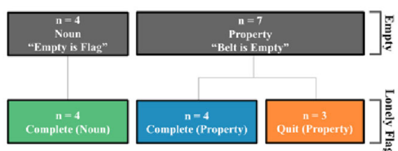

Fig. 4. The categorization of players in *Empty* and *Lonely Flag*

In the second level, *Walls of Gold*, 15 out of the 26 players (we excluded two players out of the initial 28 players from the analysis so that the remaining players have adopted the same solution) were able to successfully complete the level, resulting in a quitting percentage of 42.30%. To complete this level, players must achieve a two-stage goal of first breaking the wall and then forming winning conditions for victory. Therefore, to study player's activities and the cognitive processes involved during different stages of gameplay, we segmented players' activities into "Part-1" when players must free themselves from the walled prison, and "Part-2" when players exit to the exterior where they can access the final win state. Players are also organized into "Quit" and "Complete" groups. The detailed decomposition of the players is represented in Figure 5. One player in the Quit group did not manage to enter the second stage. These groups were used as unit variables to generate ENA visualizations.

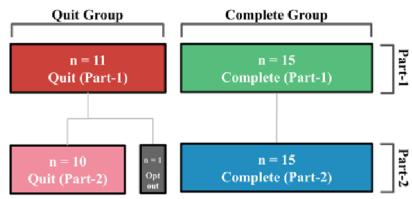

Fig. 5. The categorization of players in *Walls of Gold*

4.2 Epistemic Network Analysis

Our investigation focuses on identifying the differences in the interrelations of events between players who completed a game level and those who did not, seeking to explore the reasons why some players may quit, while others may persevere. To achieve this objective, we generated epistemic network visualizations to map the patterns of different player groups' behaviors over time in each level.

To gain a more comprehensive understanding of players' cognitive processes, we used different unit variables for each level, owing to their distinctive structural attributes. Unit variables for *Lonely Flag* grouped player data into Complete (Noun), Complete (Property), and Quit (Property) groups. Unit variables for *Walls of Gold* grouped player data into Complete (Part-1), Quit (Part-1), Complete (Part-2), and Quit (Part-2) groups. The secondary unit variable for each model groups the play data by individual-level attempts. Since our objective is to analyze the interrelated actions and choices of individual players in the game, we generated three types of codes based on pre-coded events in the click-stream data for each level, as outlined below:

1. *Undo*: the reversal of the previous action
2. *Add <Rule>*: the creation of new rules in the game. For example, the activity of forming the rule "WALL IS ROCK" is coded as "Add <Wall is Rock>"
3. *Remove <Rule>*: the removal of an existing rule in the game. For example, the activity of breaking the rule "WALL IS ROCK" is coded as "Remove <Wall is Rock>"

The numbers of codes generated for each level are as follows: *Lonely Flag* (30 codes; 15 from rule creation and 14 from rule removal), and *Walls of Gold* (30 codes; 15 from rule creation and 14 from rule removal).

Other features of network structures remain consistent for both examinations. We segmented the data based on each player's attempt at a level (conversation variables: Player ID, Restart), as we consider each player's single attempt a suitable unit for the analysis of interconnected behaviors. Given the frequency of the selected logged events in *Baba is You*, with an average rate of one event every two seconds, we used a relatively wide moving window size of 10 actions. This window size corresponds to an average gameplay duration of 20 seconds, providing an appropriate temporal context to identify relevant co-occurrences of events. This decision was informed by the fine-grained nature of the event logs, which require a relatively high moving window size compared to many previous ENA analyses [16, 19, 22].

In generating epistemic networks for each level, we utilized the ENA Web Tool, which transformed the temporally sequenced one-hot encodings of the events into a network representation, allowing us to identify relevant patterns of co-occurring events that can provide insights into the temporarily interrelated behaviors of the players during gameplay.

5 Results

5.1 Lonely Flag

We used epistemic network visualizations to map the interconnection of events in the level *Lonely Flag* among players classified into the above-mentioned categories (See Fig. 4). Figure 6 presents the difference networks between Complete (Noun) and Quit (Property) groups (left) and networks between Complete (Noun) and Complete (Property) groups (right). In constructing the epistemic networks, we included all 30 codes, but excluded edges with weights less than 0.1 and labeled only the nodes related to the use of EMPTY to enhance visual clarity. Along the X-axis (dimension 1 after means rotation), a two-sample t-test assuming unequal variance showed that group Complete (Noun) was statistically significantly different from group Quit (Property) with an effect size of d=2.26 (t(4.34)=-3.19, p=0.03*), and from group Complete (Property) with an effect size of d=2.28 (t(3.93)=-3.41, p=0.03*). The difference is not statistically significant between Complete (Property) and Quit (Property) (t(4.99)=0.22, p=0.84), which precluded the need for a difference network. In the following section, we explicate two key themes that have shed light on the transfer of learning across levels, as well as the underlying factors that account for quitting behaviors.

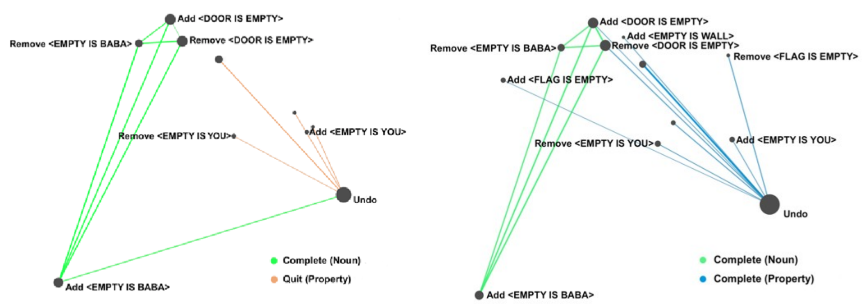

Fig. 6. The difference networks between Complete (Noun) and Quit (Property) (*left*), and the difference networks between Complete (Noun) and Complete (Property) (*right*)

Undoing as a Persistence Strategy for Property Groups

The networks indicate a contrast in the association between Undo and other game events among players in the Property and Noun groups. Specifically, we found a stronger connection between Undo and other events in players from the Property groups, whereas fewer connections to Undo were observed in the Noun group. This behavioral pattern, characterized by the formation or breaking of rules without meaningful connections to other events other than Undo, indicates repeated attempts to solve the puzzle without making progress that aligns with the objective. For example, believing that EMPTY is key to solving the puzzle, players in the Property group may repeatedly form EMPTY IS YOU, and immediately Undo their actions after realizing that Baba is no longer a controllable character.

One possible explanation for this behavior is the phenomenon of "wheel spinning," which occurs when players engage in prolonged gameplay without achieving significant progress, leading to frustration and ultimately, giving up on the level [20]. On the other hand, the fragmented actions and frequent backtracking of progress in the Property group during their exploration of the level may also reflect a lack of confidence in their decisions or an inability to comprehend the extent to which their current actions contribute to achieving ultimate success. In contrast, the Noun group demonstrates a more cohesive approach to leveraging game objects to solve the level, with their actions being more logically connected. These patterns may signify greater clarity in comprehending the connection between their actions and the win condition, leading to a more efficient and successful level completion.

Transfer of Learning Across Levels

Successful completion of *Lonely Flag* required the creation of the DOOR IS EMPTY, which causes the surrounding door to disappear, testing the player's ability to use EMPTY as a property. In the difference network shown on the right in Figure 6, the Complete (Property) group displayed a stronger association between the Add <DOOR IS EMPTY> action and the Undo, signifying the transfer of knowledge on the application of EMPTY as property across levels. Similarly, the Complete (Noun) group demonstrated robust connections between Add <DOOR IS EMPTY> and several other in-game activities, whereas no connections were found concerning the addition or removal of EMPTY IS DOOR. This indicates players who employed EMPTY as a noun in the first level were also able to perceive it as a property and deduce the method of making the doors disappear in the subsequent level. However, the Quit (Property) group did not exhibit such strong associations, indicating that players in the Quit (Property) group may have encountered difficulties in transferring their acquired knowledge to subsequent levels, which could be indicative of a possible lack of understanding of the concept of EMPTY and its variable applications. They were, however, more likely to add and remove the rule EMPTY IS YOU, but these actions would have no effect on the game board since YOU is a property rather than an object. Thus, it is unlikely that these exploratory actions would have facilitated learning of the EMPTY concept as a noun for players in the Quit (Property) group, which might be one of the reasons that they did not ultimately complete this level.

To conclude the second part, players must formulate the rule EMPTY IS BABA using EMPTY as a noun. As evidenced by the networks, a much stronger connection was observed between Add <EMPTY IS BABA> and other actions in the Complete (Noun) group as compared to the other two groups. Players who used EMPTY as a noun in the first level demonstrate a more extensive comprehension of its dual nature as both a noun and a property. Conversely, those who opt for an alternative strategy may be more likely to experience difficulties when solving the second level, even if they ultimately achieve success. Those players transferred knowledge about the use of EMPTY as a property from the previous level, which may have had an unintended negative impact on their performance. Their attachment to what they had learned previously, rather than considering new approaches, might have hindered their progress to some extent.

The results of our analysis indicate that there was no statistically significant difference between the two Property groups, and their networks showed a high degree of similarity. Nevertheless, when each Property group was compared to the Noun group, there were discernible statistical and visual differences. This suggests that variance in player actions in the second level primarily results from the strategies used in the first level, namely, the decision to use EMPTY as either a Property or a Noun. The choice may reflect their comprehension of the newly introduced concept. However, players in the Complete (Property) group may compensate for a lack of knowledge by engaging in a more distributed exploration of various activities in the second level, particularly those related to using EMPTY as a noun, such as Add <EMPTY IS WALL>, thus successfully completing this level. By contrast, the Quit (Property) group tended to explore fewer possibilities in the game. A lack of exploration and a possible inability to transfer learning from the previous level to the current one could be the reasons why those players ultimately quit the current level.

5.2 Walls of Gold

We proceed to present the findings for the second level, *Walls of Gold*. Figure 7 shows the difference networks between Complete (Part-1) and Quit (Part-1) (left) and networks between Complete (Part-2) and Quit (Part-2) (right). We created epistemic networks based on all 30 codes, but excluded edges weighted less than 0.05 to improve visual clarity. The networks for both stages illustrate notable differences in both the cognitive processes and behaviors of players who completed the level versus those who quit. Along the X-axis, a two-sample t-test assuming unequal variance showed that group Complete (Part-1) was statistically significantly different from group Quit (Part-1) with an effect size of d=1.00 (t(21.74)=-2.52, p=0.02*); Complete (Part-2) was statistically significantly different from group Quit (Part-2) with an effect size of d=1.72 (t(22.01)=4.39, p<0.01*). Our results reveal three themes related to players quitting at different stages of the gameplay for *Walls of Gold*.

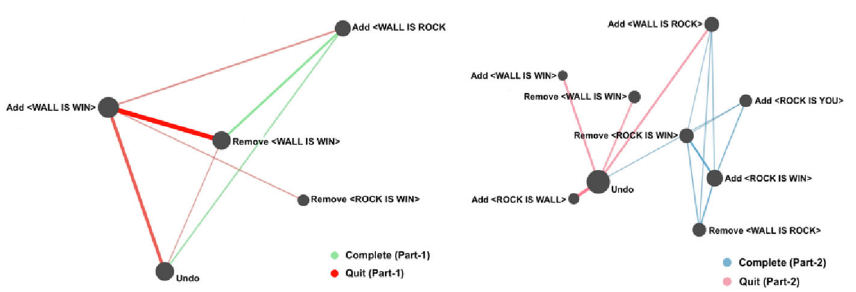

Fig. 7. The difference networks between Complete (Part-1) and Quit (Part-1) (*left*), and the difference networks between Complete (Part-2) and Quit (Part-2) (*right*).

Undoing as a Persistence Strategy for Quit Groups

Networks in Figure 7 suggest that players in the Quit groups exhibit a greater tendency to undo their actions during both stages of gameplay compared to players in the Complete group, a pattern also seen in *Lonely Flag*. Specifically, in the first stage, stronger associations were found between Undo and Add <WALL IS WIN> and Remove <ROCK IS WIN>. In the second stage, stronger associations were found between Undo and Add <WALL IS WIN>, Remove <ROCK IS WIN>, and Add <WALL IS ROCK>. The Complete group used the undo command less frequently in relation to other actions throughout the level, especially in the second stage where only two events are associated with Undo. As discussed in the analysis of *Lonely Flag*, favoring undo may indicate wheel-spinning or lack of confidence during the gameplay. The results may serve as a starting point for understanding the use of undo as a strategy for persistence as players explore actions to determine and eventually achieve the win condition.

Win-Seeking Behavior

As shown in the left network in Figure 7, the associations between the activity Add <WALL IS WIN> and several other game actions were stronger for players in the Quit group. In contrast, we do not observe correspondingly strong associations between win-related events and other actions for players in the Complete group, with the exception of the connection between Remove <WALL IS WIN> and Add <WALL IS ROCK>, which are crucial preconditions for escaping the enclosed wall prison. These findings suggest that players who quit this level exhibit a stronger inclination to engage directly and repeatedly with the WIN object throughout gameplay, perhaps without first establishing a comprehensive understanding of the level design. Players who completed the level, on the other hand, are less likely to engage with the WIN object repeatedly; for instance, within this group, three players formed win-related rules on only two occasions throughout their gameplay, while two players engaged WIN solely at the point of level success. These patterns suggest that players who complete the level may have a more holistic strategy for success in mind at an earlier point in their play. As a result, these players are less likely to engage in hasty attempts to achieve victory before overcoming the initial level obstacle. The results suggest that the broader strategies adopted by players (e.g., engaging directly with WIN without a broader strategy) may play a key role in determining whether they successfully complete the level or quit. Players who prioritize understanding the level mechanics and solutions before attempting to win are more likely to complete the game, while those who prioritize the WIN without the backing of strategy and an understanding of level complexity may, somewhat paradoxically, be more likely to quit.

Strategic Abandonment and Object Fixation

The results of our analysis also suggest that players in the Quit group tend to repeat actions from the first stage of the game, prior to breaking free from the walled prison, even as they transition to the second stage, where these actions are less relevant for success. For example, in the Quit group, we observe a stronger association between the activities Remove <WALL IS WIN> and Add <WALL IS ROCK> and Add <WALL IS WIN> in the first stage of the level. In the second stage, these activities remain more connected to other actions for the Quit group but are now more strongly associated with Undo. This suggests that these players are repeating patterns of actions that led to recent success again with an unclear or incorrect strategy in mind for how these actions will lead to level completion (this combination of actions cannot result in a win). While such actions could indicate player exploration and "testing" of the level mechanics with the goal of eventually identifying a winning strategy, repeated attempts could also be associated with frustration or confusion, such as the case of one player who attempted "Add <WALL IS ROCK>" 72 times before ultimately quitting the level.

In contrast, the networks for the Complete group in both stages exhibit marked differences from one another. Unlike the Quit group, the Complete group was more likely to strategically abandon objects (as evidenced by their weaker associations to part 1 actions) that previously helped them progress in the level, which suggests greater flexibility in their thinking to identify innovative strategies for success. As indicated by the number of visible connections to each action, players who eventually quit this level engage in slightly more explorations in the beginning stage of the game, with these activities persisting throughout the second stage of the game. In contrast, students who successfully solve the level initially start with limited actions and progressively expand their search for possible actions to win the level.

6 Discussion

The aim of this research paper was to explore possible reasons for players quitting in the puzzle-based video game *Baba is You*, by analyzing and visualizing player interactions using Epistemic Network Analysis (ENA). In constructing the network, we used codes from the automatically generated events recorded in the game's interaction log and applied epistemic network analysis to gain further insights into the players' cognition. The analysis was conducted on two game levels that (1) require cross-level knowledge to achieve success and (2) feature a more complex win state with higher rates of quitting.

Our analysis suggests that insufficient acquisition of specific knowledge components from previous levels (e.g., application of spatial reasoning mechanics such as the use of objects as nouns or properties) may be an important reason why players quit. Moreover, we found that players who prematurely engage with the final win condition without prerequisite strategies for success, who reapply objects or rules they initially encountered when they no longer lead to success, and who engage in less distributed exploration and experimentation may be more likely to quit. In both levels we analyzed, we observed that students who quit are more likely to engage in repeated or redundant actions, which may indicate a lack of confidence in their actions or a limited capacity to understand how their current actions contribute (or don't contribute) to level completion. These findings highlight the potential benefit of targeted interventions that address the specific knowledge gaps and gameplay behaviors that may contribute to a player quitting. With this in mind, initiatives to design on-demand or tailored experiences, prompts, and supports for students could prove valuable. Leveraging metrics or behavior patterns such as those identified in our analysis, educators and game designers can better identify at-risk players and provide them with targeted interventions that help to address their individual needs and promote sustained engagement. In the case of *Baba is You*, cognitive scaffolds could be built into the *Lonely Flag* level that shows learners who only used EMPTY as a property previously that it can also function as a noun. Targeted hints could encourage more experimentation and exploration of the game mechanics in *Walls of Gold* for players who over-engage with the WIN object. Finally, an expansion of support for players resorting to Undo as part of level engagement, through hints or tutorials, could help players pass disengaging roadblocks. Though the primary aim of this work is a preliminary examination of player quitting behaviors, a limitation of this iteration of the work is the smaller sample size of students, especially for the level *Lonely Flag*, which only had 11 players. Additionally, it is also important to note that other external factors beyond players' interactions, and social or cultural influences [12], may also impact students' motivation and confidence levels, leading them to potentially disengage from the game. Future research should study a broader range of levels and students to understand what aspects of the findings generalize, and account for other external factors that could impact player retention with the game.

These results suggest that the application of Epistemic Network Analysis (ENA) to investigate player behavior in video games and other learning environments holds promise for enhancing our understanding of how students learn and interact with complex systems. Utilizing automatically generated events as codes, ENA provides a window for examining constructs related to student learning, engagement, and experience, not only in games but also in other learning contexts featuring well-designed event-based logging mechanisms. Although exploratory in nature, the insights obtained from this study could potentially inform the development of targeted interventions that address specific gameplay behaviors and knowledge gaps in games like *Baba is You*, ultimately fostering sustained engagement and success. Future research will expand the scope of this inquiry by examining additional samples and contexts to further comprehend in-game learning experiences and behaviors. Our hope is that this applied example could inspire further research that explores log data as a source of rich, contextualized discourse for quantitative ethnographic investigations.

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