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Charithram: A Serious Game for Enhancing Historical Learning and Critical Thinking Through Interactive Gameplay

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Abstract
Serious games have evolved as a tool for transformation. They blend education and entertainment together to create exciting learning experiences. This paper presents the development and application of Charithram, a first-person puzzle adventure game that aims at teaching history and inculcating problem-solving skills. It focuses on the Mughal period and engages players in puzzles and environmental storytelling while encouraging critical thinking. The study focuses on the ability of serious games to overcome limitations in traditional educational methods by encouraging active learning, critical engagement, and interdisciplinary knowledge acquisition. In examining the integration of gameplay mechanics with educational methodologies, this paper underscores the broader implications of serious games as an innovative approach to interactive and meaningful education.
Keywords: *Assets creation; Blender; Puzzle-based learning; Serious game, Unreal engine 5.*

1. Introduction
In the modern era, serious games have emerged as an effective medium bridging the gap between education and entertainment as seen in [2], creating opportunities for interactive learning, as observed in [7] for educating medical students of CABG surgery. By bringing together gameplay mechanisms and educational content, these games encourage experiential learning, active participation and engagement. Traditional methods of learning history focuses on rote memorization making learning quite tedious and less engaging to students. The aim of this study was to develop a serious game that integrates historical learning and problem solving into an engaging gameplay experience where players engage with historical events while solving puzzles that test their critical thinking and reasoning skills. The game proposed in this paper highlights the important events in Indian history and teaches players about the same in an effective way. We were inspired by the works as seen in [3], in teaching Malay heritage, and wanted to create something similar but for Indian history.

The game also involves different puzzles within the gameplay environment to promote critical thinking. These puzzles are designed in such a way that they test the problem solving ability of the student while actively educating them about history. The game utilizes multiple game motivators and design principles proposed in the study conducted by [1] such as curiosity, challenges, rewards and storytelling. The development of the game was done in Unreal Engine 5 using Blueprint scripting which served as a versatile tool for creating interactive puzzles and providing enhanced environmental storytelling. Custom assets were created using Blender 4.3 which would be incorporated into the game and would also serve as rewards to students as they progress through the game. The game involves different kinds of puzzles that test the verbal, numerical and deductive reasoning of the players. The difficulty level of the puzzles will increase as the student progresses through the game. Keeping an engaging yet fair experience, can further expand on

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the field of digital education, a field which has observed a lack of interest or care from students, as seen in [8].

2. Methodology

2.1. Game Design Framework

In alignment with the study's objective to create an engaging educational experience for students, the game was designed to simultaneously build critical thinking skills as well as teach Indian history. To ensure faster deployment and easy development, we formulated the level design as a modular structure. We divide the levels as various rooms and each room can be classified as a block where the puzzles are located. In addition to the puzzle, there will be clues that will help guide the player to solve these puzzles. After solving these puzzles, the players can proceed to the next level. The rooms are designed in such a way that they can be created individually and later combined together to form a level. This modular nature of the room allows for parallel development which helps speed up the development process.

2.2. Tools and Technologies

The Unreal Engine (UE5) from Epic Games was chosen as the primary development platform because of its powerful capabilities and user-friendliness. The two main scripting languages that are available in UE5 are C++ and Blueprint Visual Scripting. Defining classes and objects to generate gameplay features is the primary function of the object-oriented visual programming system Blueprint. As Blueprint is a low code, node based system allowing developers to create gameplay mechanics without extensive programming knowledge, thereby reducing syntactic errors during development. Moreover, UE5 offers game templates that offer readymade structures for common game components. With UE5's advanced graphical capabilities, the game achieves a visually appealing and immersive experience, essential for engaging players in historical content. Blender is an open-source 3D modelling and animation software. It is widely regarded as the most efficient, feature-rich and open source solution for 3D computer graphics by experts and 3D artists. We used Blender to create visual assets for the game. Blender's integration with Unreal Engine 5 also facilitated a smooth workflow for importing assets, ensuring high quality visual representations of historical content within the game.

2.3. Gameplay Mechanics

The game employs a standard First-person-perspective (FPP) approach allowing seamless navigation and interaction. The player can navigate using W, A, S, D keys, jump using the spacebar and interact with the puzzles and clues using the E key. Additionally, the players can also examine historical artifacts (Figure 1(A) and 1(B)), manipulate environmental objects to uncover hidden clues. We used various kinds of puzzles that were integrated into the game some of which include: To motivate the players and enhance engagement, we also implemented a reward system. Each level will contain hidden historical artifacts, collecting them increases the player's overall score. The game records the time taken to complete each level, encouraging efficiency and mastery. The game features a notification system designed to assist players by providing real-time instructions and feedback throughout their gameplay experience. This system guides players on fundamental controls such as movement, interaction, and puzzle-solving mechanics, ensuring a smooth learning curve.

2.4. Game Flow

The game flowchart (Figure. 2) represents a structured progression of gameplay in Charithram, beginning with the Start node, leading players into various Events where they can collect artifacts and increase their score. From events, players proceed to Puzzles, which are categorized as either Critical or Non-Critical. If a player encounters a Critical Puzzle, they must succeed to proceed; failure results in a Respawn and a retry. In contrast, Non-Critical Puzzles allow players to investigate, but failure does not halt progression. Upon successfully solving puzzles, players move forward to the Final Puzzle, which serves as a key challenge before completing the level. If the player succeeds, they reach the Level Complete stage, followed by an Evaluation phase. After evaluation, they enter the Hub Area, where they can make additional choices, such as selecting a different game theme. Players then decide whether to continue to the Next Level or Quit the game, which leads to the End.

3. Implementation

3.1. Asset Creation

The creation of assets for Charithram was done using

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Blender, a versatile 3D modelling and animation tool. The process began by launching Blender and opening a new file. A reference image was added to serve as a guide for the asset's shape and other properties. To form the base structure of the model, a mesh cube was inserted into the scene. To create the desired shape, the reference image was shaped using vertices. For cylindrical and other similar structures, only half of the image was traced to ensure symmetry. After the tracing was completed, the reference image was removed and the traced lines were converted into a mesh (Figure 3(A)). Finally, the Edit Mode was used to fill in the structure. For cylindrical shapes and other similar structures, the spin option in Blender was used to complete the shape (Figure. 3(B)), creating a fully realized 3D model ready for use in the game. Figures 3 (A) to (C) shows the modelling process of a vase that was used in the game. The reference for the vase was inspired from Indian history(Figure. 3(C)).

3.2. Level Creation

The level creation process for Charithram began by opening Unreal Engine 5 (UE5) and selecting the "First Person Template", which provided a pre-built platform with basic actions once initialized. Next, a new level was created by selecting the "New Level" option from the File menu and an empty level template was selected. Through the Environment Light Settings menu, the environment settings, including atmospheric light, volumetric fog and other lighting effects were added. Once the environment was set, the screen entered selection mode, allowing objects to be moved in all other directions. In order to create the necessary objects, the selection mode was switched to modelling mode, where a grid like reference appeared. A cube grid was used to define the dimensions of objects, and blocks could be created using the "E" key and deleted using the "D" key. To create slopes, the "Z" key was used, which set four dots at the corners of the selected area, and by adjusting two dots along the same horizontal axis, a slope was formed. The Figure (4(A)-4(C)) displays the layout of one of the levels in the game. It shows a large area with different puzzles that the player needs to solve to progress through the game. In order to add textures, we used Quixel Bridge to search for the desired textures and download them in required quality. Later, the textures were applied by dragging and dropping them into the material section of the object's attributes in UE5. The size and orientation of each asset was adjusted using the options in the top right corner of the screen, ensuring that the level was visually cohesive and aligned with the game's theme.

3.3. Puzzle Mechanics

Charithram incorporates a variety of puzzle mechanics to challenge and engage players, each designed to encourage critical thinking and problem solving. As inferred from [4], problem solving provides a motivation factor for playing a game. The basic implementation of some of the puzzles is given as follows: Maze puzzle: Players must navigate a maze to reach the exit. Instead of being created by hand, the maze was created using an Unreal Engine 5 add-on (Maze Generator, from Fab.com). Players can plan their route and reduce annoyance by using the top-down perspective provided before they enter the maze. Once inside, players must navigate their way out of the maze using their surroundings and memories. We utilized a modular maze element from Fab Marketplace(reference). Using selection mode, we created the maze plan, positioning walkways and walls to create a balanced challenge. In order to guarantee seamless player navigation, we then modified collision settings. Additionally, we enhanced lighting and ambient effects to enhance immersion. We used subtle contextual cues, including distinctive textures and markings on particular walls, to offer direction. Painting puzzle: This puzzle uses two sets of paintings, one of which is altered and the other of which remains intact. The player's goal is to rotate the straight paintings to fit the altered set (Figure 5(A)). The paintings are placed side by side so that players can more readily compare and alter them. Every artwork is a static mesh that, when manipulated, rotates 90 degrees along the y-axis. A position variable cycles between four states (0, 1, 2, 3), with 0 denoting the default position, to track its orientation. The puzzle master receives a signal when a painting is in the proper orientation. A false signal is sent in the event that a painting is rotated out of alignment. Platform puzzle: In this puzzle, the players must cross a series of square platforms suspended above a deep pit, some of which are unstable and collapse when stepped on (Figure

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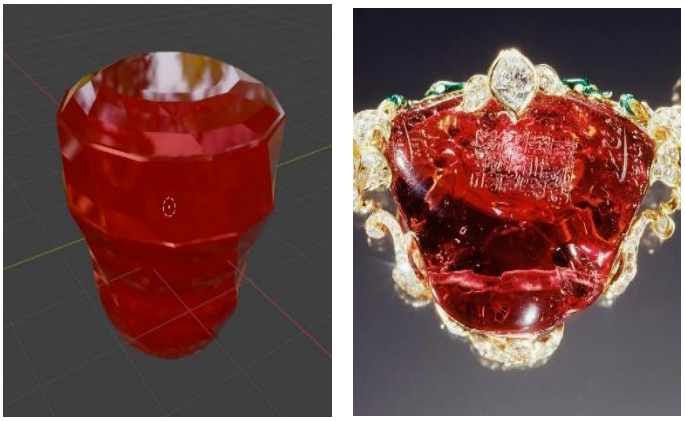
5(B)). The players need to find the correct path by deducing a riddle like a poem. The safe platforms get slightly lower when stepped on, and are achieved through a collision that applies a minor transform along the z-axis. Initially, the unstable platforms have physics disabled but upon interaction, enable gravity and physics simulation causing the platform and the player to fall down. A trigger box at the bottom of the pit detects when the player falls, displaying a game-over screen with a retry button to respawn at the puzzle's start point. Explorer puzzle: This puzzle revolves around exploration and deduction. The players are asked a query, the answer to which is given as hidden clues in the level (Figure 5(C)) The clue can be presented in various ways- either as an interactive object like a manuscript or as part of the environment, such as wall inscriptions. The puzzle is linked to a mechanism, like a door, which generates an interactive widget upon interaction. The widget contains a question and textbox for input (Figure 5(D)). When a wrong answer is given, nothing happens, a right answer triggers an event, such as the door opening via location transform. This encourages the player to closely examine their surroundings and think critically to progress.

3.4. Notification and Reward System

Notification system: Using dynamic on-screen text messages, the notification system can provide the player with vital information. These notifications appear in the top-left corner of the screen and are triggered by the player's interaction with particular trigger boxes (Figure 6). Each trigger box's message, duration, and execution type can be altered, giving you flexibility in how relevant messages are delivered. We created a widget with a text element encircled by a black border in order to demonstrate this technique. Auto-wrap was enabled to format the text into multiple lines for easier viewing. Initially hidden, this widget only becomes visible when its blueprint function is invoked.The trigger blueprint consists of a trigger box and variables for setting the notification message, duration and whether it should execute only once. Repetitive messages are prevented when the single execution variable is enabled. Once the specified duration is reached, the notification automatically disappears. Reward system: The rewards system encourages players to explore and solve puzzles more efficiently using a simple timer and score system (Figure 7). No matter the framerate, the timer's accuracy is guaranteed because it is a float variable that increases in accordance with delta seconds, which measure the interval between frames. Within the level, players are alerted to secret artifacts that can be collected to boost their score. These objects can have different looks while still having the same functionality because they are implemented as blueprints with customizable meshes. A player's score rises each time they gather an artifact. The player is shown how much time they have spent on the level and how many artifacts they have acquired out of all the ones that are accessible. Players can try collecting all the artifacts using the retry button, and after they are happy with their performance, they can go on to the hub area. Figure 1 shows A Historical Artifact (A) Inspired from The Timur Ruby (B). Figure 2 shows The Game Flow Diagram of Charitham, Figure 3 shows (A) The Mesh Model of Vase (B) The Complete Model of Vase and (C)The Reference Image for the Vase, Figure 4 shows (A) A Passage to A Locked Gate with Clues in The Game Environment. (B) A Model of the Level. (C) A Model of a Cave Environment, Figure 5 shows (A) The painting puzzle. (B) The platform puzzle (C) Exploratory puzzle- the clue. (D) Exploratory puzzle- the query. Figure 6 shows The Notification System (At The Top Left Corner), Figure 7 The Reward System with A Timer

3.5. Figures



(A) **(B)**

Figure 1 A Historical Artifact (A) Inspired from The Timur Ruby (B)

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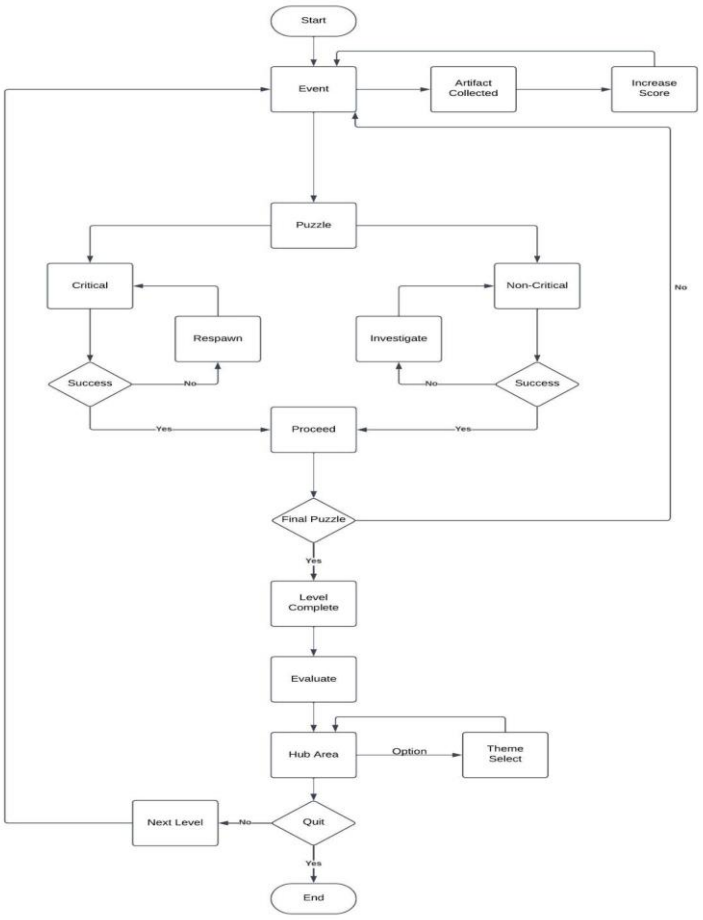
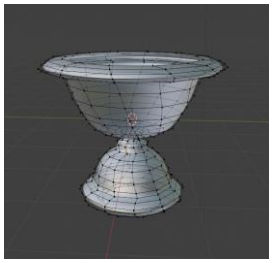


Figure 2 The Game Flow Diagram of Charitham



(A)

(B)

(C)

Figure 3 (A) The Mesh Model of Vase (B) The Complete Model of Vase and (C)The Reference Image for the Vase

(A)

(B)

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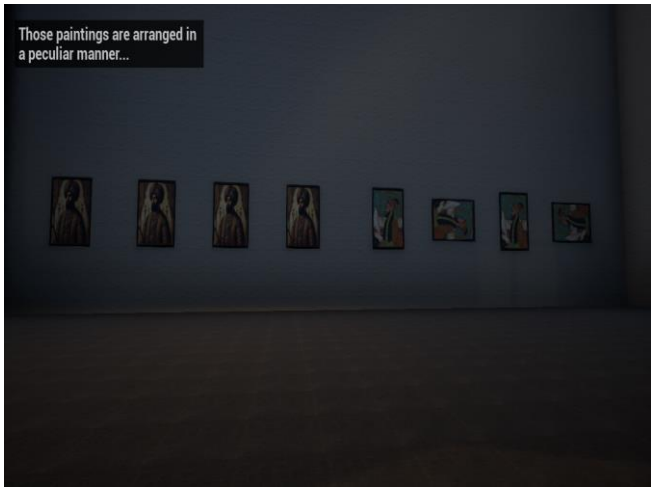
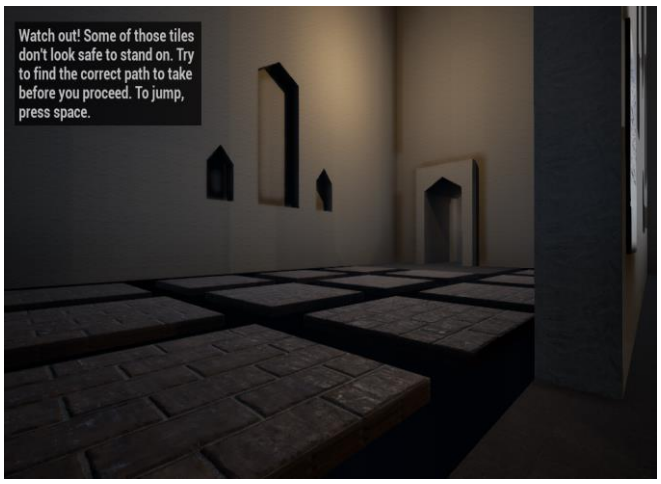
(C)

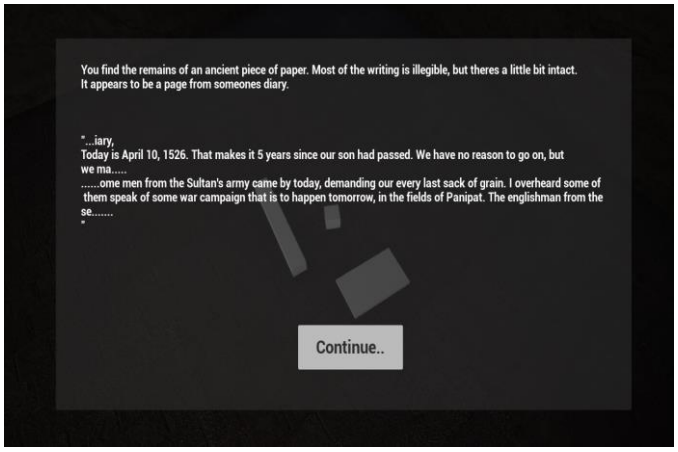
Figure 4 (A) A Passage to A Locked Gate with Clues in The Game Environment. (B) A Model of the Level. (C) A Model of a Cave Environment



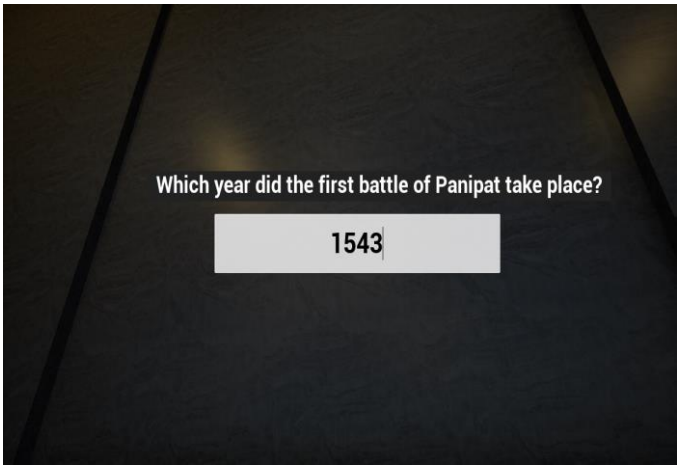
(A)



(B)



(C)



(D)

Figure 5 (A) The painting puzzle. (B) The platform puzzle (C) Exploratory puzzle- the clue. (D) Exploratory puzzle- the query.

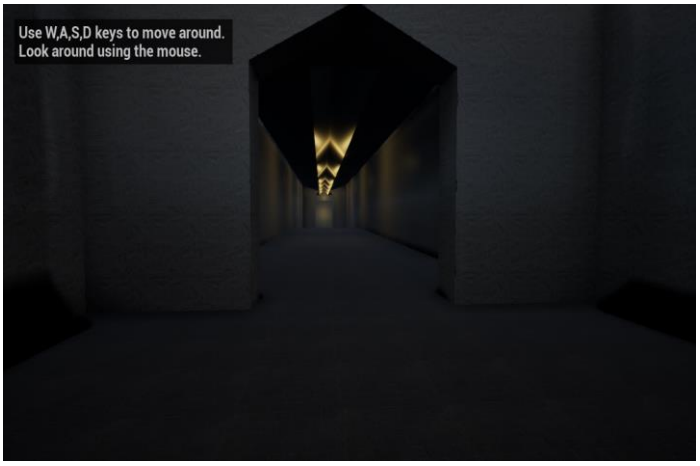


Figure 6 The Notification System (At The Top Left Corner)

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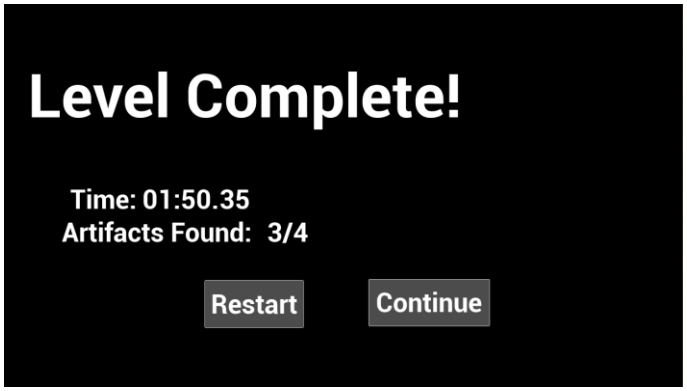

Figure 7 The Reward System with A Timer

4. RESULTS AND DISCUSSION

4.1. Results

The objective of this study was to evaluate the effectiveness of Charithram, in enhancing historical knowledge and critical thinking skills of students in an engaging and interactive manner. The experiment was conducted with a sample of 20 people, comprising both males and females. The participants played the game and answered a structured questionnaire to test their retention, engagement and overall satisfaction. We observed that all 20 participants found the game engaging and immersive, describing it as "interesting to play". About 80% of participants were able to answer all the questions correctly showing strong knowledge retention. Participants reported that they gained historical knowledge stating that the game-based approach made learning more enjoyable. However, 20% of the participants found the puzzles to be hard but were still able to learn historical information in an effective manner.

4.2. Discussion

The findings of this study demonstrate that the Charithram game serves as an effective educational tool for enhancing historical knowledge and critical thinking skills. High engagement, strong knowledge retention and positive feedback from the participants highlight the potential of serious games in learning. About 80% of players successfully answered the fact-based questionnaire after playing, suggesting that the interactive aspect of the game has enhanced knowledge retention compared to traditional rote memorization strategies. 20% of players reported that some of the puzzles were challenging, despite the fact that most of them enjoyed the game. This suggests that the difficulty should be adjusted to balance challenge and accessibility. These results, similar to that seen in [5] and [6], corroborate the notion that gamification in the classroom can increase student engagement, improve retention, and make learning more enjoyable. Future research may expand to more historical periods and integrateVR technologies for increased immersion and realism.

Conclusion

This study reinforces that the Charithram game is an effective educational tool for enhancing historical knowledge. The results demonstrated that 80% of participants successfully retained key historical facts, reinforcing the game's potential as an alternative to traditional learning methods. 20% of participants found the puzzles to be challenging indicating a need for difficulty adjustments. Despite this the overall satisfaction with the game was high., suggesting that game-based learning can be a valuable tool for historical learning and beyond.

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