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IMPROVING WORK FACILITIES THROUGH LAYOUT CHANGES TO BOOST CHECKER PRODUCTIVITYPDF

Fahri Fadli, Hernadewita Hernadewita

THE ROLE OF MAGNESIUM OXIDE (MGO) FILLERS IN ENHANCING ANTIBACTERIAL AND MECHANICAL PERFORMANCE OF POLYLACTIC ACID (PLA)-BASED BONE SCAFFOLDS FABRICATED VIA FUSED DEPOSITION MODELLING (FDM): A REVIEWPDF

Imam Akbar, Hasan Basri, Muhammad Yanis, Ardiansyah Syahrom

SMART SENSORY TABLE DESIGN: INTEGRATING ERGONOMICS AND SUSTAINABILITY FOR BETTER LABORATORY PERFORMANCEPDF

Riko Ervil, Deri Kurniadi, Saputra Saputra, Tasya Salsabila, Faras Andika Firdaus

DEVELOPING A SUSTAINABLE INVENTORY MANAGEMENT FRAMEWORK FOR THE FMCG INDUSTRY: AN ISM-MICMAC APPROACHPDF

Clara Anne, Inaki Maulida Hakim

VENDOR SELECTION STRATEGY FOR NON-ASSET-BASED TRUCKING START-UPS IN INDONESIA USING A SUSTAINABILITY-ORIENTEDPDF

Clara Bella Adriana, Inaki Maulida Hakim

A FAITH-BASED ESG DIGITAL INTEGRATION MODEL FOR ISLAMIC DIGITAL ENTERPRISESPDF

Izzun Khoirun Nissa, Alfian Rifai, Syamsuddin Syamsuddin, Sulistyowati Sulistyowati, Yuni Safitri

INVESTIGATION OF THE REMOVAL EFFICIENCY OF ADVANCED OXIDATION PROCESS (AOP) ON DYE AND CHEMICAL OXYGEN DEMAND (COD) OF SYNTHETIC TEXTILE WASTEWATERPDF

Aung Thet Ko, Wibawa Hendra Saputera, Yogi Wibisono Budhi

DATA-DRIVEN INVENTORY OPTIMIZATION FOR CRITICAL HOSPITAL DRUGS: INTEGRATING ABC–VEN CLASSIFICATION, DEMAND FORECASTING, AND (R,S,S) POLICIESPDF

Fransiska Sianne, Dina Natalia Prayogo

EXPLORING ENVIRONMENTAL STORYTELLING VIDEO GAMES AS EDUCATIONAL TOOLS FOR PROMOTING HISTORICAL TOURIST ATTRACTIONSPDF

Remy Giovanni Mangowal, Andre Andre, Raymond Sucipto

SIMULATION-BASED MODELING OF CONTAINER DEPOT OPERATIONS FOR SERVICE PERFORMANCE ANALYSISPDF

M. Naufal Asyraf, Farizal Farizal

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- [Online Submission](#)
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- [Reviewer Guidelines](#)

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All

Search

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- » [Presentations](#)
- » [Conference Schedule](#)
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- » [Timeline](#)
- [Browse](#)
- [By Conference](#)
- [By Author](#)
- [By Title](#)

INFORMATION

THE IMPACT OF GENERATIVE AI ON SUPPLY CHAIN PERFORMANCE OF NOVICE WORKERS

PDF

- For Readers
- For Authors

*Hana' Karimah, Ramadhan T. Nurcahyo, Budhi S. Wibowo***LEAGILE SUPPLY CHAIN STRATEGIES AND ARTIFICIAL INTELLIGENCE FOR FOOD WASTE REDUCTION: A SYSTEMATIC LITERATURE REVIEW**

PDF

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PDF

*Fadli Nur Cahyo, Romadhani Ardi***ENERGY CONSUMPTION PREDICTION APPROACHES IN BUILDINGS: A BIBLIOMETRIC ANALYSIS 2015-2025**

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EXPLORING ENVIRONMENTAL STORYTELLING VIDEO GAMES AS EDUCATIONAL TOOLS FOR PROMOTING HISTORICAL TOURIST ATTRACTIONS

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Abstract This study investigates the potential of using environmental storytelling video games as educational tools for promoting historical tourist attractions, specifically focusing on The Heritage Palace in Surakarta. By combining historical context with interactive narratives, these games offer immersive and educational experiences that encourage visitors to explore the attractions. The research follows a rigorous scientific methodology, including extensive investigation, careful data collection, and game design based on the mechanics, dynamics, and aesthetics (MDA) framework. The resulting game seamlessly integrates gameplay elements such as object interaction, puzzle-solving, and exploration to create an engaging and informative experience. Through user testing and evaluation, the game successfully captures players' interest while enhancing their understanding and appreciation of The Heritage Palace. The game effectively conveys the historical importance of the attraction through an environmental narrative, fostering public interest and revealing the site's rich history. This study highlights the innovative potential of video games as promotional tools, demonstrating their ability to go beyond entertainment and serve as educational platforms for promoting historical and cultural destinations.

Keywords: Environmental Storytelling, Video Games, Educational Tools, Promotion Tools, Digitalization.

1. Introduction

Environmental storytelling is a widely used narrative technique in video games in which story elements are embedded within the environment, allowing players to uncover meaning through exploration and observation during gameplay [1]. By integrating visual details, audio, lighting, spatial arrangement, and atmospheric cues, this approach creates an immersive environment that encourages players to interpret narrative information actively rather than passively receiving it. In the context of cultural and historical tourism, environmental storytelling expands the role of video games beyond entertainment, enabling them to function as media for historical interpretation and public education [2]–[5]. One well-known example is Shenmue, which presented an engaging and detailed representation of Yokosuka and even contributed to public interest in the real city and its hidden locations [6].

Previous studies have demonstrated that game-based and immersive technologies can be applied to real cultural and historical sites for education, interpretation, and visitor engagement. Pescarin et al. [7] developed an environmental educational narrative videogame for the Forum of Augustus in Rome, while Xu et al. [8] designed a mobile AR exploration game

for the Shuangta heritage site in China. Similarly, Capecchi et al. [9] employed a GPS-guided AR serious game to stimulate visits to the Renaissance village of Caldana, and Varinlioglu et al. [10] used a serious game to translate archaeological knowledge from the ancient city of Teos into playable interactions. These studies confirm that digital games and narrative interaction have significant potential in heritage communication; however, they mainly emphasize education, interpretation, archaeological understanding, or onsite engagement rather than positioning environmental storytelling specifically as a promotional strategy for a heritage tourism site. To clarify the position of the present study within the existing literature, Table 1 compares several closely related studies and highlights the differences in focus and contribution.

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Table 1. Comparison of previous heritage-game studies and the proposed study.

Author	Method	Focus	Difference from Our Study
Pescarin et al. (2020) [7]	Environmental Educational Narrative videogame for a real heritage site in PS VR	Heritage education, cultural tourism, and optimization of game production/design	Closest prior work. Our study differs by focusing on THP, promotional use, selfie-gaze, and post-pandemic recovery.
Xu et al. (2024) [8]	Mobile AR exploration game with immersive storytelling, treasure hunt, and role-playing	Playful learning, onsite exploration, and heritage engagement at Shuangta	Their focus is AR-based onsite experience and evaluation; ours emphasizes environmental storytelling in a video game as promotional media for THP.
Capecchi et al. (2024) [9]	GPS-guided AR serious game with historical-character storytelling and treasure hunt	Urban heritage awareness, visit stimulation, and alpha-generation engagement	This paper already includes visit stimulation, so our difference is stronger in environmental storytelling, THP context, selfie-gaze, and post-pandemic recovery.
Varinlioglu et al. (2017) [10]	Serious game / mobile puzzle game with mythological storytelling at a real archaeological site	Converting archaeological knowledge into playable interactions and raising heritage awareness	Their focus is archaeological knowledge communication; ours emphasizes environmental storytelling as promotional media for THP and addresses tourism behavior.

Kartasura Heritage Palace, or The Heritage Palace (THP), is a distinctive and well-known tourist attraction in the Kartasura area of Solo, Indonesia. Originally built as a sugar factory in the 1920s with a Dutch colonial architectural style, it is now a government-protected cultural heritage building [11]. Despite its historical value, the current tourism image of THP is strongly associated with “Unlimited Selfie Opportunities,” which tends to encourage visitors to focus more on taking photographs and sharing them on social media than on understanding the site’s historical significance. According to the owner’s data, THP attracted many domestic tourists after opening in 2018, but visitor numbers declined significantly after 2020 due to the Covid-19 pandemic. In addition, the phenomenon of selfie-gaze is frequently observed among visitors [12]. This condition indicates that the site’s historical and cultural value has not yet been optimally communicated. Therefore, a more creative and engaging promotional medium is needed to reintroduce THP not merely as a visual attraction, but as a heritage destination with meaningful historical content [13].

Based on the comparison with previous studies, the novelty of this research lies not simply in applying a game to a real heritage site, but in positioning an Environmental Storytelling Video Game (ESVG) as a site-specific

promotional medium for THP. In contrast to prior studies that mainly focus on heritage education, archaeological interpretation, or AR-based visitor interaction, this study addresses a more specific tourism problem, namely selfie-oriented visitor behavior, while also responding to the need for post-pandemic tourism recovery in the Indonesian heritage context.

Accordingly, the primary objective of this study is to investigate the potential of ESGV as a promotional and educational medium for conveying the historical significance of THP. By evaluating its impact on public awareness and visitor interest, this research seeks to contribute to a broader understanding of how video games can function not only as recreational products, but also as media for heritage promotion, historical communication, and visitor reorientation. Ultimately, this study aims to assess whether ESGV can help strengthen the cultural image of THP and attract new visitors through a more meaningful engagement with its historical identity.

2. Method

In this section, we present the scientific methodology employed to implement the first-person ESGV (Environment-based Video Game) approach in order to enhance the promotion of historical tourist attractions. The section is further divided into two subsections: "Workflow

of the EVSG Project" and "Game Design Using the MDA Framework."

2.1 Workflow of EVSG Project

Environmental storytelling uses a game's environment and environs to convey a story or historical context to the player. In this context, the objective is to represent the actual locations and historical elements of THP as precisely as feasible to enhance the user's immersion in engaging gameplay. Our strategy is depicted in Fig. 1 as the EVSG Project Workflow. The methodology commences with extensive THP research and data acquisition. This step involves examining historical documents, architectural designs, photographs, and any available artifacts to comprehend the location's design, layout, and historical significance. This data is required to design appropriate gameplay and immersive game elements. Additionally, to construct an accurate narrative, the architecture, and layout of THP must be meticulously and precisely converted into digital assets.

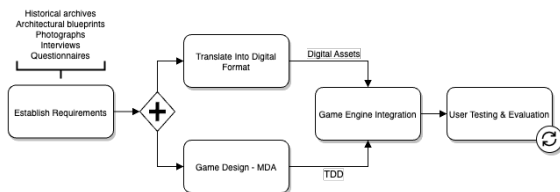


Fig. 1. Workflow of EVSG project of The Heritage Palace.

This procedure involves employing modeling and rendering techniques to generate digital assets that precisely represent aspects of THP's history. As depicted in Fig. 2, the procedure involves manually creating a Blender 3D model. We recognize that photogrammetric techniques can be used to produce quicker, more accurate, and better results. However, we do not utilize it due to technical and non-technical resource constraints. This method generates digital assets as the foundation for the THP's digital representation in the game engine.

In addition to the process of creating digital assets, the data acquired beforehand serves as the foundation for game design. We employ the MDA (Mechanics, Dynamics, Aesthetics) framework, which facilitates the systematic and structured creation of gameplay experiences. This MDA framework has been extensively implemented in video game development [14]–[17]. However, its application to the design of EVSGs remains limited. The

process of designing this game results in a Technical Design Document (TDD) that provides a detailed plan for integrating digital assets into the game engine and determining how these assets relate to players, controls, and immersive elements to emphasize the storytelling aspect.

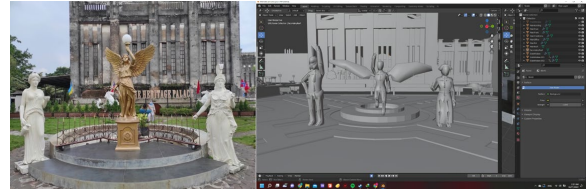


Fig. 2. The actual photograph of The Heritage Palace front yard, and the modelling process using Blender

TDD and digital assets are subsequently integrated into the Unity game engine, and the resulting mobile media is exported. The subsequent section explains the game's gameplay elements and narrative components. This product has ultimately endured user testing and evaluation. The iterative nature of this procedure enables continuous enhancement and refinement. Users, history experts, and tourists who have interacted with the game provided feedback to identify areas for development and ensure that the environment's narrative accurately reflects THP's historical context. In the following section, we describe our approach to game design using the MDA framework.

2.2 Game Design Using MDA Framework

The MDA framework is a conceptual instrument that game designers utilize in designing, analyzing, and developing gameplay [18]. This framework takes a methodical approach to designing the different layers and components contributing to the gaming experience. The rules, protocols, and components that define how a game is played are referred to as its mechanics. The mechanics include the player's actions, the dynamics of the game, the objectives, and the overall set of rules. The behaviors and experiences that result from the interactions between participants and game mechanics are known as dynamics. These dynamics include user actions, system responses, consequences, and ensuing feedback. Aesthetics, meanwhile, alludes to the emotional and sensory experience evoked by a game's design. The aesthetic elements include the game's visual and aural design, narrative

elements, and overall atmosphere. Fig. 3 depicts the MDA diagram we developed for the THP game based on the concepts and guidelines of this framework.

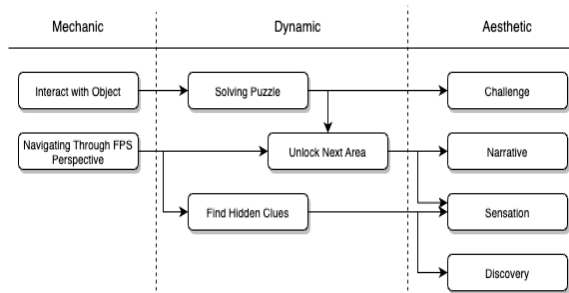


Fig. 3. The MDA of The Heritage Palace Game

Mechanic. Puzzle-solving with a combination of fundamental pickup and delivery mechanics [19] and object interaction is the primary gameplay element in THP. This game mechanic employs pressure to interact with objects and reveal concealed information to generate intrigue and challenges during gameplay. In addition, players can interact with various objects in the game to solve the level's puzzles, including taking photographs, discovering hidden keys, and collecting plants. It has been demonstrated that the first-person perspective produces a more immersive effect than other perspectives [20]. Players can use touchscreen controls with gestures such as tap, swipe, and drag to interact and navigate effectively using a first-person perspective. The gameplay progresses sequentially from one conundrum to another, resulting in a unified and structured experience.

Dynamic. Based on the previous design of the game's mechanics, the first-person perspective triggers dynamic and immersive game elements, particularly when exploring buildings. The core gameplay mechanics, namely interaction with objects and pickup and delivery, require the player to employ critical thinking and problem-solving skills to solve puzzles. Players gain access to the next area by solving each conundrum and can advance further in the game. Throughout the journey, the player is encouraged to locate hidden hints strewn throughout the environment, adding an exploration and discovery element to the gameplay. In this particular in-game situation, the narrative element is embedded, specifically by relating the level-specific THP history through narrative. As players interact with objects, seek hints, and solve puzzles, the historical narrative of THP will be revealed. This

narrative-driven gameplay mechanic gives players a sense of accomplishment and satisfaction as they progress through the story. The design of the puzzle is described in detail in the following paragraphs.

The objective of the first puzzle in THP is to incorporate elements of Environmental Storytelling into the narrative of THP's history as a sugar refinery. The narrative develops through available hints and the solution of puzzles. The first puzzle's hints illustrate the fundamental reason for establishing a sugar factory: to create employment opportunities for the people of Surakarta at the time. Visualization of these events is depicted by several individuals rushing toward the main building for employment. This visual consists of a 3D object model of employees standing outside the THP Building yard. These workers provide oblique hints so players can search for keys to unlock locks and enter the factory area. To solve the puzzle, players must read the direction of the workers' movement and use gestures to move the camera's view to locate the key concealed in the outer area of the THP building page. After completing the puzzle in this location, players will be presented with a complete story when moving to the next area.

The second puzzle illustrates how a sugar refinery became a symbol of the industrial revolution by employing machines in the sugar production process. During Dutch colonization, it became a great commodity and economically driven to build many sugar factories in Indonesia [21]. Therefore, in this second conundrum, sugar production machines are involved. This sugar factory's machine design uses previously acquired document references and interviews. The machine in this sugar refinery transports the sugar cane to the milling area using a conveyor belt. Then, there is a machine for purifying the ground substance, which is then transferred to an evaporator. This description of a sugar factory has been translated into a 3D model that is also a puzzle-solving environment. The player must locate and insert two objects into a machine to obtain the key to the next area in the second area.

The third conundrum investigates the historical context of the Dutch army's use of forced labor from Indonesian citizens to increase sugar production. These events are demonstrated by clues depicting people planting sugar cane and a puzzle requiring the player to transport sugar cane to the scales several times. The area depicted in the third puzzle is the backyard of the

THP structure, which is used to cultivate sugarcane. A 3D model of laborers planting sugarcane serves as the visual representation for the environmental narrative elements in this third area. The design of these three puzzles can provide players with an engaging and educational experience, and through interactive interaction, players can indirectly uncover the rich history of THP. Gradual complexity in level design can provide a sense of progression while playing.

To create this synergy in the game's Dynamics, proper integration of the characteristics of THP and the game's Mechanics and storytelling is needed. Every part of the game's Mechanics was carefully designed to invoke the transformation of THP's history as a very big sugar factory in the hands of Dutch's colonialization, to a heritage site that conveys the uniqueness and robustness of European colonialization structure and building framework.

Aesthetic. THP games provide players with a thrilling experience that incorporates three aesthetic elements of significance. First, this game's accurate and detailed environmental design (Sensation) generates an immersive sensation. With lush visuals and interactive elements, players can immerse themselves in the game more deeply and realistically. Second, the game uses environmental narration to produce a compelling story (Narrative). As players proceed through challenges, the historical narrative of THP unfolds, revealing intrigue and connections to THP's past. In addition, the game's dynamics present obstacles in the form of puzzles requiring analytical and problem-solving abilities (Challenges) and instilling a sense of sales and gratification in players by overcoming these odds. Lastly, the game fosters a sense of discovery by presenting THP-related information in stages (Discovery). The player uncovered the location's historical details, which generated a continuing sense of curiosity and exhilaration. Collectively, these aesthetic elements provide players with an immersive, story-driven, and intellectually stimulating experience.

3. Results and Discussion

This section examines the THP game as a promotional platform, evaluation results, and player feedback. In addition, the correlation analysis demonstrates that ESVG can attract site visitors.

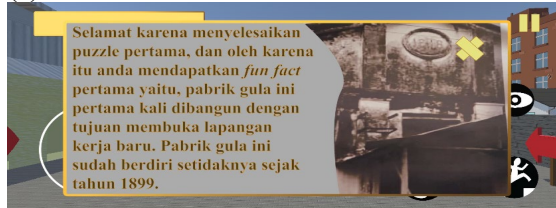
The game engine used is Unity, which is a popular and performance-friendly game engine. This game employs touchscreen controls and has been effectively ported to mobile platforms, though it is still Android-only. The user interface design depicted in Figure 4a demonstrates how the first-person perspective is implemented in the game to provide a fluid and intuitive experience for the player. This game does not require a 3D model of the player's hand, allowing players to concentrate more on the visual elements depicted on a small screen (smartphone). This game's incorporation of industry-standard FPS input controls enables easy virtual environment navigation. The left virtual joystick moves the player, while the part of the right screen uses the touchscreen to alter the player's perspective (change the viewing direction). Moreover, some games that uses virtual joystick already incorporated the use of external peripheral to improve the user experiences [22]. The positioning of crucial buttons, such as the jump and interaction buttons, in the bottom right corner of the screen facilitates access to the game's primary action, namely interaction with objects.

Figure 4b visualizes the effort to improve the efficacy of environmental storytelling in the THP game. Each time the player solves a conundrum, a narrative segment is delivered that reveals the historical context of the sugar factory. The narratives explain significant events, including the sugar factory's sensitivity, the sugar machine's industrial transformation, and the Dutch army's use of forced labor in Indonesia. The game not only engages players in the gameplay by immersing them in the rich history of THP but also teaches them about the cultural heritage of the location.

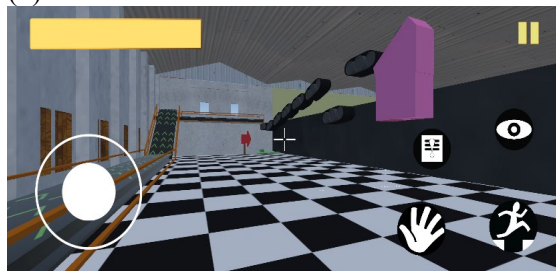
Figure 4c depicts the sugar factory building and factory machine details from the FPS and UI perspectives. The game reveals several details, such as interactive elements and arrow-represented to hidden clues; players are encouraged to investigate their surroundings and unearth the story behind the operation of the sugar factory. This design decision adds a touch of whimsy, difficulty, and player engagement and inquiry.



(a)



(b)



(c)

Fig. 4. a) The game UI; b) The delivery of environmental storytelling; c) Game UI inside sugar factory

The validation procedure was conducted to evaluate the THP video game's efficacy as a platform promotion. The games are distributed via a Google Drive link, and participants are instructed to play them on their Android devices until completion. The validation data collection employed the snowball sampling technique, in which participants were also asked to disseminate questionnaires to relatives or families who met the specified criteria. The target respondents for this validation procedure are individuals between 25 and 34 because a high prevalence of mobile gaming characterizes this age range [23]. Using Google Forms, a survey questionnaire was developed to collect participant feedback and information. The questionnaire consisted of a series of questions that explored the playing experiences of the participants and their perceptions of the game's efficacy as a promotional platform for The Heritage Palace. Table 2 presents the survey questions and the proportions of responses. For each port, the Likert scale ranges from 1 (strongly disagree) to 5 (strongly concur).

Table 2. Survey questionnaire for user validation

Statemen	1	2	3	4	5
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ts						
The first puzzle is easy to solve.	0	0	0	18,75	81,25	
The second puzzle is easy to solve.	6,25	6,25	12,5	37,5	37,5	
The third puzzle is easy to solve.	3,12	3,125	18,7	21,87	53,12	
The Heritage Puzzle game is interesting.	6,25	15,62	12,5	6,25	59,37	
Playing this game makes me more interested in visiting The Heritage Palace.	6,25	18,75	12,5	12,5	50	

Based on questionnaire results, an analysis has been conducted to obtain participants' responses regarding the game's difficulty level, educational elements, interest, and overall opinion. In addition to the quantitative model questions, the questionnaire also poses qualitative questions. Participants were asked their opinion regarding THP as a tourist destination and how they gained knowledge regarding THP after playing the game. According to most participants, the first level of the conundrum was straightforward to solve. In comparison, responses to the second and third levels with easy and medium difficulties vary. This fact demonstrates that the game presents levels that increase gradually as the level progresses.

Based on the educational aspect, most of the participants gained additional knowledge from this game. For example, participants learned that the Solo Palace played a role in the history of THP, an understanding that THP was once a sugar factory during the colonial era of the Netherlands, the existence of a prison, and the significance of the THP location during the industrial revolution era. In addition, most participants agreed that THP offers an interesting

game, while a small minority expressed reservations regarding the engaging aspect of this game.

Due to this game's educational component, most participants acquired additional knowledge. Participants are aware, for instance, that the Solo Palace has played a role in the history of THP, that THP was a sugar factory during the Dutch colonial period, that a prison existed, and that THP's location was significant during the industrial revolution. Aside from that, most participants agreed that THP presented an intriguing game, while a few others voiced objections regarding the game's exciting aspects. In addition to providing engaging responses, participants recognize the historical significance of the game, recognizing its potential as an excellent learning opportunity. Most respondents concurred emotionally wholeheartedly that playing THP increased their desire to visit the actual THP. Only some individuals expressed disinterest or a lack of intent to visit.

After playing the game, players were queried about the factors that sparked their interest in visiting THP. The response highlighted the compelling historical story and narrative of the game, the visual representation of THP, and the desire to compare actual locations to their visual representations in the game as key influencing factors. These insights

provide valuable information regarding the efficacy of THP's ESGV as a promotional tool and demonstrate its potential to attract visitors and stimulate interest in visiting actual heritage sites.

In addition to statistical analysis, we employ correlation analysis to examine the relationship between various variables and the promotional efficacy of video games. The correlation analysis method is frequently employed in studies of a similar nature, such as those examining the correlation between video games and violence [24], the correlation between the amount of time spent playing video games and the development of real-world skills [25], the correlation between video game engagement and academic scores [26], [27], between personality and behavior in video games [28], and between video game addiction, stress, and bruxism [29]. It can be concluded that the variables considered in this correlation analysis are questions 1-3, labeled "Puzzle," question 4, labeled "Game Appeal," and question 5, labeled "Likelihood." The analysis includes this variable to determine the relationship between game difficulty, game appeal, and the likelihood that participants will visit the original location. The correlation analysis results are presented in Table 3.

Table 3. Correlation analysis of the relationship between variables that induced the efficiency environmental storytelling FPS as platform for tourism

	Puzzle 1	Puzzle 2	Puzzle 3	Game Appeal	Likelihood
Puzzle 1	1				
Puzzle 2	0,813632413	1			
Puzzle 3	0,776516367	0,794843759	1		
Game Appeal	0,743178133	0,612285762	0,871525777	1	
Likelihood	0,689329431	0,626373877	0,870840162	0,948961553	1

The correlation analysis revealed several significant relationships between the THP game's variables and its potential as a tourism promotion platform. First, there was a positive correlation between the perceived difficulty of the first puzzle (Puzzle 1) and the difficulty of the second puzzle (Puzzle 2), indicating that participants who found the first puzzle simple were more likely to comprehend the second puzzle. The correlation coefficient = 0.8136 confirms this. This fact demonstrates that participants experience consistent difficulty throughout the game.

Similarly, a correlation coefficient of

0.7765 was observed between the perceived ease of solving the first puzzle (Puzzle 1) and the ease of solving the third puzzle (Puzzle 3). These findings indicated that participants who rated the first conundrum as simple would also be capable of completing the third puzzle. This discovery resolves the difficulty of conundrum progression consistency.

Moreover, there is a positive correlation between the perceived attractiveness of the game (Game Appeal) and the perceived simplicity of solving each puzzle (Puzzles 1-3). The correlation coefficient ranged between 0.7432 and 0.8715, indicating that participants who

found the conundrum simple were likelier to find the game engaging. This number demonstrates that when designing a puzzle game with multiple levels, the difficulty progression from one level to the next must be considered carefully. A low game appeal can be triggered if the player encounters an anticlimax, such as advancing to a more accessible level than the preceding one.

There is a positive correlation between the likelihood that participants will exhibit an interest in visiting THP (Likelihood) and the perceived attractiveness of the game (Game Appeal), and the perceived ease of solving the puzzle (Puzzle 1-3). The correlation coefficient ranged between 0.6893 and 0.9489, indicating that participants who found the game engaging and the puzzles simple were likelier to indicate an interest in visiting THP. It must be recognized that game appeal includes game design, environmental design, and the design of the narrative presentation within the game. This demonstrates that the game effectively generates player interest and increases their propensity to visit real THP venues. Based on the results of this correlation analysis, when designing a puzzle-based game, it is essential to consider the escalating difficulty level, the player's fascination sparked by the narrative, and the reward for completing the game successfully. A diagram (see Fig. 5) was constructed to visually represent these findings to illustrate the congruence between respondent responses and the previously mentioned correlation insights.

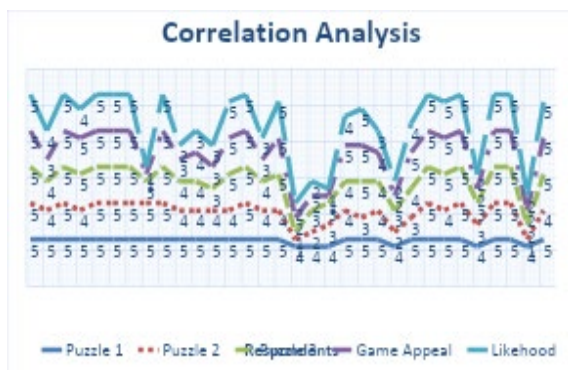


Fig. 5. The visualization of correlation analysis and consistencies of respondent inputs

To further research and determine the impact and significance of Environmental Storytelling as a way to promote historical site, particularly The Heritage Palace, a Paired Two Sample for Means t-Test was used to analyze the results of questions given to 30 users before playing the game (Pre-Test) and after playing the

game (Post-Test). Question 1 determines the intensity of the user's interest on The Heritage Palace, and Question 2 determines the knowledge the users have on the history of The Heritage Palace. The result of the t-Test is presented in Table 4.

Table 4. Paired Two Sample for Means t-Test results

	Pre-Test	Post-Test
Mean	8.5	26
Variance	112.5	8
Observations	2	2
Pearson		
Correlation	-1	
Hypothesized		
Mean		
Difference	0	
df	1	
t Stat	-1.842105263	
P(T<=t) one-tail	0.1583091034	
t Critical one-tail	6.313751515	
P(T<=t) two-tail	0.3166182069	
t Critical two-tail	12.70620474	

Based on the t-Test results, the mean of the Post-Test is much larger than the mean of the Pre-Test results. The Pearson correlation points as a perfect negative relationship. The t Stat ends up as around -1.842, which means the difference between means are quite remarkable. Both the One-tail p and Two-tail p values results in much larger values than 0.05, but the t Stat value is nowhere near the thresholds needed in the t Critical one-tail and two-tail. Results show that the means are very different, but there is not enough evidence to prove that the difference is real statistically. Future researches into the subject should be accompanied with much larger number of observations to give a stronger conclusion.

4. Conclusion

This study elevated Environmental Storytelling in the FPS Puzzle video game genre, with The Heritage Palace as the study's subject. We design games using the MDA framework following a standard procedure for game development. In addition, through a series of validations involving target users and correlation analysis, the developed games' results are validated to demonstrate the game's educational and promotional functions. The findings of this study increase the promotional potential of video

games for historical and cultural tourism destinations. Video games can effectively convey the historical significance of a location and entice visitors to the actual location by employing elements such as environmental narrative, engaging puzzle design, and immersive gameplay experiences.

It is essential to observe, however, that this study has limitations. THP research is restricted to a narrow scope. Future research must investigate a broader spectrum of video games and attractions and validate and generalize the current findings. Future research may incorporate objective measures with larger sample sizes to improve the validity and dependability of the results.

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