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Enhancing challenge-based immersion in cultural game using appreciative fuzzy logic

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ABSTRACT

Many traditional games in Indonesia are considered cultural heritage and are in serious decline; young generations no longer know about them. Serious games have been considered a potential educational tool for cultural heritage preservation. Lack of immersive experience due to over-focus on the learning content is a common problem in those games. Very little research also discusses cultural heritage serious game design frameworks. This study uses the appreciative fuzzy logic system (AFLS) to enhance the challenge-based immersive experience (CBIE) in the Joglosemar cultural heritage game. The AFLS provides autonomous challenges, such as enemy numbers and aggressive behavior, and the frequency of item appearances in the games using fuzzy logic with respect to the appreciative serious games (ASG) concepts. The ASG is the design guide for serious games that divides the game activities into 4-D: discovery, dream, design, and destiny. We use three ASG-based serious games to evaluate the CBIE produced by AFLS. The game experience questionnaire (GEQ) is used to measure the player experience, while the cross-validation is used to measure the AFLS performance. Results show that the AFLS enhances the CBIE. The study contributes mainly to provide reliable intelligent system for automated serious game design.

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1. INTRODUCTION

With over 1300 distinct ethnic groups, Indonesia has some of the world's most culturally rich heritage [1]. Traditional games are also considered part of this heritage [2]. However, their popularity and awareness continue to decline among the younger generation [3]. The gradual loss of various traditional games in Indonesia has been a serious concern that should be addressed immediately. The use of serious games to preserve cultural heritage, called cultural serious games, has gained significant attention in recent years. Cultural serious games have the advantage of providing a fun experience to improve cultural awareness among the next generation [4]. Previous research by Bai *et al.* [5] explores the use of serious games to preserve intangible cultural heritage. The research found that serious games' cultural identity and aesthetic quality significantly impact user perceptions, which in turn influence behavioral intentions. The

work by Ye *et al.* [6] also stated that serious games could increase learning performance and motivation in cultural heritage education.

Despite the advantages, using serious games for cultural heritage education poses a difficult challenge in designing immersive games, resulting in subpar gameplay [6]. Serious games often exist just as prototypes, and the released serious games don't have many actual players [7]. Indeed, the main objective of serious games is to educate, not entertain. However, the most significant advantage of the game itself is to be fun [8]. Therefore, though the main objective is to educate, the experience should be designed to be fun and immersive.

Several approaches have been made to improve the immersive experience in serious games. Utilizing virtual reality (VR) is the most common approach to enhance the immersive experience. The research conducted in [9]–[11] have reported improvements to the immersive experience made by using VR. However, VR requires expensive tools, and it is not recommended to use VR devices for a long time [12]. Therefore, VR is limited in its accessibility as an educational tool that requires continuous learning. Immersive experience in the game should be tools-agnostic. There are many games without complex tools and featuring only simple graphics, but have very immersive gameplay, such as vampire survivor, stardew valley, and dead cells. Aside from VR, very few studies aim to improve the immersive experience in serious games, recent studies including Haryanto *et al.* [13] focused on improving imaginative immersion using appreciative serious games (ASG) as a game activity design framework, then Siswoko *et al.* [14] using behavior trees to enhance the immersive experience in the cultural games.

Artificial intelligence (AI) has been used to improve experience in serious games in various research. Junior *et al.* [15] explores three primary ways ChatGPT could support serious board game design, then Chen *et al.* [16] highlight the combination of AI and business simulation games (BSG). AI could also act as a virtual assistant in the chess game to treat dementia patient [17]. According to researchers at [18], [19], AI could provide better personalization for serious games. The use of AI in serious games is often limited to algorithm performance measurement, player modeling, and e-sport business intelligence [20], therefore showing the gap between the use of AI and how AI could comply with serious game frameworks. On the other hand, very little research discusses immersive experiences without VR and the framework for immersive serious games.

Designing immersive serious games requires the framework as a game design guide. In the previous research [19], we use the ASG concept to address the problem. ASG uses the concept of appreciative learning, consisting of four stages, discovery, dream, design, and destiny, to design the game activities that produce an immersive experience [21]. In this study, we propose a novel AI framework using fuzzy logic that complies with the serious game framework. The appreciative fuzzy logic system (AFLS) is the AI for serious game design that complies with the serious game framework, ASG. We use three ASG-based serious games to evaluate the challenge-based immersive experience (CBIE) produced by AFLS. The game experience questionnaire (GEQ) is used to measure the player experience.

2. METHOD

The main contribution of this study is an intelligent framework called the AFLS, which dynamically conforms to the ASG architecture to enhance the CBIE in cultural serious games. Therefore, the method is divided into four parts, consisting of the ASG architecture for the cultural serious games, the design of CBIE in the game, the development of AFLS in the game, and the evaluation that will measure the player experience and the AFLS performance in producing the dynamic content.

2.1. Appreciative serious game architecture for cultural serious game

Figure 1 shows the ASG architecture that consists of the appreciative learning 4-D model: discovery, dream, design, and destiny; as the design guide for serious game activity [19]. The 4-D model serves as a guide for all activities within the game. The discovery stage emphasizes exploration activities, the dream stage focuses on objective selection, the design stage is about achieving those objectives, and the destiny stage involves activity's post-goal attainment, which then leads back to the discovery stage at the next level. The 4-D model poses a difficult challenge because it needs to adjust the various activities dynamically.

2.2. Challenge-based immersive experience

According to Haryanto *et al.* [13], there are three types of immersion: imaginative immersion, sensory immersion, and challenge-based immersion. Imaginative immersion in games denotes the profound involvement and absorption players encounter when they perceive themselves as wholly integrated into the game's universe. Sensory immersion in games implies the profound engagement of players within the game world facilitated by the audio-visual components of the game. This form of immersion is characterized by the

sensory input from the game (such as sights and sounds) predominating over real-world stimuli, eliciting the sensation of physical presence in the game environment. CBIE in games occurs when players become deeply engaged due to the game's difficulty and the necessity to overcome challenges. This form of immersion is driven by the balance between the game's challenge and the player's abilities. The major components of CBIE encompass [22]:

- Ability alignment: the game presents obstacles that are appropriately calibrated to the player's ability level, neither excessively easy nor overly difficult.
- Advancement: players get a sense of achievement as they surmount progressively challenging obstacles.
- Engagement: concentrating and developing strategies maintains players' profound involvement in the game.
- Reward: immediate positive feedback on performance aids players in comprehending their advancement and identifying areas for enhancement.

When these aspects are optimally matched, players attain a "flow" characterized by complete immersion and enjoyment of the gameplay experience. CBIE is one of the most important elements in serious games, keeping players from leaving.

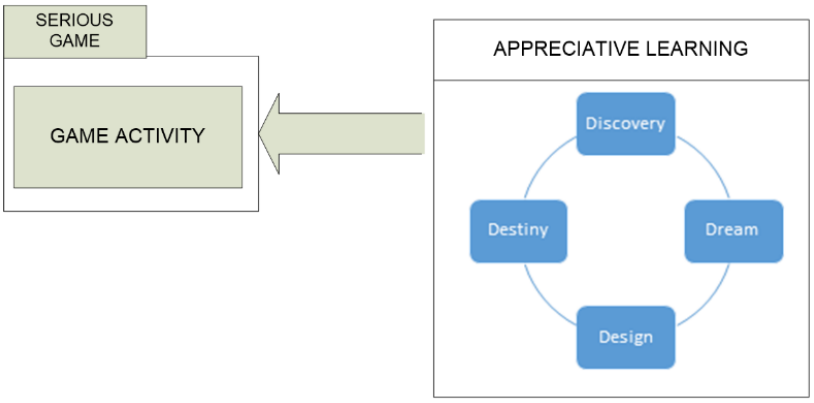

Figure 1. Appreciative serious game architecture

2.3. Appreciative fuzzy logic system in the appreciative serious game

Figure 2 shows the role of AFLS as an adaptivity bridge between ASG and the game activity design. We then develop the membership function and rules of AFLS. There are four fuzzy systems for all ASG activities. The fuzzy system's development has three stages: fuzzification, inference, and defuzzification. During the fuzzification phase, we establish membership functions for the inputs and outputs associated with each activity. We ascertain the variable and value for each membership function based on the study conducted by [23]. Table 1 illustrates the membership functions for each activity. The AFLS output will comply with four components of CBIE: ability alignment, advancement, engagement, and reward.

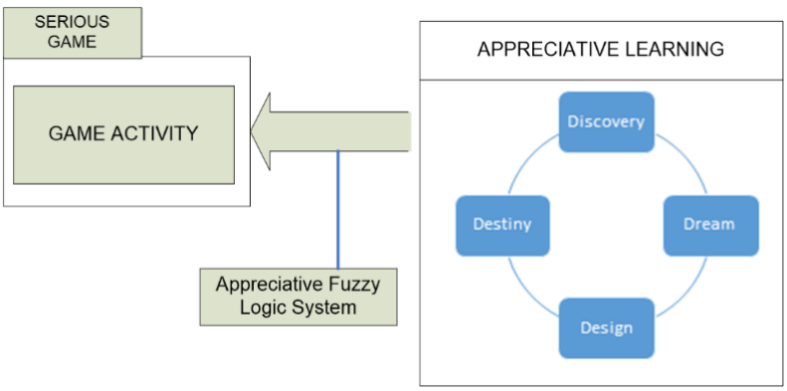

Figure 2. AFLS-based ASG

Table 1. Membership function for each activity

Activities	CBIE elements	Membership function
Discovery	Ability alignment	Input: exploration level (explvl) Input: exploration time (exptime) Output: dynamic difficulty adjustment (difficulty)
Dream	Advancement	Input: dynamic difficulty adjustment (difficulty) Input: objective selection (objsel) Output: objective rating (objrating)
Design	Engagement	Input: objective rating (objrating) Input: score Output: resource quality (resqual)
Destiny	Reward	Input: resource quality (resqual) Input: number of win) Output: achievement level

The discovery of AFLS resulted in the dynamic difficulty adjustment, and the dream AFLS will produce an objective rating. The objective rating determines how many objectives will open based on the player's choice and dynamic difficulty adjustment produced in the discovery AFLS. The objective rating and score are then used as input for the design AFLS, resulting in resource quality. Then, resource quality and the number of wins will determine the achievement level. The range for each fuzzy linguistic variable value is established utilizing the symmetric ratio approach of game-balancing [24]. Figures 3 to 6 show the membership functions for the discovery AFLS, dream AFLS, design AFLS, and destiny AFLS.

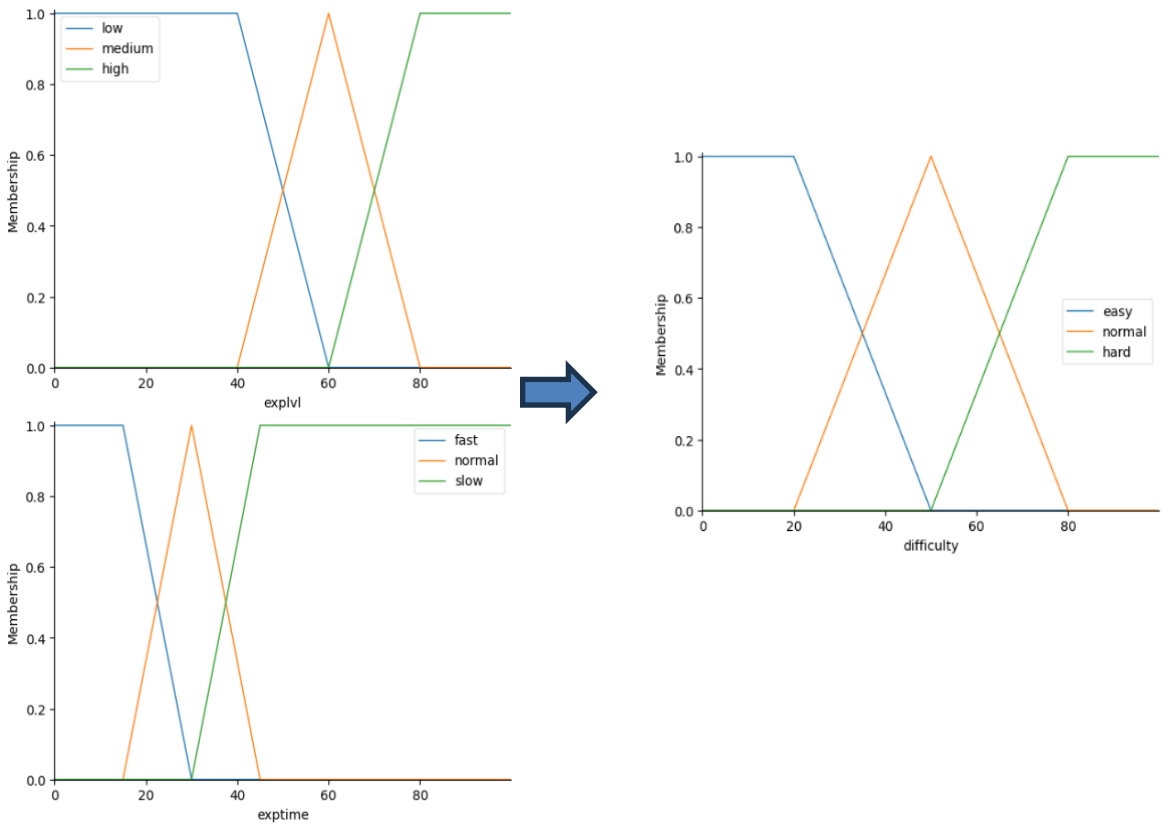

Figure 3. Discovery AFLS

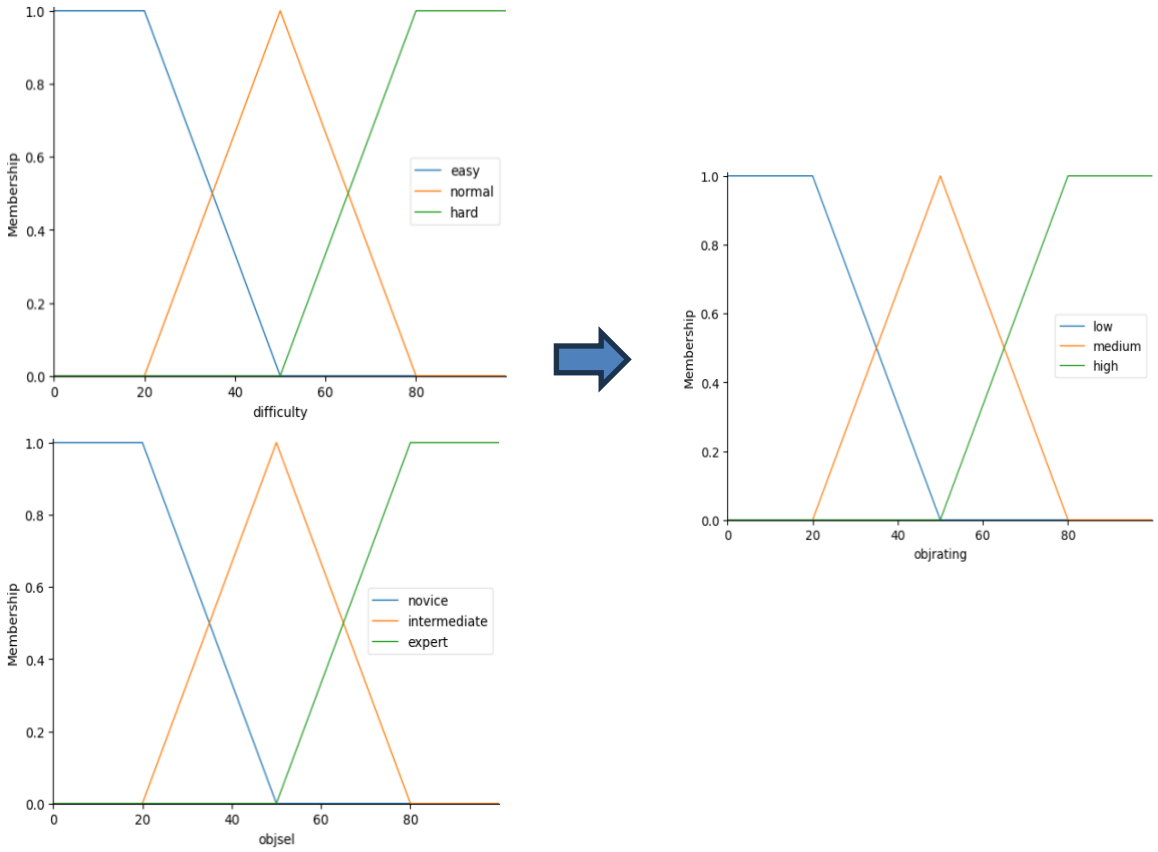

Figure 4. Dream AFLS

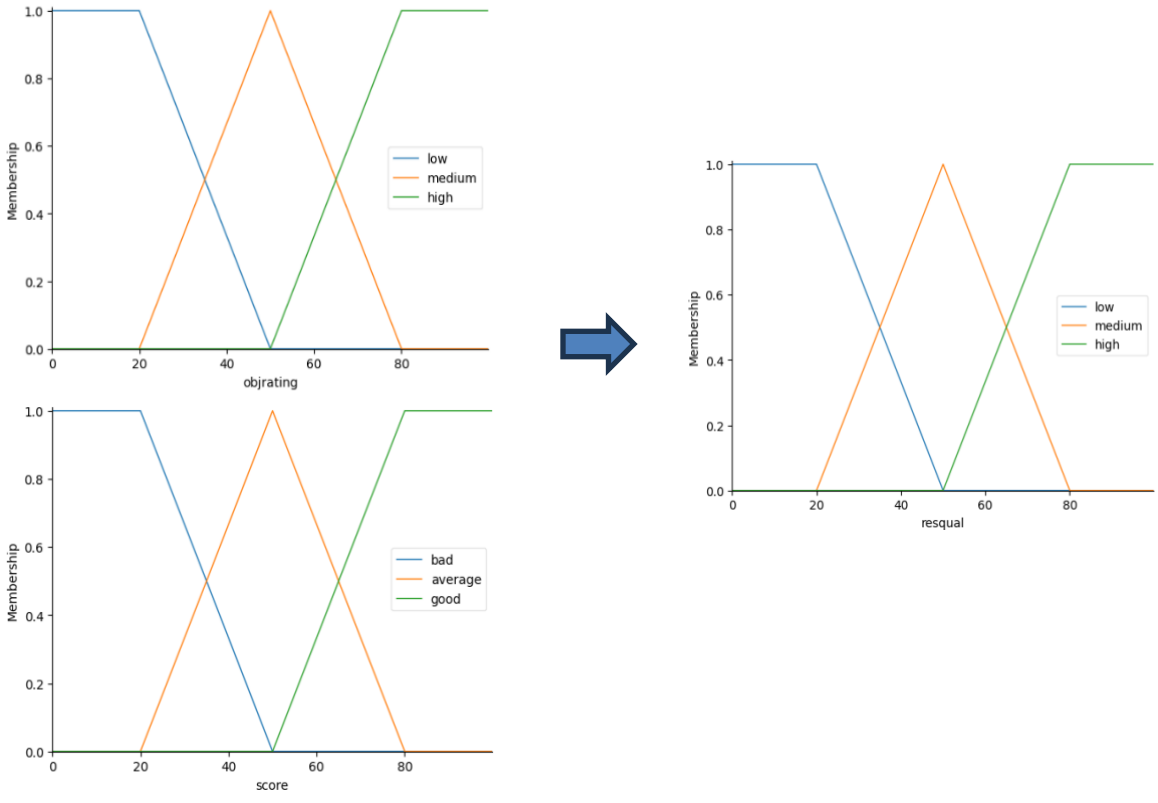

Figure 5. Design AFLS

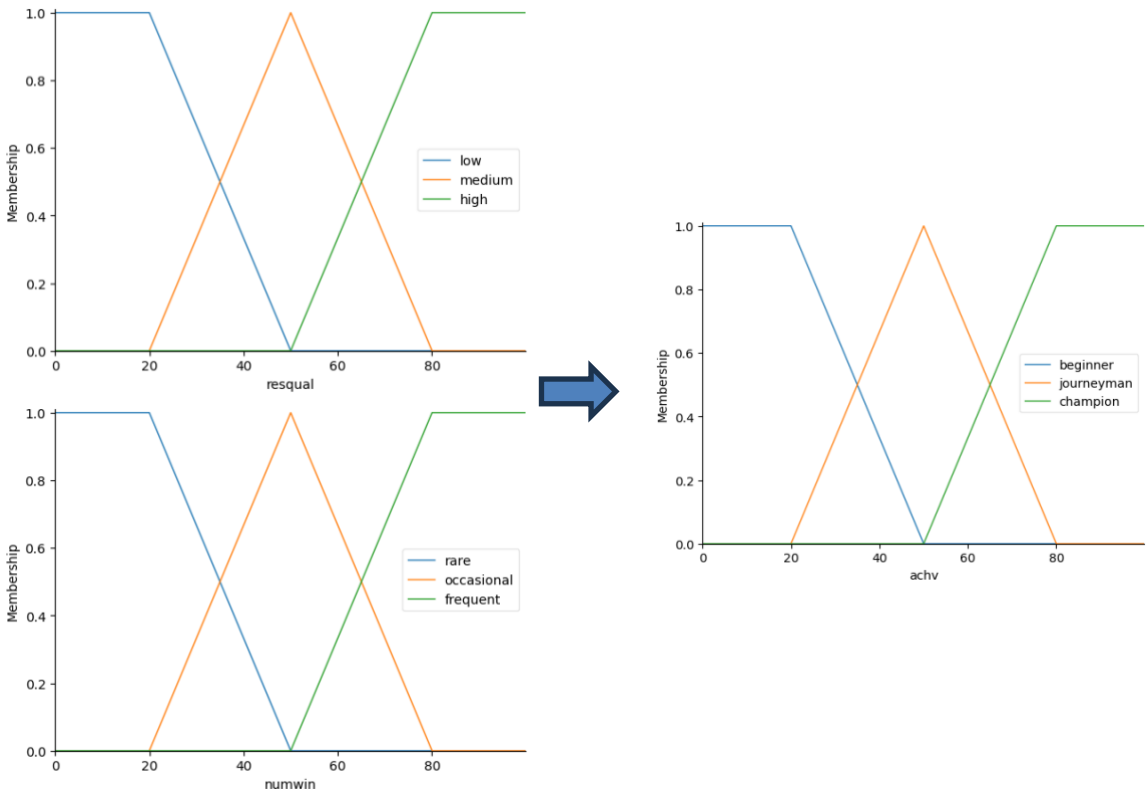

Figure 6. Destiny AFLS

The triangular membership function is characterized by three parameters: a, b, and c. In this context, a and c represent the base points of the triangle, while b denotes the apex. The equation presented in (1) defines the triangular membership function, as illustrated in Figure 7.

$$Triangular\ (x, a, b, c) = \begin{cases} 0, x \leq a, x \geq c \\ \frac{x-a}{b-a}, a < x \leq b \\ \frac{c-x}{c-b}, b < x \leq c \end{cases} \quad (1)$$

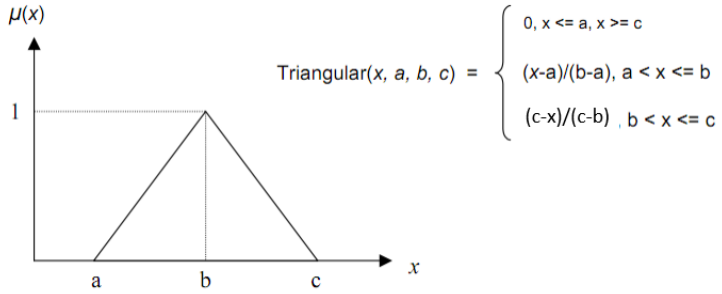

Figure 7. Triangular membership function with parameters a, b, and c

The trapezium membership function is characterized by four parameters: a, b, c, and d. In this context, a and d represent the "feet," while b and c denote the "shoulders". The formula presented in (2) defines the trapezium membership function, as illustrated in Figure 8. Table 2 shows the rules for discovery,

which is Table 2(a) shows discovery AFLS rules, Table 2(b) shows dream AFLS rules, Table 2(c) shows design AFLS rules, and Table 2(d) shows destiny AFLS rules.

$$Trapezium\ (x,a,b,c,d) = \begin{cases} 0, x \le a, x \ge d \\ \frac{x-a}{b-a}, a < x \le b \\ 1, b < x \le c \\ -\frac{x-d}{d-c}, c < x \le d \end{cases} \quad (2)$$

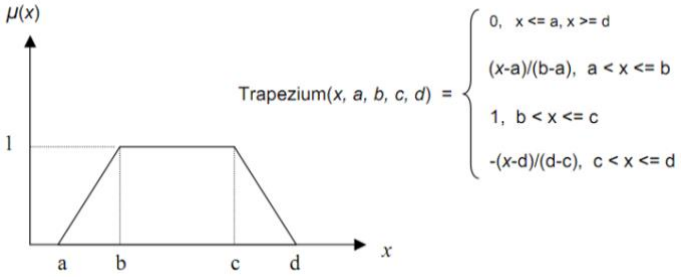

Figure 8. Trapezium membership function with parameters a, b, c, and d

Table 2. AFLS rules for the (a) discovery, (b) dream, (c) design, and (d) destiny stages

(a)

IF		THEN
Exploration level	Exploration time	Difficulty
Low	Fast	Easy
Low	Normal	Easy
Low	Slow	Normal
Medium	Fast	Easy
Medium	Normal	Normal
Medium	Slow	Normal
High	Fast	Normal
High	Normal	Hard
High	Slow	Hard

(b)

IF		THEN
Difficulty	Objective selection	Objective rating
Easy	Novice	Low
Easy	Intermediate	Low
Easy	Expert	Medium
Normal	Novice	Low
Normal	Intermediate	Medium
Normal	Expert	Medium
Hard	Novice	Medium
Hard	Intermediate	High
Hard	Expert	High

(c)

IF		THEN
Objective rating	Score	Resource quality
Low	Bad	Low
Low	Average	Low
Low	Good	Medium
Medium	Bad	Low
Medium	Average	Medium
Medium	Good	Medium
High	Bad	Medium
High	Average	High
High	Good	High

(d)

IF		THEN
Resource quality	Number of wins	Achievement level
Low	Rare	Beginner
Low	Occasional	Beginner
Low	Frequent	Journeyman
Medium	Rare	Beginner
Medium	Occasional	Journeyman
Medium	Frequent	Journeyman
High	Rare	Journeyman
High	Occasional	Champion
High	Frequent	Champion

2.4. Joglosemar cultural heritage game

We developed the Joglosemar cultural heritage game, which consists of three traditional Indonesian games, as a testbed for this research. The games are dakon, engklek, and gobak sodor. Dakon or congklak is a two-player game using a special board called a dakon and several pellets. The main objective of this game is to collect as many pellets as possible in a certain area on the board called home. The winner is the one who has more pellets in his/her home. Though it is a popular traditional game in Indonesia, the origin of this game is in the Middle East. Engklek is a simple game that can be played alone or with friends. The player draws a certain box on the ground, puts the stone on one of the boxes, and jumps with a single leg to each end while avoiding the box with a stone inside it. Before it became popular in Indonesia, it is believed that the Dutch had brought the game to Indonesia. The main origin of gobak sodor is Central Java. This game is played by 3-5 persons per team, divided into the keeper and attacker teams. The lines are drawn on the ground as the

main routes for the keeper and as the game area boundary. The keeper should keep the attacker from reaching the other end of the area while staying in their lines. The winner is the team that could reach the other end of the area. Figure 9 shows the architecture of the Joglosemar cultural heritage game, which uses AFLS-based ASG (Figure 2). Table 3 presents the game activity design based on ASG, which consists of 4-D models: discovery, dream, design, and destiny.

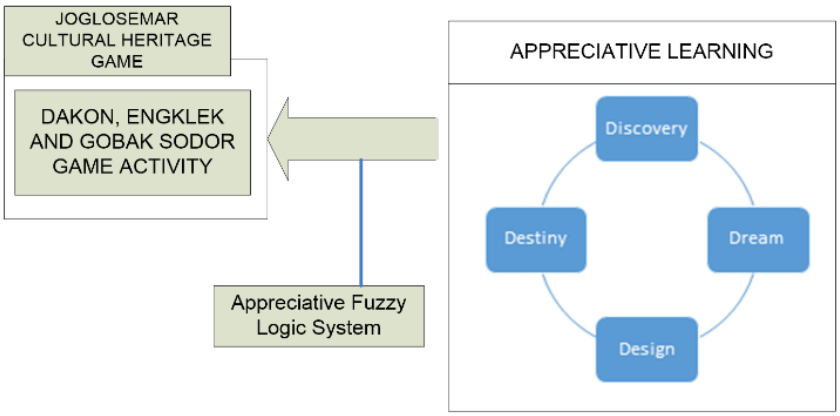

Figure 9. Architecture of Joglosemar cultural heritage game using AFLS-based ASG

Table 3. Activity design of Joglosemar based on ASG

Activities	Details
Discovery	Explore the area to find the information, interact with non-playable characters, interact with game objects
Dream	Choose and determine objectives
Design	Using methods and gathering resources to finish objectives
Destiny	Complete objectives, get game event, get reward

2.5. Game experience questionnaire

The GEQ is utilized to assess player experience. GEQ evaluates gaming experience across five components: competence, flow, immersion, positive affect, and negative affect [25]. In this study, we only concentrated on the assessment of CBIE. Table 4 presents the revised core module of CBIE GEQ for this study. The scoring for each item is as follows: not at all (score: 0), somewhat (score: 1), moderately (score: 2), considerably (score: 3), and extremely (score: 4). The average scores will represent the total score for the GEQ questionnaire, with higher values indicating superior performance.

Table 4. Modified GEQ CBIE module

NO	Player responds	CBIE elements
1	I felt challenged	Ability alignment
2	I had to put a lot of effort into it	Ability alignment
3	I enjoy the difficulty of the game	Ability alignment
4	I felt time pressure	Advancement
5	I want to get a higher score	Advancement
6	I am aware of my progression in this game	Advancement
7	I was fully occupied with the game	Engagement
8	I forgot everything around me	Engagement
9	I was deeply concentrated in the game	Engagement
10	I want to win	Reward
11	I am satisfied with my achievement	Reward
12	I want to try again	Reward

3. RESULTS AND DISCUSSION

We develop Joglosemar cultural serious game prototype as the testbed for the AFLS to enhance the CBIE. The player could choose one of the three Indonesian traditional games (daikon, ankle, or global sodor) in this game. Figure 10 shows the gameplay of dakon, Figure 11 shows the gameplay of engklek, and Figure 12 presents the gameplay of gobak sodor.

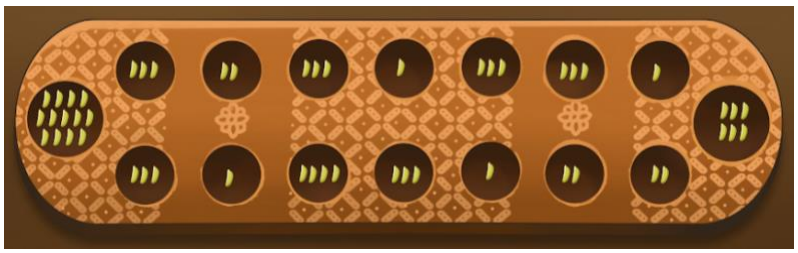

Figure 10. Gameplay of dakon in Joglosemar cultural game

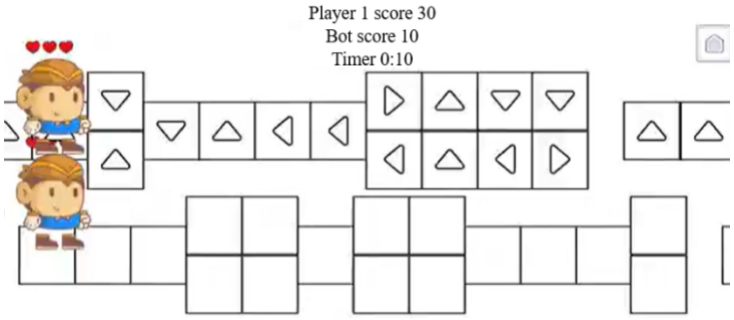

Figure 11. Gameplay of engklek in Joglosemar cultural game

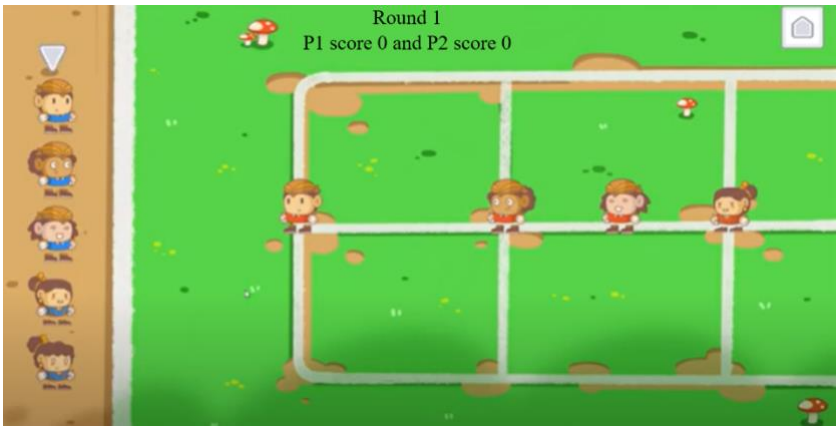

Figure 12. Gameplay of gobak sodor in Joglosemar cultural game

3.1. Appreciative fuzzy logic system result

This survey had 10 respondents, 5 of whom were avid gamers and the rest casual gamers. The respondents played the Joglosemar cultural game, and we documented the overall AFLS result for each respondent. Table 5 shows the AFLS results. The 10 respondents played the game three times, and the overall exploration level, exploration time, objective selection, score, and number of wins were taken as inputs for the AFLS.

3.2. GEQ CBIE comparison between AFLS and non-AFLS cultural serious games

With the same respondents, we also measured several serious games in the Play Store with the same traditional games as the Joglosemar game (dakon congkak, hopscotch, and galasin), using GEQ CBIE, and then compared the GEQ CBIE scores between the games without AFLS and with AFLS. We also include the non-AFLS Joglosemar game in this evaluation. Table 6 shows the overall GEQ CBIE Score for non-AFLS cultural serious games, and Table 7 shows the score for the AFLS cultural serious games. The survey found that AFLS could slightly improve the CBIE of players. Most of the respondents felt more motivated because of the challenge.

Table 5. The AFLS results

Respondents	Discovery AFLS (ability alignment)		Dream AFLS (advancement)		Design AFLS (engagement)		Destiny AFLS (reward)		AFLS overall result
	Exploration level	Exploration time	Difficulty	Objective selection	Objective rating	Score	Resource quality	Number of wins	Achievement level
1 (AVID-GAMER)	50.92	67.18	50.00	97.67	50.00	70.00	50.00	90.00	50.00
2 (AVID-GAMER)	80.77	75.73	81.30	72.28	79.98	80.00	81.34	80.00	81.30
3 (AVID-GAMER)	55.03	74.83	50.00	83.98	50.00	80.00	50.00	75.00	50.00
4 (AVID-GAMER)	83.38	69.05	81.30	76.13	80.71	70.00	79.53	80.00	80.60
5 (AVID-GAMER)	90.43	95.69	81.30	60.83	79.36	90.00	80.43	85.00	81.38
6 (CASUAL-GAMER)	35.11	51.46	50.00	12.02	18.57	70.00	41.11	60.00	41.95
7 (CASUAL-GAMER)	30.09	57.68	50.00	35.70	37.06	60.00	38.37	70.00	40.80
8 (CASUAL-GAMER)	29.77	24.26	20.72	59.38	30.53	50.00	31.78	55.00	33.11
9 (CASUAL-GAMER)	26.46	56.76	50.00	36.67	37.99	60.00	39.24	60.00	40.41
10 (CASUAL-GAMER)	38.72	26.26	19.92	1.34	18.57	70.00	41.11	65.00	40.83

Table 6. Overall GEQ CBIE score for non-AFLS cultural serious games

Respondents	Overall GEQ CBIE score (non-AFLS)				Average GEQ CBIE score
	Dakon congkak	Hopscotch	Galasin	Joglosemar non-AFLS	
1 (AVID-GAMER)	3.3	3.1	3.4	3	3.2
2 (AVID-GAMER)	3.1	3.1	3	3.1	3.075
3 (AVID-GAMER)	3	2.9	2.7	2.8	2.85
4 (AVID-GAMER)	3.1	2.9	2.9	2.9	2.95
5 (AVID-GAMER)	3.03	3	3.1	3	3.0325
6 (CASUAL-GAMER)	3.3	3.2	3.4	3	3.225
7 (CASUAL-GAMER)	3	3.1	3.1	2.9	3.025
8 (CASUAL-GAMER)	3.1	3.2	3	3	3.075
9 (CASUAL-GAMER)	3.2	3.3	3.2	3	3.175
10 (CASUAL-GAMER)	3.2	3.1	3	3.1	3.1
				Total GEQ average score	3.07075

Table 7. Overall GEQ CBIE score for AFLS cultural serious games

Respondents	Joglosemar (ith AFLS)
1 (AVID-GAMER)	3.6
2 (AVID-GAMER)	3.4
3 (AVID-GAMER)	3.2
4 (AVID-GAMER)	3.05
5 (AVID-GAMER)	3.1
6 (CASUAL-GAMER)	3.5
7 (CASUAL-GAMER)	3.4
8 (CASUAL-GAMER)	3.7
9 (CASUAL-GAMER)	3.42
10 (CASUAL-GAMER)	3.5
OVERALL GEQ SCORE	3.387

4. CONCLUSION

The experiment demonstrates that the AFLS may dynamically modify the challenge or achievement based on game conditions and player performance, hence enhancing the player's CBIE. Consequently, the AFLS may serve as a foundation for developing cultural serious games. Nonetheless, the AFLS for CBIE is optimally solely for uncomplicated gameplay in a simple game. It may not function effectively in more intricate games like role-playing or strategy games. The AFLS could be implemented in future works for more complicated games, such as strategy or role-playing games.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
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Va : **Va**lidation
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R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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