2025

SciEd
SEAQIS Journal of Science Education

SEAQIS Journal of Science Education (SciEd)
ISSN: 2987-8101 | E-ISSN: 2964-7533
Vol: 5, No: 1, PP: 21-37
www.journal.qitepinscience.org

Research Paper Open Accsess

Preliminary Study on Game-Based Learning to Promote Javan Leopard Conservation: Perspectives from Prospective Biology Teachers

Diki Muhamad Chaidir[1], Purwati Kuswarini Suprapto[1], Liah Badriah[1], Dani Ramdani[1]

[1]*Biology Education Department, Faculty of Teacher Training and Education, Universitas Siliwangi*
**Corresponding author, e-mail: dikimc@unsil.ac.id*

Article history:
Received: February 7, 2025
Revised: March 19, 2025
Accepted: April 15, 2025

Abstract

Research on game-based learning has been widely conducted to support biology education in the classroom. Thistype of learning should also have an additional impact on students, one of which is introducing endangered species, such as the Javan leopard (Panthera pardus melas). This study explores the initial stage of developing Game-Based Learning (GBL) media and its impact on prospective biology teachers' interest, attitude, andknowledge regarding Javan leopard conservation. The research method used a quantitative and qualitative approach, with asurvey comprising both open and closed-ended questions to assess the responses of prospective biology teachers to the biology game application focused on ecological communities. Interest was measured on a Likert scale; attitudes were measured through multiple-choice and agreement-scale questions; and knowledge was assessed through multiple-choice and true/false questions, while open-ended questions were applied for suggestions and recommendations from GBL. The respondents were 108 students who had previously tested the developed application. In the data analysis, descriptive statistical methods were used to interpret quantitative data, while qualitative analysis was conducted using word clouds to depict the answers of prospective biology teacher students in open-ended questions. The demographic data revealed that 73% of students typically play games for less than 1 hour per week, 72% play online games, and adventure is the most frequently played genre. Additionally, 92% of students had never played a game related to leopards before, and only about 27.1% of students had prior knowledge about leopards, mostly from their teachers at school. After using the application, 68% of students expressed increased interest in leopard conservation, improved knowledge, and demonstrated a positive attitude. Furthermore, 88% of students felt that the game helped raise their awareness of leopard conservation. This study concludes that game-based learning, which integrates information about endangered species like the Javanleopard, has enormous potential to support biology education and raise awareness of biodiversity conservation.

Keywords: Biology Education; Javan Leopard; Local Species; Conservation Learning

Introduction

One of the species that needs special attention from all parties, including in the field ofeducation in Indonesia, is the Javan leopard. After the extinction of tigers from Java Island in the 1980s, the endemic and critically endangered Javan leopard (*Panthera pardus melas*) became the only major carnivore left on the island (Ario, Mercusiana, et al., 2022; Ariyanto et al., 2024; Wibisono et al., 2018). Threats to the Javan leopard also occur frequently, such as illegal hunting, habitat destruction,

fragmentation, and conflict between humans and illegal wildlife trade (Ario, Murdyatmaka, et al., 2022; Gomez & Shepherd, 2021). The sharp increase in human-to-Javan leopard conflicts due to habitat degradation that has continued in the last 15years urges urgent efforts to restore habitats and manage conflicts to create a balance between wildlife conservation and community needs (Gunawan et al., 2017). An important analysis of population, distribution, and occupancy has been carried out as a recommendation from biological, policy, and conservation aspects for the survival of leopards on the island of Java (Ario, Mercusiana, et al., 2022). Based on this, various efforts are needed in the conservation of leopards, one of which can be done through education.

Education has an important role, as it significantly influences local attitudes towards leopard conservation (Rani et al., 2024). This is also in line with the research conducted by Dhungana et al. (2022), experiences with tigers or leopards, and education make a significant positive contribution to attitudes towards tigers, leopards, tiger conservation, and leopard conservation. Another example is in the case of snow leopards in India for conflict mitigation, especially in capacity building and awareness programmes, one of which is also carriedout through education (Moheb et al., 2022). The importance of active environment-based education towards action and involvement of various parties in order to create an effective generation of environmentalists (Alamshoev et al., 2024). Based on various experiences about the role of education for leopards, it is also important to be initiated to be carried out in Indonesia.

Studying the role of biology education in preserving Javan leopards in Indonesia is crucial because it can increase awareness, improve knowledge, and develop positive attitudes toward conservation. Education plays an essential role in making individuals environmental stewards (Altassan, 2023; Goodale et al., 2025; Yadav et al., 2022). However, little research has been done on the role of biology education in acquiring knowledge and the involvement of students in Javan leopard conservation. So far, research on Javan leopard education has only led to aspects of knowledge, perception, and conflict in society in general (Dewanti & Marhaento, 2021; Partasasmita et al., 2016).

By filling this knowledge gap, the research can uncover how conservation can be associated with biology education, identify sound practices in instruction, and suggest curriculum changes considering the protection of local biodiversity. The study will also assist in evaluating whether current teaching approaches prepare future biology instructors to advocate for Javan leopard conservation. Doing so will assist in educational development and conservation so that students and teachers will be active participants in protecting Indonesia's unique wildlife.

Education can play a role in communicating and teaching about the value of threatened species (Robinson et al., 2018). Biodiversity conservation education is the key to building a society that cares about and actively participates in nature conservation efforts; therefore, it needs to be an integral part of formal education (Børresen et al., 2023). Game-Based Learning has also been used to study the biology, ecology, and conservation of jaguar species in South America (Almeida et al., 2024). As for Indonesia, several GBLs have also been developed based on the use of local potential endemic species in each region, such as in Papua (Yuliawan et al., 2022) and Borneo (Ramadiani et al., 2021). Game-Based Learning has also been used as an effective learning method in biodiversity conservation among Indonesia’s secondary school students, with significant knowledge improvement results (Wijoyo et al., 2025). Therefore, educational efforts through meaningful learning are needed that integrate current technological advances in Javan leopard conservation efforts, which is Game-Based Learning.

The use of GBL has been widely carried out in improving the quality of learning in the classroom. As interest in using 3D games for education increases, more and more research is trying to integrate gamification elements in learning to increase engagement and improve student learning outcomes (Sanzana et al., 2024; Situmorang et al., 2024). GBL activities can also have a positive and fun impact on biology learning (Jones et al., 2019). The advantage of GBL is that students can interact, solve problems, and assess their actions, which can help them find many solutions to a single problem (Cosme et al., 2020).

In a systematic literature review that has been conducted, the application of digital games in biology learning can increase student engagement, foster social interaction through collaboration or discussion, and offer personalised and adaptive learning experiences that are tailored to individual needs and abilities, which ultimately motivates students to actively participate in the learning process (Situmorang et al., 2024). Studies show that well-designed educational games, combining learning theory and elements of entertainment games, can help develop students' 21st-century skills (Qian & Clark, 2016). If it is associated with games that explicitly discuss conservation, it is currently popular and evolving (Sandbrook et al., 2015; Tan et al., 2018). In order to design this GBL, it is necessary to understand the context of the material itself, learning objectives, learning tasks, and the accuracy of the technology used so that it can follow the expected learning outcomes.

GBL can also increase the understanding of biodiversity and motivation of students (Meekaew & Ketpichainarong, 2018). Relating to biodiversity is also important in understanding the local species found around the school environment. Teachers who have more knowledge about local species can have more confidence during biology learning, especially about wildlife (Skarstein & Skarstein, 2020). Emphasis on the role of teachers in imparting species knowledge to students and increasing public awareness of native species is a part of general education for biodiversity conservation (Gerl et al., 2021). GBL is effective in raising awareness about biodiversity threats such as invasive species (Miralles et al., 2021). Moreover, it has another impact on students, one of which is to introduce endangered local species such as the Javan leopard.

The role of education through GBL can contribute to the conservation of the Javan leopard. It is also expected that there will be more prospective teachers who are aware and concerned about the existence and conservation of leopards. Besides that, they can also help various Javan leopard research scientists as a liaison to deliver the results of their research to students and increase the awareness of Javan leopard conservation. This is in line with research conducted by Wright et al., (2021), showing that collaboration between teachers and scientists, which allows the use of real data from the local environment, strengthens learning in conservation education.

The problem found in the classroom is that only a few students relate their assignments in the conservation biology course to local species such as leopards. This issue may affect their interest, attitudes, and knowledge about leopards as future biology teachers. The low interest of students in Javan leopards can be seen from the lack of involvement in discussions and assignments, as well as limited participation in field studies related to local biodiversity in the classroom. If left unaddressed, these issues can affect their abilities as aspiring biology teachers to foster awareness and appreciation for local wildlife conservation among their students (Palmberg et al., 2018). Students also lack concern and responsibility in understanding and supporting efforts to preserve this species. Lack of knowledge can be reflected through conceptual errors, ignorance of the conservation status of leopards, and the

inability to link their ecological role to ecosystem balance. If this knowledge is not strengthened, students as prospective biology teachers may have difficulty in teaching the importance of conservation and knowledge about local species to their students (Skarstein & Skarstein, 2020). Therefore, it is also important to prepare prospective biology teachers who know about the conservation of local species, one of which is the Javan leopard.

Prospective biology teachers who understand Javan leopard conservation are also expected to provide new insights into biology learning that emphasizes the introduction of localspecies. The aim of this study is to explore the initial stage of developing Game-Based Learningmedia and its impact on prospective biology teachers' interest, attitude, and knowledge regarding Javan leopard conservation. In addition, it is also expected to provide benefits both practically and theoretically, especially in biology learning related to biodiversity conservation. It is hoped that this research can also contribute to and benefit the Indonesian Biodiversity Strategy Action Plan (IBSAP) (Ministry of Environment and Forestry, 2024), especially in national target 16, at point 16.1 on increasing biodiversity knowledge through formal and non-formal education.

Methodology

Participants

The research used a quantitative approach, with a survey comprising both open and closed-ended questions to assess the responses of prospective biology teachers to the biology game application focused on ecological communities. The number of respondents was 118 students who had previously tested the developed application. All these respondents are prospective biology teacher students enrolled in Conservation Biology courses in the Biology Education study programme, Siliwangi University.

Questions related to respondents' demographics, experience playing games, interest inleopard conservation, knowledge about leopards, attitudes towards leopard conservation, and recommendations for games that have been made and game recommendations related to Javanleopards in the future. The administered questionnaire underwent prior validation through expert review, conducted by two lecturers specializing in conservation biology education, achieving an average validation score of 0.95. Questions were created using open and closed questionnaires that referred to several sources. The questionnaire sheet is designed to measure students' interest, attitudes, and knowledge regarding Javan leopard conservation through Game-Based Learning.

Questions about several types of games were adapted from Qaffas (2020). Interest was assessed using a Likert scale, comparing students' enthusiasm before and after playing the game. Questions about attitudes and knowledge were developed from Barthwal and Mathur (2012); Dhungana et al., (2022); and Uduman et al., (2022). Attitudes were measured through multiple-choice and agreement-scale questions, evaluating their willingness to support conservation efforts and their views on the coexistence of humans and Javan leopards. Meanwhile, knowledge was tested using multiple-choice and true/false questions, covering topics such as threats to the species, its ecological role, and conservation programmes.

These instruments provide a comprehensive understanding of how Game-Based Learning influenced students' awareness and perception of Javan leopard conservation. After that, analysis was carried out using descriptive statistics, as well as qualitative analysis using word clouds (Pro Word Cloud from add-ins in MS Office) based on answers about from prospective biology teacher students on open questionnaires.

Results and Discussion

Results

Demographics Information

Based on the demographic information of the respondents in Table 1, it could be seen that prospective biology teachers who filled in were dominated by women (90.7%), with the frequency of playing games being less than 1 hour (72.9%). 72% of respondents preferred to play online games with the adventure genre (27.1%), while 92.4% of respondents had played games related to the leopard species. Some games that have leopard characters are included Mobile Legend, Oasis, Temple Run, and Ultimate Leopard Simulation (smartphone-based games)

Table 1. Demographics Inform

Gender	**N**	**Percentage (%)**	**Game Genre**	**N**	**Percentage (%)**
Male	11	9.3	RPG	17	14.4
Female	107	90.7	FPS	3	2.5
Gaming Frequency (in a week)	**N**	**Percentage (%)**	Adventure	32	27.1
			Simulation	28	23.7
Less than 1 hour	86	72.9	MOBA	29	24.6
1-3 hours	24	20.3	Other:	9	7.6
4-6 hours		4.2			
More than 6 hours		2.6	**Ever played a game related to leopards**	**N**	**Percentage (%)**
Type of network	**N**	**Percentage (%)**			
Online	85	72.0	Yes	109	92.4
Offline	33	28.0	No	9	7.6

Game-Based Learning using Leopards

The GBL that was created aims to observe ecological events related to populations and food chains, which initially did not use species native to Indonesia, namely lions (*Panthera leo*). In fact, in terms of morphology, it is almost similar because it belongs to the same family (Felidae), so it is recommended to use local species such as the Javan leopard (*Panthera pardus melas*) in addition to that other species such as Javanese rabbits and grasses are also introduced in the GBL. This graphic basis was developed using Blender application, which is also widely used for other biology learning (Suprapto et al., 2019). Figure 1 is the basic shape of a leopard created using Blender application which later be used for the game in Figure 2.

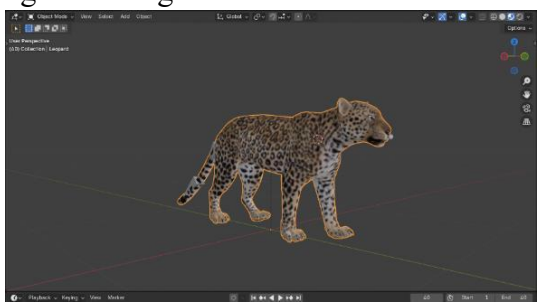


Figure 1. 3D Structure of a Leopard Created through a 3D Blender

Figure 1 was the display of a Javan leopard designed using Blender application. The design was made as similar as possible to the Javan leopard based on its morphological structure.

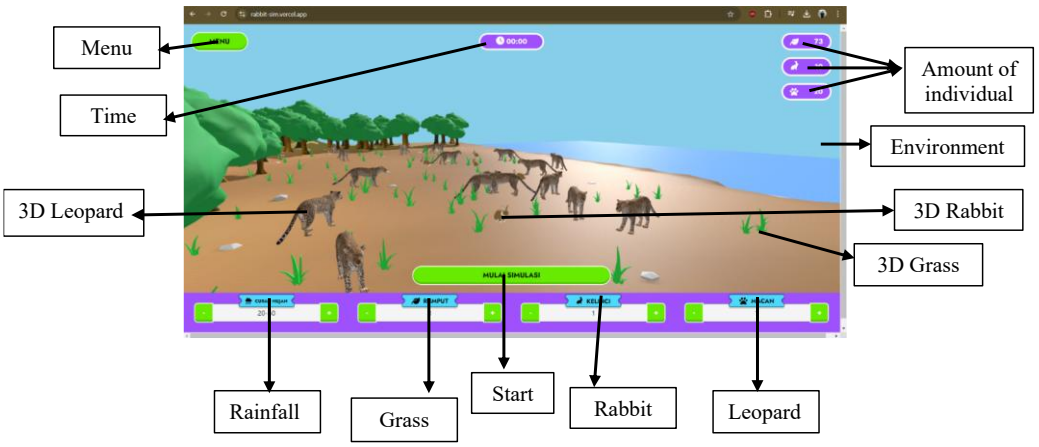


Figure 2. View of the Game-Based Learning Application containing Javan Leopards and Their Preys (Javanese Rabbits)

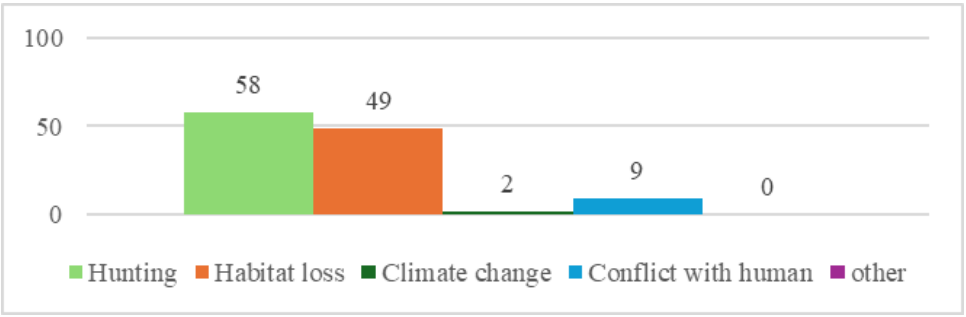


Figure 3. The Answers to The Biggest Threat to Leopard Conservation, according to Prospective Biology Teachers

Figure 2 was a display image of the entire application developed. The image depicted the design of a community in an ecosystem with a few species, as an image of the sustainability of each existing species.

Knowledge, Interests, and Attitudes towards Leopards' Threat and Conservation

The first question related to knowledge about leopards was the biggest threat to the Javan leopard in Indonesia. Based on the answers from prospective biology teacher students, the answers were in Figure 3 as follows:

Based on the answers submitted by prospective biology teacher students, the biggest threats to leopards were hunting with 58 answers (49.1%), habitat loss with 49 answers (41.5%), climate change with 2 answers (1.7%), and conflict with humans with 9 answers (7.6%). Based on the references studied, the main cause of the threat to the Javan leopard was the loss of Javan leopard habitat (As'ary et al., 2023; Gomez & Shepherd, 2021; Gunawan et al., 2017). The differences between student perceptions and scientific evidence indicated the need for improvements in conservation education, especially in providing a deeper understanding of the key factors affecting the survival of endangered species. Therefore, more data-based learning and scientific references need to be strengthened so that students can have a more accurate understanding of Javan leopard conservation. Table 2 was a follow-up question regarding the knowledge of prospective biology teacher students related to the conservation of the Javan leopard.

Table 2. Prospective Biology Teacher Knowledge about Javan Leopard Conservation in Indonesia

Statements	Yes (%)	No (%)
The Javan leopard is an endangered species	100	0
In the Gunung Sawal Animal Sanctuary, West Java, there is still a Javan leopard	87.3	12.7
The Javan leopard is the peak of predator on Java Island	84.7	15.3
I already know about the conservation efforts of the Javan leopard	70.3	29.7
In Indonesia, leopards do not attack human settlements	66.1	33.9
In Indonesia, leopards are naturally only found on Java Island	54.2	45.8
Javan leopards have been found outside conservation areas	49.2	50.8

Based on Table 2, almost all respondents (100%) were aware that the Javan leopard is endangered. This shows a high level of awareness regarding the threats faced by this species. Belief in Existence in the Wild: Most respondents (87.3%) were confident that the Javan leopard still exists in the Gunung Sawal Wildlife Sanctuary in West Java. This indicates that the Javan leopard population can still be maintained. Understanding of Ecological Role: Most respondents (84.7%) understood that the Javan leopard is the apex predator on Java Island, indicating an understanding of its important role in the ecosystem. Level of Knowledge about Conservation Efforts: Around 70.3% of respondents stated that they were aware of the conservation efforts of the Javan leopard. This shows that there are quite good socialization efforts regarding the conservation of this species. Myths about Attacks on Settlements: There are varying perceptions regarding leopard attacks on human settlements. About 66.1% of respondents believed that leopards did not attack human settlements, but there were still about 33.9% who had the opposite perception. Understanding of Natural Distribution: Most respondents (54.2%) understood that leopards were naturally only found on Java Island. Perception of Existence Outside Conservation Areas: Respondents' opinions were quite evenly divided regarding the possibility of finding Javan leopards outside conservation areas.

Figure 4 illustrates the source of information that prospective biology teacher students know about leopards for the first time. From the data presented, we could see that 54 respondents (45.8%) knew about leopards through television. This shows that television media has a significant role in disseminating information about wildlife, including leopards. Considering the era of prospective biology teachers as children, the internet condition is still limited, so a lot of information comes from television. According to Aitchison et al. (2021), it was difficult to measure the usefulness of various wildlife TV programmes that could reach global audiences. However, based on the responses from the respondents, television can provide essential information for education in identifying endangered species.

The second position was occupied by 32 respondents, with the source of information from teachers in schools (27.1%). This indicates that formal education in schools also makes a considerable contribution to introducing students to the animal world, including leopards. 16 respondents chose book (13.6%), 10 respondents chose video platforms such as YouTube (8.5%), and 1 respondent chose a lecturer (0.8%).

Meanwhile, other sources of information accounted for only 5 (4.2%) of the total

respondents, which were posters that usually display various types of animals.

Figure 5 shows the responses from prospective biology teacher students related to their interests in the conservation of the Javan leopard.

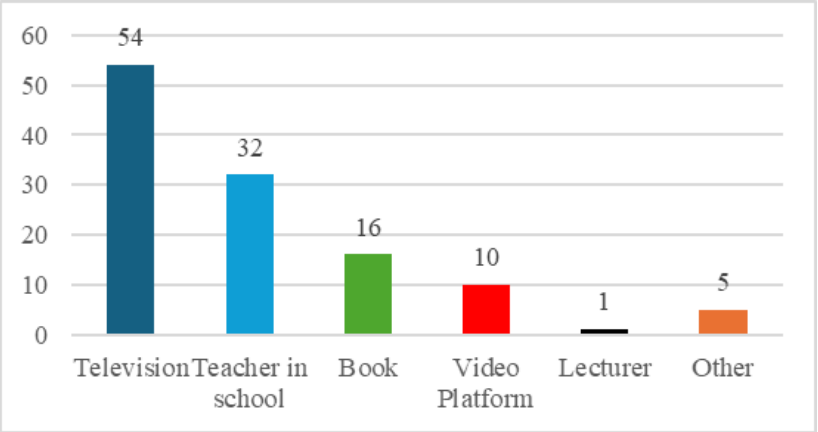
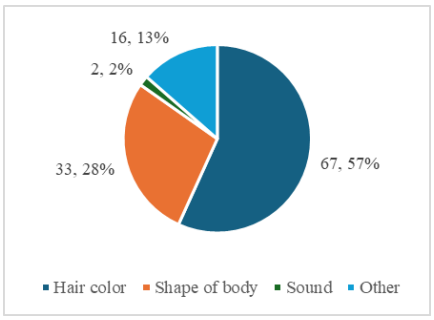
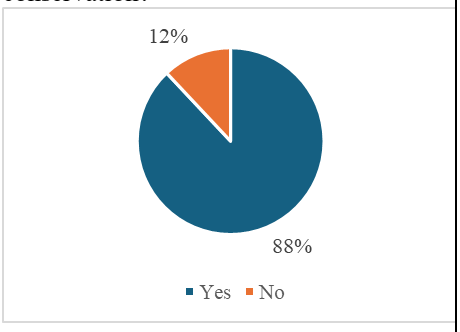


Figure 4. First Time Knew about Leopards

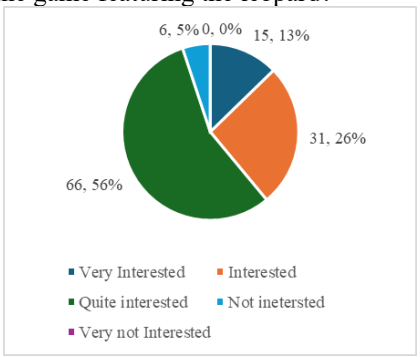
a. Physical traits of leopards



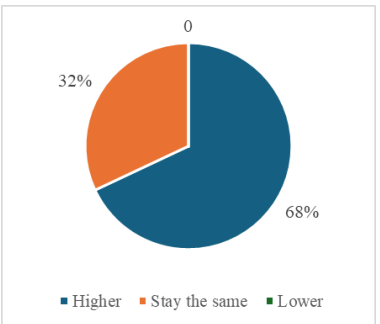
b. Do you feel like the game you played has increased your awareness of leopard conservation?



c. How interested were you in the topic of leopard conservation before playing the game featuring the leopard?



d. After playing the game, your interest inleopard conservation becomes:



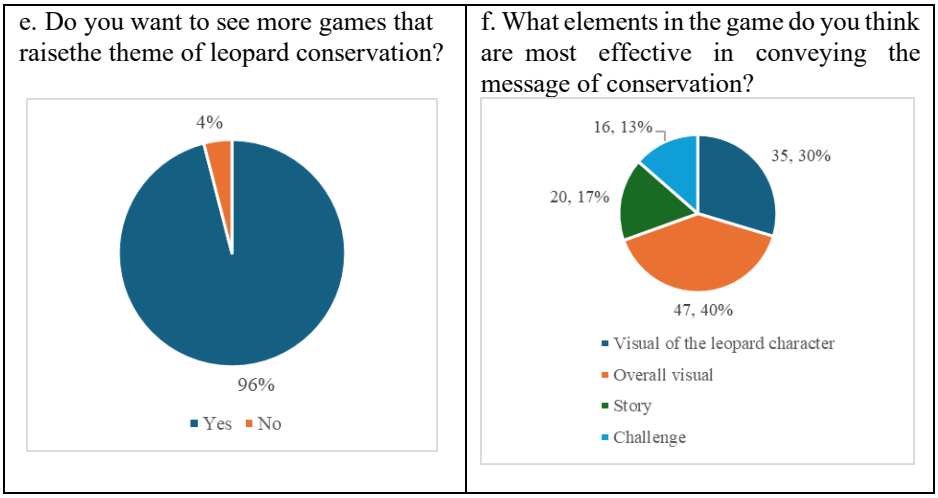


Figure 5. Prospective Biology Teacher Student' Interests in the Conservation of Javan Leopard

The first graph (a) shows the physical characteristics of leopards that respondents remember the most after playing the game. The results were quite interesting: most respondents remembered the colour of leopard hair (67.57%). This indicates that its distinctive coat colour is the most prominent and memorable physical feature. The second graph (b) shows the effectiveness of the game in raising awareness about leopard conservation. The results were very positive, as most respondents (88%) felt that after playing the game, their awareness regarding the importance of leopard conservation increased because the game managed to convey the message about the importance of animal conservation.

The third graph (c) shows the level of respondents' interests in leopard conservation before they played the game. The results showed that most respondents had a high interest in leopard conservation before playing the game (66.56%), meaning that they generally already had awareness of the importance of preserving wildlife. The fourth graph (d) shows the change in respondents' interest in leopard conservation after they played the game. The results were very positive with most respondents (68%) stating that their interest in leopard conservation increased after playing the game. This shows that the games played are quite effective in raising awareness and concern for wildlife conservation.

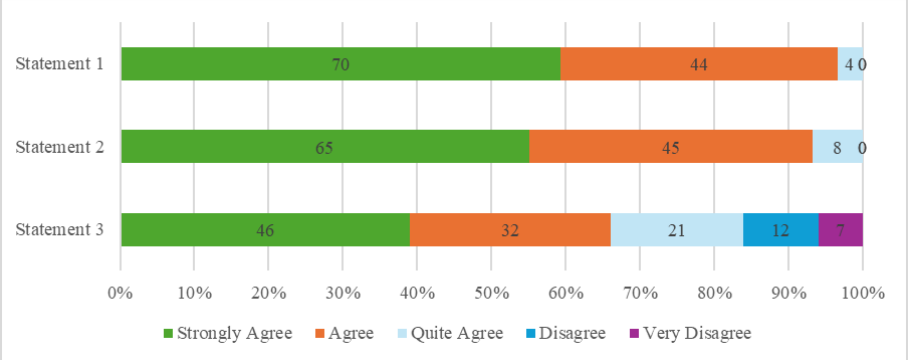


Figure 6. Attitudes of Prospective Biology Teachers towards Javan Leopard Conservation

(Statement 1: If I were a teacher or parent, I would teach students about the importance ofprotecting leopards; Statement 2: Conservation education should be integrated with the curriculum in schools; Statement 3: Leopards and humans can live in harmony)

The figure showed the results of a survey that measured the level of respondents' approval of three statements related to leopard conservation and conservation education. In Statement 1 (the invitation to teach the importance of leopard protection to students), the majority of 70 respondents (59.3%) strongly agreed, followed by 44 (37.3%) who agreed, while only 4 respondents quite agreed (3.4%). For Statement 2 (conservation education should be integrated into the school's curriculum), 65% of respondents strongly agreed, 45% agreed, 8% quite agreed, and none of the respondents disagreed. Statement 3 (humans and leopards can live in harmony) received more varied responses. Only 46% of respondents strongly agreed, 32% agreed, while 21% quite agreed. As many as 12% of respondents disagreed, while 7% very disagreed. From these results, there is strong support for the teaching of leopard conservation and the integration of conservation education in the curriculum, but there is more doubt aboutthe possibility of harmonious living between humans and leopards

Challenges Ahead in The Development of Game-Based Learning to Raise Awareness of Leopard Conservation

Based on this, questions were then made that led to recommendations and expectations for Game-Based Learning related to leopard conservation. Question 1: What features would you like to see in the game about leopard conservation? Question 2: How can the game contribute more to leopard conservation efforts in the real world? Question 3: What kind of games do you think can be more effective in educating the public about leopard conservation? This question can also be the basis for other researchers in the development of GBL for the conservation of endangered species in the future. The questions were analysed using Word Cloud as shown in Figure 7, Figure 8 and Figure 9 as follow.

Figure 7. Word Cloud on Expected Features in the Game

Figure 7 was the result of a Word Cloud that highlighted various keywords related to leopard conservation and aspects that support its protection efforts. The words "leopards" and "conservation" appeared most dominantly, suggesting that the focus was on conservation efforts for the species. Surrounding these words were important concepts such as "habitat", "features," "education," and "ecosystem," which referred to critical aspects of conservation, such as habitat conservation, educational elements, and the importance of ecosystem balance. Words such as "players," "game," and "simulation" denoted a game-based or simulation-based approach to engaging the public in conservation missions, in which players participated in scenarios of habitat management, species protection, and ecosystem restoration. Other concepts, such as "poaching" and "rehabilitation", emphasize challenges and solutions to preserve leopards in the wilderness. Based on the results of Word Cloud, it can also be concluded that some additional features in the game still need to be made, such as the addition of players because multiplayer games are quite a trend, and each student can interact directly in the game.

Figure 8. Word Cloud on the Contribution of Games towards Conservation in the Real World

Based on the Word Cloud in Figure 8, the game could contribute to the conservation of the Javan leopard. Based on the questions raised, most of the respondents' words obtained from the game could play a significant role in raising awareness and understanding of the Javan leopard conservation. The contribution of education through GBL using leopards provides various interesting perspectives. Games can also be given in another way, not only through digital form but also through simple learning, which is role-playing.

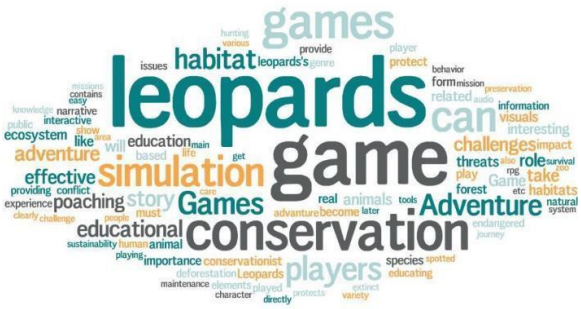


Figure 9. Word Cloud on Effective Types of Games for Conservation Education

Based on the results of the open questionnaire in Figure 9, the types of Javan leopard conservation games were depictions of habitats, simulations, adventures, and challenges. These various game recommendations can certainly contribute to Javan leopard conservation education. It also shows that games can effectively increase public awareness and understanding of the importance of preserving the Javan leopard species. Games have enormous potential to be an effective tool in educating the public about the importance of leopard conservation. By designing games that are engaging, educational, and relevant, we can inspire the younger generation to care about nature conservation and take concrete action to protect endangered species such as the Javan leopard.

Discussion

Game-Based Learning inserts information on the Javan leopard regarding its contribution to biodiversity conservation due to various factors: deforestation, plantations, and infrastructure development. Habitat loss reduces leopards' movement space and the availability of prey and disrupts the balance of the ecosystem (Shanida et al., 2018). The loss of such habitat can also increase conflicts with humans. Games can be a powerful tool to understand and overcome conflicts in conservation (Redpath et al., 2018). Prior knowledge of leopards from the prospective biology teacher can also provide an overview of what is included in their long-term memories when they first knew leopards. This proves that various media such as television, YouTube, books, and social media have increased public awareness of wildlife conservation (Shrader & Louw, 2023; Wu et al., 2018). From here, we must also realise the important role of teachers in schools to introduce the species that exist around their students.

Although the game only provides information about 3D images of leopards that are more oriented towards the community in ecology, it can provide a new insight into GBL that leads to the conservation of rare species. With the game, students can also learn about endangered organisms and the importance of biodiversity for life, as well as apply scientific knowledge and skills to educate the public about conservation (Hacıoğlu & DönmezUsta, 2020). The games should be developed more into other interesting and educational aspects that contribute to biodiversity conservation. This is in line with Tan et al. (2018), stating that if the conservation games were used correctly, they played an important role in making conservation more interesting and in-depth.

Based on the analysis of Word Cloud (Figures 7-9), the ideal leopard conservation game is not only to entertain but also to provide a powerful biodiversity conservation education. In GBL, players should be exposed to realistic ecosystem simulations, allowing them to play an active role in conservation missions that reflect real-world challenges. By including features such as species rescue missions, direct interaction with dynamic environments, and in-depth storylines, the game should also be able to

provide an educational and entertaining experience. In addition, it can be developed with additional multiplayer elements, charming visuals, and the integration of scientific knowledge, ensuring that this game is relevant and interesting for players of all ages, including students and the public.

The educational aspect of the game can focus on a deep understanding of ecology, leopard biology, as well as the significant role of biodiversity conservation. Through an interactive approach, players learn about the leopard's natural habitat, its threats (poaching and habitat destruction), and the conservation efforts being undertaken by experts. By engaging players emotionally through immersive simulations, the game also has the potential to develop empathy for wildlife and raise awareness about the importance of maintaining the balance of the ecosystem. Appropriate and interesting game-based game design can be used as a new involvement to improve ecological literacy, an ecological challenge related to biodiversity conservation (Callahan et al., 2019). GBL can serve as an effective educational tool, motivating players to take real action in their daily lives, supporting species conservation, as well as being part of real-world biodiversity conservation efforts.

GBL is recommended as an innovative method in protected wildlife conservation education, as it can provide an interactive, in-depth, and engaging learning experience. Through realistic ecosystem simulations and missions that reflect real conservation challenges, the game can improve players' understanding of the importance of preserving biodiversity. Students' involvement in educational games can affect the effectiveness of learning (Yu et al., 2021). Players are not only invited to understand the biological and ecological aspects of wildlife (such as leopards) but also invited to experience the firsthand impact of threats such as poaching and habitat destruction. This game can serve as an effective educational tool by motivating players to engage in conservation efforts through a fun and interactive approach. If this play-based learning continues to be developed, it could potentially support conservation research for players to collect data or utilise games in identifying solutions to real-world problems (Sandbrook et al., 2015). Thus, GBL has enormous potential in increasing public awareness, especially the younger generation, regarding the importance of protected wildlife conservation and the balance of the ecosystem.

Many studies have shown that GBL enhances students' engagement, motivation, and conceptual understanding of biodiversity and conservation issues. For instance, research by Wijoyo et al. (2025) stated that GBL used in biodiversity conservation learning can significantly increase knowledge. This is in line with the research conducted by Kamaruzaman and Rozuki (2024), which strengthens previous research on GBL in endangered species conservation by showing that interactive and immersive features effectively improve engagement, knowledge retention, and pro-conservation attitudes among learners. However, some studies (Adipat et al., 2021; Behnamnia et al., 2023; Jääskä & Aaltonen, 2022) have reported challenges in the use of GBL, such as limited accessibility, technology constraints (high cost), and physical game constraints that also impact cognitive load and stress. Although there are uncertainties regarding these challenges, this study is expected to provide new insights into GBL. In addition, while the study focuses on rare species such as the Javan leopard in the context of local conservation, it may offer unique findings that are not directly comparable to the broader GBL study.

Because this research is a preliminary study in the development of ecological education games, this research only includes the Javan leopard as one of the elements in the game. There is no analysis of thinking skills for prospective biology teacher students, because it is only a promotional medium for the conservation of the Javan leopard. The statistical analysis used is still simple; there is no way to see the correlation of various existing aspects between

knowledge and interest or knowledge and attitude. The GBL that has been developed will be further researched to see how the game affects critical thinking skills.

Conclusion

The study concludes that Game-Based Learning (GBL), which includes information about endangered species like the Javan leopard, has great potential to support biology education and raise awareness about biodiversity conservation. It is recommended as an innovative method for wildlife conservation education because it offers an interactive and engaging learning experience. With the right design and content, games can be both fun and effective for learning, while also promoting efforts to conserve endangered species. The study found that introducing local and threatened species through GBL for prospective biology teachers can improve their knowledge, attitudes, interest, and concern for the conservation of threatened species like the Javan leopard.

Acknowledgements

We extend our sincere thanks to Sukma Jaya and Atthariq Insanulhaq for their assistance in distributing the questionnaire and creating the 3D design of the leopard. We also appreciate the contributions of Ari Hardian and Asep Yudi Supriatna, laboratory staff of the Biology Education programme at Siliwangi University. Additionally, we are grateful to FORMATA (*Forum Konservasi Macan Tutul Jawa*) for continuously providing updates on the population and distribution of the Javan leopards, as well as for their dedication to public education, collaborative efforts, and various mitigation measures addressing human-Javan leopard conflicts.

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