

Connecting biogeography, ecology, and history through a game-based learning approach

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ABSTRACT

Biogeography, the study of the distribution of plants, animals, and other living beings on Earth, is an interdisciplinary science that is naturally based on several distinct disciplines, such as history, ecology, and geology. Nevertheless, to connect all these subjects may be tricky for beginners undergrad students. One useful tool is the Game-Based Learning (GBL) approach, a well-documented strategy for stimulating curiosity and enhancing student engagement in formal education. However, selecting appropriate games for GBL is difficult, especially when aiming for a multidisciplinary courses as ecology or geography, for instance, where educators need to teach natural and social sciences combined. The present work explores the use of an ancient type of unbalanced board game – the hunting games – prevalent across various cultures on different continents, to ignite students' curiosity and guide their interest across multiple disciplines. We begin with a systematic review of the history of hunting games and their educational applications. Subsequently, we examine the possible origins of these games and use this analysis to propose various applications of a game-based learning strategy that integrates natural and social sciences. This research offers valuable insights for educational policymakers and educators, demonstrating the benefits of GBL and highlighting the potential for incorporating cultural heritage aspects into new formal education projects.

Keywords: *Biogeography, Cultural heritage, Formal education, Game-based learning, Indigenous traditions, Multidisciplinary projects, The jaguar's game.*

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Highlights of this paper

- Traditional hunting games can contribute to a transdisciplinary approach, acting as a chain link between biology, geography, history, and mathematics.
- The identification of similar games in different parts of the world allows the application of the learning strategies in this work to various cultures and contexts across the globe.
- Aspects not yet clarified by the scientific community concerning the origins and dissemination of these games can stimulate students' curiosity and engagement.

1. INTRODUCTION

Could an ancient strategy game endure for thousands of generations and survive the journey across the Bering Strait to South America, ultimately being played by aboriginal people today both in Asia and South America? Several open questions led to the introduction of a multidisciplinary approach to teaching several disciplines, stimulating curiosity and strengthening the students' engagement in formal education.

Games are largely applied as appealing tools to foster students' enthusiasm in several disciplines (Dichev & Dicheva, 2017). Bai, Hew, and Huang (2020) review quantitative studies on gamification, and the authors show a positive enhancement in learning through the planned use of games in teaching. Beyond all types of games and available digital possibilities, board games still play an important role in students' lives.

Board games are exciting tools for teaching, and the subjects they cover can be naturally related themes like mathematics and probability when students need to foresee the next moves and their chance of winning, but also other topics, such as grammar (Paris & Yussuf, 2012) sustainability (Despeisse, 2018) interprofessional education (Schmuck & Arvin, 2018) nephrology (Zakaria, Zukiman, & Shah, 2020) and even cancer spread (Grigoryan, Ghazaryan, Varderesyan, Mkrtumyan, & Petrosyan, 2018). Those games were created aiming for educational improvements and can be part of a more detailed strategy for any academic level, such as those used in group learning activities (De Hei, Strijbos, Sjoer, & Admiraal, 2016). Still, games associated with cultural heritage from several civilizations bring excellent opportunities for teaching an extensive range of disciplines, promoting the discovery experience, and stimulating curiosity. Furthermore, some of these games are still played nowadays by the traditional communities where they are from, a practice that keeps local knowledge passed across generations.

In this context, 'The Jaguar's Game' is one of at least 13 distinct names given to very similar games in different regions across the world; most of them are described as hunting games. These hunting games share a strong link with the cultural heritage of the communities where people play them, especially in Asia and Latin America. All these similarities raise important questions concerning its origins and the way it spread through distant and different cultures.

This article aims to link the cultural heritage embedded in these hunting games to new teaching and learning possibilities for educators and students. It will start with the method used for research, followed by a systematic review of the use of hunting games in education and its origins. Next, in the discussion section, explaining what the

game is, where it seems to come from, and its link to the cultural heritage; finally, we discuss the scientific literature concerning the game organizing the search in themes: mathematics, geography and history, and biology and how it can be used in new educational projects.

2. METHODOLOGY

Before presenting and discussing the possible multidisciplinary strategies of hunting games in formal education, we aim to demonstrate the relevance of these hunting games in the educational process embedded into the cultural heritage of several traditions. To do so, we started with a short definition of game-based learning (GBL) strategies, and next, we performed a systematic review of this theme, which aims to highlight the existence of similar traditions in such different cultures across the world and use this fact to discuss the diversity of application possibilities of such games in several disciplines of formal education.

We determined the keywords for literature selection following multiple search iterations, varying the searched terms combinations and using Boolean operators. We started with the Portuguese term “O jogo da onça” and its English and Spanish translation, and combined it with the description of similar games in the book of Murray (1952). As consequence, we used the information about hunting games in other books, such as Culin (1898); Parker (1909); Murray (1952); Bell (1969) and Depaulis (1998) and in the articles from Capettini (2004); Musser Golladay (2007); Vinha (2010); Lima, Ramos, and Carvalho (2014); Kimara (2018) and Nascimento and Guedes (2019). We searched for academic articles from the period up to 2023, using: Web of Science, Science Direct, Taylor and Francis Online, Sage Publications, SpringerLink, Wiley Online Library, and Google Scholar. We also searched for different terms using a few transliterations from Asiatic languages. All those different names and the corresponding places are detailed in the following sections. For selection (or exclusion) criteria, we aim at both cultural descriptions and educational research, such as the context in which the games were played, different applications of the games in formal education, as well as eventual computational analysis of the games. Furthermore, we searched for websites, regional and local newspapers and communities in social networks, once there were several initiatives from the non-academic sector to promote the indigenous culture, especially in South American languages, i.e., Portuguese and Spanish. The selected articles, books and websites are cited in the Discussion section. Figure 1 shows a schematic summary of the methods.



Figure 1. Schematic representation of the methods.

2.1. Limitations

This study has encountered limitations concerning: (a) the lack of English literature about hunting games, most of the specific literature was found in Brazilian Portuguese and Spanish; and (b) the absence of self-provided texts from the aboriginal communities, most of which we found was produced by non-indigenous scholars, which limits the historical outreach of this research. Furthermore, this study focuses on the educational application of such hunting games, and also on the history of such traditional board games in the cultures in which they occur.

3. LITERATURE REVIEW

3.1. Game-Based Learning

This work is not on gamification, i.e., we do not suggest using typical game strategies in no-gaming situations, such as rewards, badges, etc, as detailed by Dichev and Dicheva (2017). Indeed, the use or the study of an existing game aiming at one or more learning objectives is better described by game-based learning. Connolly, Boyle, MacArthur, Hainey, and Boyle (2017) showed that game-based learning strategies can deliver a positive impact on 21st-century skills, namely, creativity, cooperation and problem-solving. Still, this strategy could be enhanced by planning the choice, the adaptation, the implementation and the evaluation of the game used as a base (Pan et al., 2021). Nevertheless, there are known limitations of such a strategy in the educational process, as pointed out by Greipl, Moeller, and Ninaus (2020): The games maybe not always engaging for all learners, and they can be expensive to develop and implement, especially in developing countries. Another important issue is the limited application on higher education, as pointed out by Hung (2017).

The games we discuss in this work, also known as hunting games, solve most of the limitations typically found on GBL, once they are inexpensive and strongly linked to the cultural traditions of several cultures.

3.2. Ancient Hunting Games

In this work, we were especially focused on a specific kind of hunting game, those that are already part of the traditions of different aboriginal people, which we call ancient hunting games. Table 1 shows the numeric result of the literature survey concerning this theme. One important aspect to mention is that most of the results on Scholar Google are not complete articles, but abstracts from seminars and conferences, with little or lacking available information from their original work.

Table 1. Main numbers concerning the survey of these themes on three scientific databases.

Key-words and Boolean operators	Scholar Google	Science-direct	Springer-link
"jogo da onça" (pt)	209	0	1
"Adugo" AND "game" (en)	46	0	1
"Adugo" AND "jogo" (pt)	61	0	0
Yaguarete korá (es*)	42	0	0
"los tigres y los perros" (es)	8	0	0
"ajedrez guarani" (es)**	1	0	0
"komikan" AND ("juego" OR "game")	21	0	0
"Tigers and Goats" AND "game"	41	1	6

Note: * Actually, it is a Guaraní name typically used for Spanish speakers in Latin America.

** There were 1.190 results of the "Ajedrez guarani" term directly on the Google search engine, including not only dedicated webpages but also communities in social networks such as Facebook or Instagram.

The most studied (or at least, the most published) hunting game is The Jaguar’s Game (TJG), a translation from ‘O Jogo da Onça’ in Portuguese. It is a board game for two players, traditionally played by native indigenous people in South America. According to the classification used by Bell (1969) we can label it as a war game where the two

players have different roles and objectives, which is often called a hunting game. There are descriptions of this game, still with different names, as being part of indigenous groups in different regions: ‘Adugo’ in the Mato Grosso State, ‘Jogo da onça’ in all the other Brazilian States (Agencia Estado, 2003) and ‘Yaguareté Korá’ (in Guaraní language it means ‘The Jaguar’s Cave’) or ‘El Ajedrez Guaraní’ in Misiones region by Mbyá-Guaraní people, in Argentina and Paraguay (El Orijiverde, 2020). Additionally, it is known as Komikan among Mapuche people between Chile and Argentina (Capettini, 2004; Hajduk, Lezcano, & Cúneo, 2013) and Taptana in Chile and Peru (Depaulis, 1998). The game’s rules vary slightly between all regions of South America, but in all of them, the hunter piece is a jaguar and the other pieces are other mammals that the jaguar can devour. There have been local movements in those regions aiming to promote this game and its cultural heritage dissemination, especially in the last decade.

3.3. The Rules of The Jaguar’s Game

The discussion of the regional variation of the game’s rules needs a referential set of rules. For this purpose, we will adopt the Brazilian group of rules for the initial description, once it is the version with more scientific literature available. TJG is a two-player board game played with two types of pieces. One of the players is the Jaguar - a single piece that is more free to move - while the other player is in charge of 14 dogs. All these pieces are displayed on a board (Figure 2 (a)) very similar to Alquerque’s board. According to Bell (1969) it probably arrived in Europe with the Moors invasion in the 8th century. Figure 2 (b) shows the game’s initial setup. The set of spots in the bottom part of the game board is called “the jaguar’s cave”, which is also one of the game’s names, and it is an important difference from the Alquerque board.

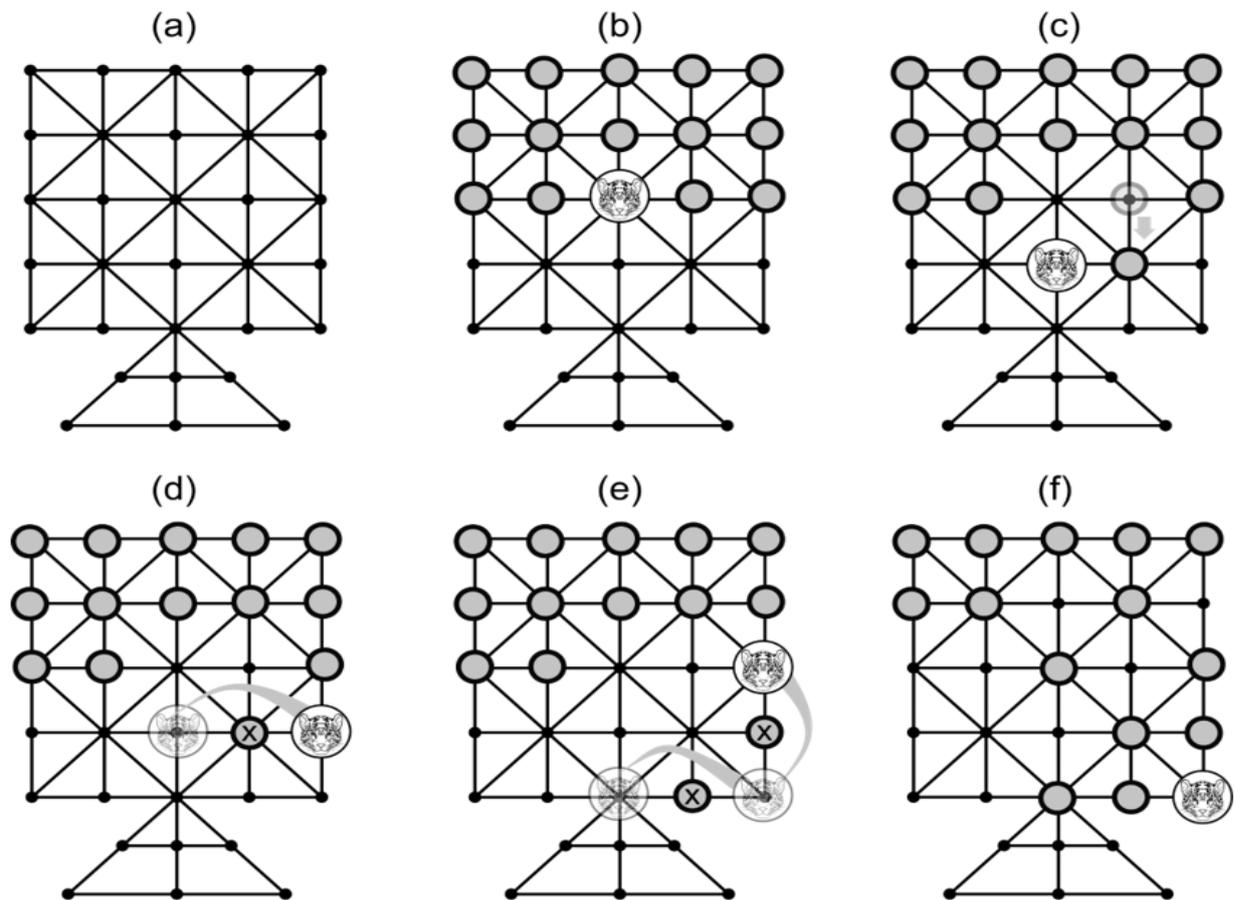


Figure 2. (a) TJG board, in which the pieces are arranged as shown in (b) for the initial setup of TJG in the Brazilian style. (c) The jaguar is the first to move, and the players alternate turns. The jaguar can “eat” or “capture” (d) one or (e) more dogs; (f) the dogs win when they corner the jaguar (Author’s original work).

The jaguar piece is the first to move, and it is free to move to each adjacency spot, as illustrated in Figure 2 (c). The goal of the Jaguar player is to capture (or to devour) at least five dogs - and the Jaguar piece can do so by jumping over one or a chain of dogs, as exemplified by Figure 2 (d) and (e), respectively. The dogs' goal is to corner the jaguar in such a way the jaguar is no longer free to move, which is shown in Figure 2 (f). Each player can make one single move per turn.

3.4. The Boards

The game board may seem complex or unusual for beginners, but it is simple and can be quickly drawn by hand, following the steps shown in Figure 3. Indeed, native people from South America usually play TJG on the ground (El Orijiverde, 2020; Lima et al., 2014; Vinha, 2010). Also, the pieces can be made out of similar and smaller stones or pieces of wood for the dogs, and a slightly different object for the Jaguar. In Figure 4, pictures dating from 2003 show an elder chief of Meruri (a tribe of the Bororo indigenous people in Brazil), explaining how to draw and play the game.

In the following sections, we discuss the open questions about the game origins and the potential of TJG as a multidisciplinary approach for teaching not only 'Science, Technology, Engineering and Maths (STEM)''-related disciplines but also social sciences. These applications are suitable not only in the countries where TJG and its related games are from but indeed in every place in the world in which teachers intend to promote a ludic opportunity to discuss history, biology and geography.

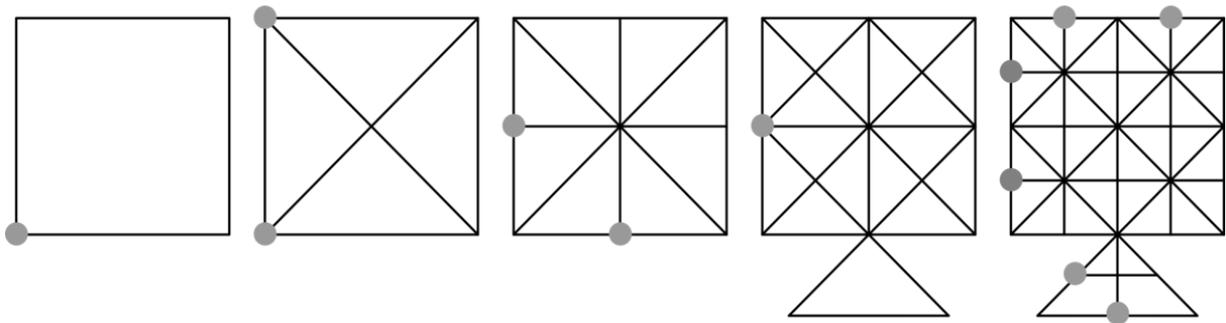


Figure 3. Starting from the left, a practical step-by-step procedure to draw the gameboard of the Jaguar's Game, in which the big square is crossed (second panel), which can help to align the next lines (third panel and so on). The grey circles indicate the spots where one should begin drawing the lines (Author's original work).



Figure 4. On the left, the elder Chief of Meruri shows how to draw the board game Adugo on the ground, and how to play it using pieces of rock, at the right. Photographed by Fabian Silbert and Alfredo Alves during an expedition led by Mauricio A. Lima into the Bororo's region (Brazil) in 2003. Courtesy of Mauricio A. Lima, in private communication.

4. DISCUSSION

4.1. Questions Concerning the Game's Origins

Among the slight differences within the game rules in South America, we highlight a few: In Paraguay and Argentina, there are 15 dogs, and the initial setup is different - the Jaguar begins inside its “cave” (El Orijiverde, 2020). Furthermore, the cave’s size differs between regions in South America, being bigger in Peru, as illustrated in the insets in Figure 4. In this context, missing information concerning the game’s origin could shed light on the beginning of these differences. Table 2 summarizes the main differences among these hunting games.

Table 2. The main differences in rules of the traditional hunting games similar to TJG.

Country or Region	The main difference compared to TJG
Paraguay and Argentina (Misiones)	There are 1 Jaguar vs 15 dogs; The jaguar’s initial position is different from TJG.
Peru	The “cave” is bigger, with more spots.
Spain and Mexico	There is no “cave”, and in Spain, the “hunter” description is inverted.
Nepal	There is more than one hunter, the Tigers.
Sri Lanka	There are four “caves”.
Japan and China	There are 1 warrior vs 16 soldiers.

Some authors Lima et al. (2014) and Vinha (2010) discuss the hypothesis that TJG was introduced in South America by European settlers and missionaries, inspired by the Fox and Geese board game, a well-known hunting game (Bell, 1969). However, a closer look at the practice of both games shows essential differences between them. On the other hand, Alfonse X, in 1283, described a much more similar game called “corner the rabbit”, in which eleven “men” need to trap a rabbit, in the same way as described for the dogs in TJG, and the rabbit can capture the men by jumping over them (Musser Golladay, 2007). Nonetheless, the “corner the rabbit” game has no cave on the board, just as the game played in Mexico, called the Coyote and Chickens (Kimara, 2018).

The first writing reports mentioning TJG are a dictionary of the Inca native language from Santo Tomás in 1560, and a short description by Bertonio in 1612 (Depaulis, 1998). Furthermore, Depaulis (1998) shows an interesting illustration of “The Inca emperor Atahualpa playing taptana in jail with his guard”, dated from 1615, where one can clearly identify an Alquerque board - the same used in TJG and “Corner the rabbit”. Since the establishment of a net of pathways called Peabiru linking the Peruvian Andes to the Atlantic coast in pre-Columbian times (Bustamante, Pádua, Maia, & Ferreira, 2014) TJG could have been created by (or introduced to) Inca people and spread throughout the Peabiru pathway towards the tribes located in today's Brazil. Nonetheless, there are Asiatic traditional games that are surprisingly similar to TJG, as described in the following section.

4.2. The Similarity with Other Board Games and Geographical Distribution

The Alquerque group of games are all based on the Alquerque board, and according to Musser Golladay (2007) the first mention of its name dates from the 10th century. Most of the games based on this board are war games, in which both players have the same number of pieces and have the same goal - which is very different from TJG goals. Murray (1952) suggests that Spanish people may have learned “corner the rabbit” from the Moors, and he also claims that the game described by Alfonse X in 1238 is the first description of a hunting game. Furthermore, due to the non-existence of this kind of game in Africa and the lack of written reports in older Arabic literature, Murray (1952) states its origins should lie in Asiatic cultures. Indeed, there are several TJG-like games in Asia - and, surprisingly, they do have one or more caves on the board.

In Nepal, there is a traditional board game called ‘Bagha-Chall’, also known as ‘Tiger and Goats’, which is surprisingly similar to TJG (Jin & Nievergelt, 2009). Some authors (Agarwal & Iida, 2018) describe Tiger and Goats

as a millenary game whose rules did not change all over the centuries, without referencing older literature about the game's origin. (Parker, 1909) also describes 'Diviyan Keliya', translating it as 'Leopards and Cattle', played in Sri Lanka, also very similar to TJG, but with four caves, instead of one in TJG. In his analysis, cattle always win when played carefully. Culin (1898) describes a similar game called 'Juroku Musashi', played in Japan, where 16 soldiers play against one general on a board with caves. Culin (1898) also wrote about a Chinese version of Juroku Musashi, called 'Shap luk kon tséung kwan', which is played by men and children in the street drawing the board on the ground. Figure 5 shows an illustrative world map, where there are reports of variants of TJG played by local communities.

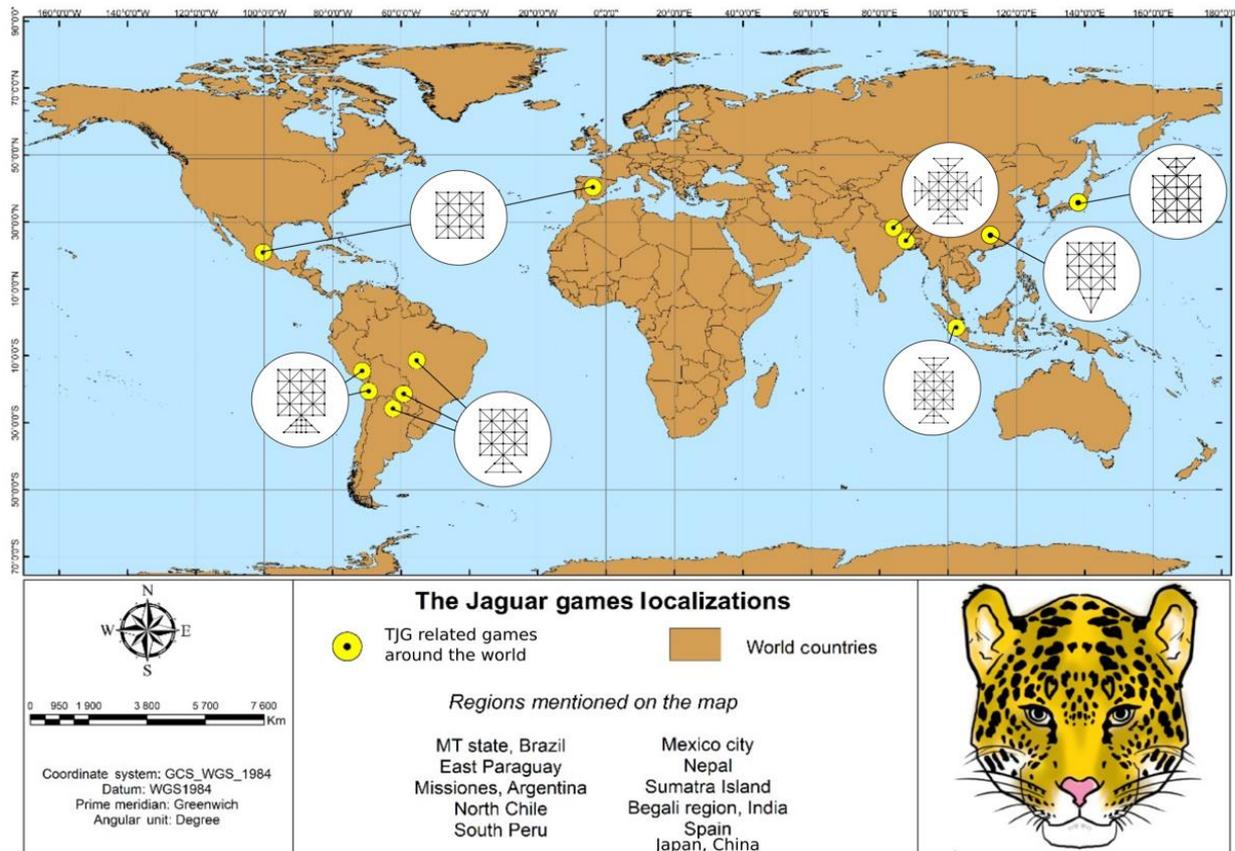


Figure 5. World map of TJG-related games around the world, showing their approximate site and the board used.
Source: Lima et al. (2014); Vinha (2010); Murray (1952) and Culin (1898).

4.3. Open Questions

Concerning the origin of the game, to the best of our knowledge, there are still important open questions, which can be used as a starting point for several GBL and multidisciplinary projects:

i) If the advent of the hunting games came to Europe with the moors but started in Asia, as suggested by Bell (1969) why do the boards in Asia and South America have more similarities than the version 'Corner the Rabbit' report firstly in Spain in the 13th century?

ii) Both in Asia (by the local communities) and in South America (by some Indigenous groups) the game is played by drawing the board on the ground and using rocks, seeds, etc., as pieces for the hunter and the prey. Is there any possibility for an ancient origin of this game in Asia before the peopling in America (Mendes, Alvim, Borda, & Tarazona-Santos, 2020) through the bearing bridge at the end of the last ice age?

iii) While in Asia the hunter is the tiger, a native animal, and the prey are usually the goats, also natives from Asia, why in South America indigenous people use dogs as the prey.

Regarding questions (i) and (ii) there is still room for field trips and archaeological work, but one can use question (iii) to discuss a set of important issues, as detailed in the next section.

4.4. the Role of the Dogs

In the game, a new player who chose the dogs to play may see it as a disadvantage against the jaguar piece, which is more free to move. Nevertheless, the collective effects of the dog's pieces soon show up as a balanced situation. In the wild, not all caninids hunt in pack formation as wolves do. The maned wolf in Brazil (*Chrysocyon brachyurus* Illiger, 1815), for example, lives and hunts alone. Works conducted by Chavez et al. (2022) and by Perini, Russo, and Schrago (2010) shows there are more than 10 different species of native caninids in South America, but none of them is wolves or none of them was domesticated as the dogs were from the wolves. Nevertheless, Bergström et al. (2020) work on biogeography and archaeology shows that there were domestic dogs in pre-Columbian cultures when the European explorers arrived at the end of the 14th century, especially in Maya and Inca-related cultures (Bergström et al., 2020). Additionally, there was a group of indigenous people who lived in Rio Grande do Sul state in Brazil 1500 years ago where dog fossils revealed evidence for the presence of domestic dogs in Brazil (Guedes Milheira, Loponte, García Esponda, Acosta, & Ulguim, 2017) but there was no continuity of dogs among the next generation of indigenous populations in such region. Furthermore, a genetic study of fossils revealed those dogs in Maya and Inca domains were descendants of Asian dogs, probably coming with the first humans from the north (Bergström et al., 2020). This chain of facts leads to the question: why do Brazilian indigenous people use dogs to chase the Jaguar in the game, even without dogs (or wolves) in their daily life? Furthermore, does the Jaguar eat dogs?

Dogs were one of the first species to be domesticated by humans, being an essential ally for ancient populations (Clutton-Brock, 1995). Currently, this interaction remains with other purposes, and the global population increase suggests that there are over one billion of these animals worldwide (Gompper, 2014). The dog population growth has shown direct and indirect adverse effects on natural communities, such as predation, pathogens transmission, competition for resources and hybridization. Historically, this interaction contributed to the extinction of 11 vertebrate species and 188 threatened species globally (Gompper, 2014).

Many vertebrate species interact with dogs as potential predators and competitors or even as prey. At least 13 wild predators have been recorded to consume dogs, such as the grey wolf (*Canis lupus* Linnaeus, 1758) in Europe, leopard (*Panthera pardus* Linnaeus, 1758) in Asia, puma (*Puma concolor* Linnaeus, 1771) in North America and South America, and hyenas (*Hyaena hyaena* Linnaeus, 1758) in Africa (Butler et al., 2014). Several wild species are hunted with dogs, but the jaguar is particularly dangerous because it can ambush dogs in the Forest (Koster, 2009). Other species potentially hazardous to dogs, such as the puma (Fletcher, 2006; Miranda, Menezes, & Rheingantz, 2016) ocelot (*Leopardus pardalis* Linnaeus, 1758) (Husson, 1978) and giant anteater (*Myrmecophaga tridactyla* Linnaeus, 1758) (Husson, 1978) discourage the use of this animal by hunters in the Neotropical regions. Even so, dogs are widely used in hunting and are considered a strategy that maximizes capture success (Koster, 2008).

4.5. The Jaguar Feeding Habits

The jaguar (*Panthera onca*, Linnaeus 1798) is the largest Neotropical feline and has its ecological importance in the top-down control of prey populations and small predators (Fisher, Russ, & Alcalá, 2001; Roemer, Gompper, & Van Valkenburgh, 2009). Its biogeographic distribution shows that it is widely distributed across various habitat types in America, the jaguar occupies a high position in the trophic chain and plays an important role in regulating ecosystems (Perilli, Lima, Rodrigues, & Cavalcanti, 2016; Rabelo, Aragón, & Bicca-Marques, 2019).

Considered an opportunistic predator, the jaguar has a generalist diet with high prey diversity, although it shows a preference for medium and large port prey. Jaguars have strong jaws adapted to attack prey with armour to defend themselves (Miranda, Jácomo, Tôrres, Alves, & Silveira, 2018). The prey diversity mainly includes mammals and reptiles, like capybaras (*Hydrochoerus hydrochaeris* Linnaeus, 1766), anteaters (*Myrmecophaga tridactyla* Linnaeus, 1758 and *Tamandua tetradactyla* Linnaeus, 1758), deer (*Mazama americana* Erxleben, 1777 and *Ozotoceros bezoarticus* Linnaeus, 1758), pigs (*Pecari tajacu* Linnaeus, 1758 or *Dicotyles tajacu* Linnaeus, 1758 and *Tayassu pecari* Link, 1795), raccoon (*Procyon cancrivorus* Cuvier, 1798), armadillos (*Dasyus novemcinctus* Linnaeus, 1758 and *Euphractus sexcinctus* Linnaeus, 1758), coati (*Nasua nasua* Linnaeus, 1766) chelones (*Chelonoidis carbonaria* Spix, 1824), caimans (*Caiman yacare* Daudin, 1802) (Azevedo & Murray, 2007; Miranda et al., 2016; Perilli et al., 2016). Although there are few attacks on human reports, domestic animal predation on farms is common and results in human-jaguar conflicts. These conflicts between humans and predators have been present since the beginning of animal domestication about nine thousand years ago. Since then, jaguar attacks on farms in Neotropical regions have been documented in Venezuela, Hoogesteijn, Hoogesteijn, and Mondolfi (1993) and Polisar et al. (2003) Chile (Rau & Jiménez, 2002) Argentina (Perovic & Herrán, 1998) Belize (Rabinowitz1 & Nottingham, 1986) and Brazil (Conforti & Azevedo, 2003; Manzatti, 1999; Mazzolli, Graipel, & Dunstone, 2002; Michalski, Boulhosa, Faria, & Peres, 2006; Rylands, Silva, Calaça, Sábato, & Oliveira, 1995). Although the role of domestic animals in the jaguar's diet is still unknown, dogs are often mentioned as prey for these animals (Palmeira & Barrella, 2007).

To update the game, one can suggest other native species which could play as “dogs”: the white-lipped peccary, the *Tayassu pecari* (Link, 1795), known in Brazil as “queixadas”, could be an interesting opponent to the Jaguar in the game - they are always in groups of dozens and are protective against hunters - even human hunters are afraid of a group of white-lipped peccary. A similar description could be made for coati (*Nasua nasua*). Also, the giant otter (*Pteronura brasiliensis* Gmelin, 1788) lives in groups and is spread throughout a great part of South America.

4.6. Analysis: the Jaguar's Game Applied in Formal Education

Several authors have been promoting the dissemination of indigenous culture in Latin America. Nonetheless, most of the literature on this subject is published in Portuguese and Spanish. The educational focus on the indigenous culture and environmental issues is seen in the works of Vinha (2010) and Da Silva Pereira (2020) respectively. There was also an institutional application of the game, in the Cultural Competition of the Jaguar's Game promoted by the Municipal Education Secretariat of São Paulo city, Brazil, held in 2020. The goal was to encourage the construction of a board with pieces from TJG using alternative materials. This approach aimed to stimulate students to play the game with other family members even without a printed version of the board game (São Paulo, 2020).

4.6.1. Mathematics-Related Disciplines

In Brazil, there were initial studies on improving the teaching of mathematics by using TJG as an appealing starting point in formal education (Da Silva Pereira, 2020). There was also technical analysis about the game possibilities, still in Portuguese, concerning TJG. Nascimento and Guedes (2019) estimated the game tree by the brute force approach - a method to measure the game's complexity, by making a grapho where each board state is a grapho node, and the nodes are connected by lines to all the other nodes describing a possible next move. This study revealed that TJG has a higher complexity than Draughts' game.

Similar studies were also made concerning Asiatic hunting games. Agarwal and Iida (2018) estimate the game refinement value and difficulty level for two variants of 'Tiger and Goats', also discussing the game's origin and popularity. Roza, Siregar, and Solfitri (2020) used 'The Game of Rimau' to address a set of competencies linked to

Mathematics Learning Activities (MLA): such as “Analyze relationships between angles as a result of two parallel lines cut by a transverse line”, “Associate the perimeter and area formulas for different types of squares and triangles”, and “Explain empirical and theoretical probability for the occurrence of an experiment”. These competencies are broken down into a list of MLA describing, step by step, which action should the teacher and the students perform to deal with that competency. The authors use ‘The Game of Rimau’ as a background and as an appealing issue to perform MLA concerning basic geometry (by drawing the basic shapes and calculating their parameters), geometric transformations (such as reflections, rotations and translations), and introduce probability studies to teenagers.

Additionally, [Yew-Jin and Nievergelt \(2004\)](#) analyzed the ‘Bagha Chal’ game (‘Tiger and Goats’), splitting the game into three phases: a placement phase, a sliding phase and an endgame-sliding phase. Although the authors classify their study as incomplete, they estimated that the tiger (equivalent to the jaguar) has a better chance in the beginning, but goats (similarly to the dogs) have more possibilities in the long run.

4.6.2. Geography and History

One of the biggest challenges in teaching geography and history, in recent years, is to migrate from the teaching method based on explanation of concepts (historic model of teaching in Brazil), towards more interactive and citizen-based teaching. This last method reinforces logical reasoning and students' emotional intelligence ([Kaya, 2018](#); [Pereira, Araújo, & Holanda, 2011](#)).

Therefore, several pedagogical strategies emerge with the aim to contribute to more efficient teaching of geography. As examples, we can cite problem-based learning ([Pawson et al., 2006](#)) interactive technologies ([Su, Huang, Zhou, & Chang, 2017](#)) and electronic and board games. In the context of board games, TJG gains significant prominence in the teaching of geography and contributes to various aspects of geographic knowledge.

As it is an indigenous game, it refers directly to the history of the formation of the Brazilian people and their origins, allowing them to address the recovery of cultural values that were abandoned or lost during the globalization process and that are currently reflected in expressions of prejudice. In addition, this approach directly complies with what is proposed in the Brazilian Federal Law 11.645, which establishes the guidelines and bases of national education, to include in the official curriculum of the Brazilian education network the mandatory theme "Afro-Brazilian and indigenous history and culture" ([Goulart, Da, & Melo, 2013](#); [Santos, 2018](#)). The theme of the game and its adaptable character also contributes to the teaching of physical geography. As simple as it may be, it is possible to approach the theme of Brazilian morphoclimatic domains ([Ab'saber, 2012](#)) and the dynamics of different landscapes ([Stintzing, Pietsch, & Wardenga, 2020](#)) from the occupation patterns of the animals chosen in the game, by asking the students to choose which animal could be the hunter and which animals could be the prey depending on the given natural habitat.

Within the landscape conjuncture, we still notice that The Jaguar's Game allows us to analyze the territorial expressions of the geographic spaces, which are where occur the social, environmental, economic and political dynamics, physical bases of geographic study; Analyzing the objectives and movement patterns of the game pieces, we can say that this is an activity that encourages the cognitive development of spatial intelligence, considering that the main skills that define spatial intelligence have a remarkable influence on the understanding of geographic space, as proposed by [Bez \(2011\)](#). As spatial intelligence skills are stimulated by the game, we can mention the notions of spatial location (from the understanding that the action position refers to geolocation and, consequently, to a geographic coordinate) and the learning of the cardinal points from the movements of the characters.

The biogeography discipline is also an interesting example. Introducing a naturally multidisciplinary subject such as biogeography can be challenging. Usually, this concept is not well understood by students even at the

undergraduate level, as shown by [Morales-Ramirez and Wang \(2022\)](#) in a Singapore survey among Geography students. The open questions concerning these world-spread hunting games may work as a starting point to discuss biogeographic concepts such as environmental biogeography, human biogeography and spatial biogeography.

In short, TJG is an efficient pedagogical tool for teaching geography, mainly because of its ability to stimulate sociocultural (such as indigenous themes) and environmental/spatial aspects (landscapes, biomes, morphoclimatic domains, spatial intelligence, etc.), reaffirming its importance as a disseminator of geographic knowledge within a modern learning context. Furthermore, the open question about the geographical distribution of hunt games, as shown in Figure 4, can be used as a starting point to ask questions like: What do those regions have in common? Is there any important geographic feature linking those regions? Concerning geopolitics, colonisation and travel trades, one also can ask why are there no similar games in Africa, North America and Oceania. Future uses of TJG in formal education can benefit from several mysteries concerning the game origin, the geographical distribution of similar games and the symbolic role of its pieces.

4.6.3. Biology and Ecology

In the teaching of natural sciences, one can use TJG at different education levels:

(i) In early childhood education, TJG will present nature and animals playfully, enabling children's contact with wildlife and show the importance and existence of the interaction between species, not only about the South American fauna but also in the Asiatic versions of the hunting games, showing similarities between the wildlife in different continents.

(ii) As for the teaching of young people and adolescents, notions of food chains, foraging, and species interactions can be explored and the importance of cooperation between individuals to protect against hunters. The Jaguar's Game can be applied to introduce or reinforce concepts of ecological interaction, such as predation, for example. Predation is fundamental to regulating the size of prey and predator populations in an ecosystem, maintaining its dynamic balance. With the game it is possible to show the function of prey and predator in an ecosystem, reinforcing the importance of conserving both, and emphasizing that the predator is not always the villain, since it regulates the prey population size and *vice versa*.

(iii) At the undergraduate and graduate levels, the deepening of ecology issues can be addressed, such as the species' living area, the impacts of landscape changes on the environmental balance, and the importance of biomes and ecosystems. The game can also be applied to show how some animals at the top of the chain, for example, the feline *Panthera onca*, need large areas for effective feeding and reproduction. According to [Oliveira \(2013\)](#) the average area required for *Panthera onca* in the Brazilian Amazon is 100 km² for 1 or 2 individuals and may be smaller in more anthropized areas, i.e., where the land use and the land cover are used for farming or other human activities. In this sense, TJG can also help to reinforce the fact that the loss of natural habitat, due to extensive human activities, can cause extinctions, especially of predators. The game can also highlight the importance of protected areas since they can be the main or even the only places foraging and sheltering for them.

(iv) Moreover, for the general public, the game can be used as a source of environmental education to bring people closer to nature-conservation topics, presenting and valuing the indigenous cultures. Another interesting approach is to explain why predatory animals, which occupy the highest trophic levels in the food chains, need so many preys. In the game, for the jaguar to win it needs to capture at least five dogs, and in the food chains, this makes perfect sense. Carnivores at the top of the food chains have a smaller amount of energy since it is dissipated in the previous trophic levels ([Odum & Barrett, 2009](#)).

5. CONCLUSION

The academic literature on The Jaguar's Game and related hunting games are reviewed and presented as an multidisciplinary possible strategy for game-based learning projects. Also, the present work organized the information concerning the origin of this kind of traditional hunting game. Although it does not answer the questions about the origin of mentioned hunting games, this work states clearly the limits of the existing literature concerning this subject. Additionally, it analyzes the local and regional studies on the application of game-based learning strategies in different disciplines of formal education, such as mathematics and geography. In summary, the use of board games linked to cultural heritage allows teachers and students to appreciate the funny experience of playing, while working enthusiastically on transdisciplinary subjects, such as: (i) History - Why is this game so close to Asiatic games? (ii) Biology, Ecology and Nature conservation - What are the jaguar feeding habits? Does the jaguar really eat dogs? Did the Incas have dogs? (iii) Geography - Where was (or still is) this game played? Are there differences among the different groups who still play it? What do these different regions of the world have in common? To the best of our knowledge, some of these questions, especially concerning history and geography, are still challenging even for the academic community. For students, these questions appear as a true mystery, strengthening the motivation to learn more about human migrations and all aspects of human cultural heritage. Still, the described studies demonstrated that hunting games can be employed as an important ally in education at a multidisciplinary level in different cultures in the world.

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