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Implementation of a Playful Microproject Based on Traditional Games for Working on Mathematical and Scientific Content

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Abstract: According to previous research, we consider it necessary to extend the use of games, as mediating elements, in the learning of STEAM (Science, Technology, Engineering, Arts and Mathematics) contents rejected by many students. For this, we have carried out an educational research project on games, with an ethnomathematical approach, since games are an important cultural sign with mathematical and scientific potentialities. We have prepared an anthropological study and an analytical one, generating a catalogue of games from different cultures. Thus, we have verified that, starting with culture, we can get to the game, but we posed the query as to whether, starting from certain games, we could achieve enculturation, by activating mathematical and scientific content in the players. To answer this query, we have created a curricular design called "playful microproject" with three traditional games from different cultures and geographical contexts. The microproject was implemented with 32 participants, from 8 to 12 years old. To analyse the results of the microproject, a case study was carried out using qualitative methodology. As part of the playful microproject, the necessary materials for each game were made by hand, and the games were then played. Both the realization of the games and the act of playing showed evidence of mathematical and scientific content, although more in the act of playing. The results revealed that: (1) the three games mobilized 21 categories of analysis, made up of scientific-mathematical content; (2) the three games proved to be equivalent in strong didactic potential; (3) that the microproject provides a valuable intercultural educational approach. The contents evidenced constitute a fundamental part of the Primary Education curriculum: classify, organize, measure, and quantify items, as well as formulate hypotheses, draw conclusions, place oneself in space, and design strategies, among others. It is concluded that these games can promote scientific-mathematical enculturation in a contextualized way.

Keywords: game-based learning; traditional games; ethnomathematics; steam; intercultural education; primary education

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1. Introduction

1.1. Background

Huizinga considered humans to be Homo Ludens or "man who plays" [1]. For this author, play is a cultural phenomenon, a social impulse that extends to all civilizations, as an essential element of each culture that subjects create and use throughout the whole of their lives [2,3]. We assume his vision and value the importance of play as a cultural sign that characterizes each social group and belongs to all humanity, as it originates with the development of society itself and leads the person towards integration into a social group [4].

Regarding the repercussions of play in each subject, its educational influence is undeniable. Play, however, is the ideal scenario for acquiring a great deal of learning. For example, some games help in the structuring of language [5], and others favours development of thinking [6]. According to Garaigordobil [7], there are a number of studies that demonstrate how play is a key part in the development of learning in children and adults. In accordance with this idea, there is currently a complete line of international research on playful learning, which includes game-based learning, on which our study focuses, centred on the educational use of traditional games.

We consider play as a key element in the development of the person, taking, as reference, the ideas of Piaget [8], where he interprets play as the means by which the child comes into contact with and develops in the environment, thereby learning to understand reality. This is somewhat related to the proposal of Vigotsky, who affirmed that the game is a social activity [9]. In consideration of these ideas, it becomes necessary to highlight that, despite their importance in current and future society, the skills associated with scientific thinking are often not developed in the classroom and, therefore, need to be promoted through educational and cultural tools, such as games [10]. To the point of taking it as a reference for an educational research project that has been taking shape for a number of years, and which has, as its precedents, various studies on play, its classifications and potential for working on mathematical and scientific content [11–13]. This project comprises four components: anthropological study, analytical study, educational study, and field research (Figure 1). A summary of the first two stages (anthropological and analytical study) can be consulted in a previous publication [14], and the final two stages are presented here.

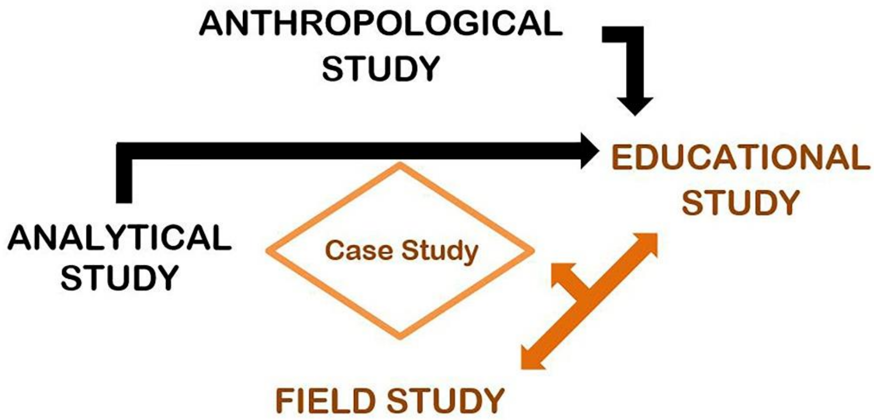

Figure 1. Project components and their relationship to the case study.

The four studies are consecutive and linked, metaphorically configuring a continuous curve. The results of the first generated the research questions of the second, and from this arises the third, focusing the attention on three paradigmatic games united in an MPL that is implemented, constituting "a case"; the fourth study takes, as an object of investigation, the case generated in the third. First, in the anthropological study, we investigated the culture, confirming that the game is one of its idiosyncratic values. We did this in the case of Jamaican culture, compiling its most popular games and discovering scientific-mathematical and social aspects of a dozen games rooted in Jamaica. Then, through a second analytical study, we studied a sample of 40 multicultural games, developing a catalogue with detailed characteristics of these games. In the final stage, we selected, from this catalogue, 3 popular games that share a common origin: the game of checkers. With these games, we conducted a third educational and a fourth research studies. We found that these games arise from broadly different socio-geographical contexts and ancestral cultures, but they are currently connected by emigration and tourism. Next, we developed a didactic proposal in the form of an Interdisciplinary Playful Microproject with the three selected games, and finally, we carried out a "Case Study" on the MPL, showing scientific-mathematical content and forms of learning that can be promoted through games. The first two studies lead from culture to games, as a circumference arc, and the two studies that we present here fit into the base of that arc and build the arc backwards: from games to culture. This leads to enculturation in mathematics and science, implicit in games, and to current interculturality based on ancestral heritage.

In the phase corresponding to the anthropological study, the first element is culture associated with play. Bishop [15] indicated that there are six types of activities carried out by all social groups. Playing is one of them. Focusing on this idea, the anthropological study of our project is pertinent, due to the nature of play, and fundamental, because our work is grounded on the research programme denominated Ethnomathematics [16–19], which investigates the relationships between mathematics and different cultures, making the existence of mathematics visible in all of them. From this focus, mathematics can be defined as a three-dimensional creation constructed by: formal science, a mode of individual thought, and social interaction [20,21]. Ethnomathematics includes these three components and is defined by several authors as follows: "Mathematics practiced between cultural groups identifiable as national tribal societies, guilds, children of a certain age, and professional classes" [22]; "A cultural product that has been developed as a result of several activities" [23]; Mathematics implicit in each practice [24], which emerge in all cultures; "modes and techniques (tics) of comprehension, grasp, and explanation of the natural and cultural setting (mathema) in different cultural systems (ethno) [25]. The literature on Ethnomathematics is currently extensive, with notable references for the present work [26–33].

Rosa & Orey [34] relate mathematics to other areas of cognition, such as language or meanings—something tremendously related to culture and its dissemination. At this point, one of the ethnomathematical principles of Gerdes [24] is noteworthy, where the importance of emphasizing the implication of sociocultural factors (game) in education, learning, and development of mathematics is addressed. That is the aim we focus our mathematical and scientific interest on, with games that offer cultural elements applicable to mathematics teaching.

Ideas that were already raised by Alsina and Planas [35], where they make a comparative analysis of the procedures involved in the game and in mathematics, some of them being: knowledge of the rules, acquiring familiarity by relating some pieces to others, making comparisons and interactions of elements, explore the procedures used by other players or discover interesting problems and solve them. Finally, mention of the reflection by Miguel de Guzmán [36] relates to the game and the teaching of mathematics through the following thought: "Mathematics has been/is art and this artistic component related to play is consubstantial to mathematical activity". That is to say, in all mathematics, there is a game, and in every game, there is mathematics.

Once the concepts of play and ethnomathematics have been identified, it is necessary to address what the analytical study consists in the classification and analysis of the games selected, focusing mainly on their mathematical and scientific aspects [37,38]. The purpose of this study is to obtain information on the potential of games for developing STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning, where the arts are present in diverse forms, for example creativity, but where learning is also supported and improved in cognitive, physical, language, social, and emotional domains [39]. The term was coined by Yakman & Lee [40] as a framework for education via disciplines focused in an integrated manner. In other words, it was a new paradigm that proposes the sciences (including mathematics) and technology interpreted via engineering and the arts [41]. The complete potential of STEAM goes beyond aesthetics and takes in arts related to language, culture, history, and humanities [42]. The influence of STEAM education can be appreciated in our proposal for playful microprojects based on traditional games [43,44]. It provides a context for the learning of values that is appropriate for a project of this type, which is something that Park & Ko [45] commented on when they indicated that STEAM education should take into account integrative thinking systems, creativity, and values. Using the areas of Mathematics and Science as a starting point, we carry out the educational study, which involves the creation of the design and implementation of a playful microproject centred around three traditional games, through activities inserted into an educational model based on values of an intercultural type [46].

The field study is comprised of a case study involving the analysis of the implementation of the microproject, showing that it allows for work on scientific and mathematical content.

1.2. Game-Based Learning and STEAM Education

Recent years have seen a growing presence of creativity in education [47]. Skills relating to creativity, intellectual curiosity, critical thinking, media literacy, intercultural cooperation, and interaction are defined by experts as 21st century skills [48,49]. Teaching creatively means adopting imaginative approaches to make learning more interesting, exciting, and effective [50]. The incorporation of game-based learning strategies is a good option for putting this type of creative teaching into practice [51].

One of the objectives of the use of games at school can be the comprehension of concepts, improvement of techniques (knowledge games), or the acquisition of problem-solving methods—strategy games [52,53]. A number of different studies draw attention to the positive impact this type of learning has on reasoning capacity [54] and maths and science performance [55] Games have a positive impact on learning mathematics and attitudes toward this subject [56]. Analogous to our research, other works have proposed to use games "as a potentially useful tool to introduce and teach specific material to specific populations" [57], while another study has undertaken activities similar to our microproject [58], proposing "praxis games" founded on the concept of situated praxis.

Situated praxis encourages the design and development of games that guide players to discover knowledge inside a range of communities, domains, and experiences.

Others [11] highlight the development of skills associated with playful thinking, such as proposal of objectives, analysis of problematic situations, divergence, or generation of ideas, and convergence in practical solutions. The use of games is, therefore, a powerful tool for working on innovative thinking and developing creativity [59]. Games encourage the acquisition of basic abilities, such as those associated with learning self-regulation (learning to learn) and autonomy (personal initiative), as they provide experiences according to the demands of the player and set achievable goals that give the confidence to keep learning [60]. This, and another study [61], relates to our microproject, given that it studies the effects of the use of self-constructed materials.

Game-based learning promotes the development of social skills [62], motivation to learn [63], improvement in attention, concentration, complex thinking, and strategic planning [64].

Games even help to internalize multidisciplinary knowledge [65], foster logical and critical thinking, and develop cognitive skills associated with problem solving [66] and decision making [67].

All of the above infers the value of using games in STEAM education. However, play is not simply a methodology for intellectual learning; it is also a tool for building contexts in which students find themselves immersed, thus their integral nature and suitability for putting STEAM education proposals into practice. In this regard, López-Fernández [68] frames play in two types of spheres: socio-civic and aesthetic. The social-civic sphere includes cooperative games, given that the interests of each individual are linked to those of his or her colleagues and have a bearing on situations often ignored from an educational perspective (conflict resolution, consensus). Regarding the aesthetic sphere, taking advantage of the creativity that originates in play, it concerns developing creative taste and capacity, and there is emphasis on games relating to construction, roles, and drama. These games mobilize creativity because they suppose the completion of diverse tasks and the solving of specific problems: building a house, making a suit, shopping in a fictitious market, etc. Thus, a close relationship is formed between scientific and mathematical domains and disciplines, such as design and entrepreneurship, which is an ideal interaction for promoting STEAM education.

1.3. Learning Based on Traditional Games as an Intercultural Education Channel

Throughout history, play has been a constant presence in all cultures and societies, even the most primitive. We are born, evolve, and live with play [69] (p. 32). From the ethnomathematical standpoint, games have been studied, placing great importance on their cultural representability and their educational applications, as in the case of Aroca studying children's games [70,71] and Palhares examining various educational levels [72–75].

When speaking about traditional games, we are referring to those passed down from generation to generation, being part of the cultural background created by society. These games "constitute authentic cultural heritage. They are an expression of a way of living, acting, entering into contact with the medium and of being able to communicate with others" [76] (p. 30). That is, traditional games, and those that derive from them, fulfil a function of enculturation, conserve and transmit deep popular culture values, favour and facilitate social relationships, and help to conserve the heritage of play. They hold great value in themselves, as they comprise past, present, and future cultural tradition that education should foster [77]. Further, knowledge of other cultures' manifestations of play holds special relevance now because it facilitates a more open attitude from students towards contributions of colleagues from other places of origin [78]. The putting into practice of learning strategies based on traditional games directly contributes to appreciation, understanding, and value on the part of students of different cultural manifestations, a key idea for intercultural education, so closely linked to ethnomathematics [46]. The use of traditional games is ideal for promoting social and intercultural values, as "traditional games reproduce the changing social values in each era given that they are the reflection of the society in which they are immersed" [79] (p. 54). Traditional games emphasize the social component of play, strengthening social skills and cultural values [46].

1.4. Objectives

The educational study and the field study have their own goals but are interrelated.

The educational objectives consist of designing, creating, and implementing activities based on the traditional games selected, constituting a playful microproject, with the ultimate aim of mobilizing mathematical and scientific content in the players.

In the sense of qualitative case studies, hypotheses are proposed here as research questions. Thus our research hypothesis, in the case study that brings together the two educational and field studies, is the following:

"The three traditional games selected have proven mathematical and scientific potential, so they can trigger thoughts and communication that bring together mathematical and scientific content, if they are implemented through an appropriate and efficient didactic design".

This is not properly a "hypothesis" but rather the nucleus of a group of research questions that we have classified as "how", "what", and "how many" concerning the possibility of achieving the educational and research objectives.

How?

How is it possible to demonstrate manifestations of mathematical-scientific content through the creation and implementation of a playful microproject of an ethnomathematical nature? If the games used are able to stimulate mathematical and scientific thinking in the players, in game activities and in the construction of game materials, will we be able to capture meaningful evidence of these activations by observing the players?

If the participants who play interact in pairs, how can we better capture the reasoning of the pairs (on videotape or through observation)? Can this be done by observing their actions, listening to their conversations, asking them questions, answering their questions, or analysing their productions?

What?

What are the elements of mathematical and scientific concepts or procedures that are activated by these games? Are they only conceptualization or also reasoning? Are they related to the curricular goals of primary education? Are they related to each game, or are they common to the entire playful microproject? Can the existence of activation episodes related to the didactic design be affirmed?

How many?

To what extent can we affirm something more than sporadic manifestations? Can we quantify the evidences in the playful microproject? Play activities and making play materials are carried out. Do these two situations have a similar educational potential, proven by quantifying evidence of both types?

2. Materials and Methods

2.1. Educational Methodology. Playful Microproject

Microprojects are interdisciplinary teaching proposals that have the objective of developing skills from a social constructivist perspective, creating activities based on relevant signs from one or more cultures [44,80]. In this work, the signs are traditional games and the activities are focused on play, to which we have designed a "playful microproject". We selected three traditionally inspired board games related to different cultures, taking into account the results of prior anthropological and analytical studies.

The games selected are: The Dog and the Goats (Africa: Canary Islands, Guanche culture), The Towers of the Alhambra (Southern Europe: Spain, Nasrid culture), and Mijnlieff (Northern Europe: Scandinavia, Viking culture).

The game "The Dog and the Goats" is a variation of "Checkers", specific to the Canary Islands, highly established amongst the peoples of a fundamentally pastoral culture [81]. This traditional game was made popular by the "Guanche" people, of Berber origin, who inhabited the Canary Islands before the Spanish conquest in the 15th century [82]. Due to the geological formations of the zone, the islanders made their game boards on flat, smooth stones, which are conserved today (Figure 2). As far as the pieces are concerned, they probably used small stones, seeds, or shells. As regards the rules, these have varied little over the centuries [83]. The game simulates the actions of a dog responsible for helping the shepherd herd the goats, which are feeding freely in the countryside. The goats don't want to enter the pen and, between them, try to stop the dog by grouping around it. The board is made up of 16 (4×4) square or rectangular spaces, whose corners indicate the places to be occupied by the pieces or checkers. There are two types of pieces: 12 white pieces that represent the goats and a single black piece that represents the dog. The objective of the game is to be the first to completely stop the movements of the other player. In other words, the player with the goats will win if he or she manages to immobilise the dog, surrounding it without leaving any spaces. The dog will win if it manages to capture enough goats to avoid being surrounded, jumping over them as in the game "Checkers". The dog always starts the game, moving from the centre vertex towards any other empty neighbouring vertex. It can move forwards or backwards but only one space at a time, except if it can jump over a goat, capturing it, or by doing successive capture jumps in a row. The goats also move one space at a time, always sideways or forwards and, unlike the dog, never backwards. They cannot capture the dog by jumping over it, either.

The game "The Towers of the Alhambra" was created by Francisco López Martin in 2012 [84], set in the emblematic monument of the Andalusian city of Granada: The Alhambra. This genuine fortress of the Nasrid culture was built before the 15th century and includes 35 towers connected by walls, palaces, Arab baths, houses, and gardens, constituting the most important architectural ensemble of Muslim origin in Europe. The game is from the Halma (jump in Greek) family, a concept devised by George Howard Monk in 1883 [85]. In these games, pieces jump over each other to fill the opposite squares. The board, in the form of a checkerboard, is the lid of a box made out of wood and decorated with the traditional ornamental technique known as "marquetry" (Figure 3). This craft is still practiced in Granada and consists of covering a wooden object with small geometric pieces of wood, mother of pearl, or bone such as with a puzzle. There are five pieces for each player. The pieces are small metal sculptures that represent the most striking of the towers of the north wall (bronze) and the south wall (copper) of the Alhambra. The aim of the game is to be the first to move all pieces to the opponent's starting area, so that the opponent wall is "conquered". To do so, it is necessary to move all of the pieces forwards crossways (never diagonally) to adjacent squares. It is possible to make simple or multiple jumps over your own pieces, but not over your opponent's, with the exception of the tallest tower (guide tower) which can jump over the opponent's pieces and is the only one that can move backwards, if no other move is possible.

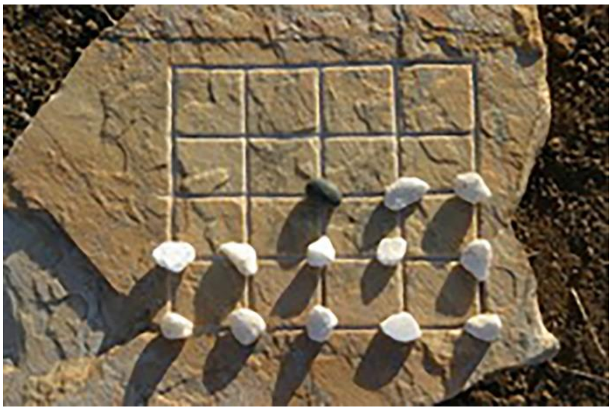

Figure 2. The Dog and the Goats game board with pieces at start position [83].

Figure 3. Board and pieces for the Towers of the Alhambra game, separate and with the initial starting point of the pieces (top). Towers of the Alhambra walls and Granada marquetry objects (bottom). (Source: own creation).

The game "Minjlieff" was created in 2010 by Andy Hopwood, inspired by ancient Talf type games [86]. It was named best abstract game in the 2010 UK Games Expo, the most relevant board games convention in Britain. The launch of the Android version has made it popular, as it can be played online. Talf are old Germanic board games that were played on a square board, simulating two armies, and they imitated the military successes of Viking attacks. They spread wherever the Vikings passed through, including Iceland, Britain, Ireland, and Lapland [87]. The playing of board games fits into the cultural habits of these Nordic groups, given that winter lasted for months and Viking families stayed inside their homes, which were spaces for feasts, conceiving projects, preparing expeditions, and relaxing with board games. Viking culture is hugely attractive in modern society, with its influence being appreciated in music, literature, cinema, and games [88,89].

It is a game for two players; each with different coloured pieces moved one square at a time. There are four signs that characterize the four types of existing pieces and indicate the moves that the opponent can make: towards, away, neighbouring squares, or squares on a common vertex. The board is very original, as it is formed in different ways with four square boards containing 2 × 2 squares (Figure 4). The symbols on the pieces are inspired by runes, signs that made up part of the Viking alphabet and that were typically engraved on stones (Figure 4). Each player has eight pieces, two of each symbol. During play, each piece determines the squares where the opponent can play his or her next piece. If a player is unable to do what the piece indicates, he loses his turn and the opponent puts another one where he wants. The objective of the game is to get the highest possible score, with each point obtained by placing three pieces of the same colour in a row (vertical, horizontal, or diagonal), as in the game "Three in a row". The game ends when no more pieces can be played.

Figure 4. Boards and pieces from the game Minjlieff (top and bottom left). Viking runes and box engraved with the Viking Valknut symbol (bottom right) [90–93].

In order to design the playful microproject activities, special attention has been paid to mathematical and scientific content, but aspects relating to technology, engineering, and art that can be worked with in the games have also been taken into account, exploiting their potential for developing STEAM learning.

2.2. Research Methodology: Case Study

The research methodology followed for the development of the case study is qualitative, descriptive, and interpretative.

The data-gathering techniques employed were direct, observations of the participants were recorded in a field notebook, and the video recording of the microproject was undertaken during the implementation sessions. At all times, a camera was placed on a tripod or held by the researcher, providing video and audio recording of all the evidence, behaviours, and conversations of the students for later analysis. In addition, the researcher in charge of the implementation manually wrote down in a notebook any action that might be relevant to the investigation, resulting in approximately 20 pages of annotations on the sessions conducted. The notes were also analysed.

To interpret the information, we carried out a content analysis [94], with the aim of finding situations that involve mathematical and scientific processes or concepts, activated in the players during the construction and use of the selected games.

Given that we found no precedent techniques contextualized in games, we generated them as part of the study [95], from the results of the analytical study, in which mathematical and scientific content was shown that can be worked on with the traditional games selected. An instrument has been created that combines this mathematical and scientific content [96] associated with the games with the essential components of culture established by Huxley [97]: artefacts, mentifacts, and sociofacts.

Looking in detail at these components for the specific case of a game, we can understand artefacts (material technology of a social group) as being the game materials, that is, board and pieces, mentifacts (abstract elements via which the culture of a group is guided) as the objectives and challenges in the game, and sociofacts (laws that are related with links between individuals and the group [98]), as being the organization rules of the game. The categories are thus obtained a priori, and grouped into three types, for the games implementation analysis (Table 1).

Based on this instrument, a check-list (Appendix A, Table A1) was created and applied to each player, collecting the data of evidence of the categories activated in the players by the game, captured on the recorded video or through observation. The evidences of each category were obtained through this check-list, applying the content analysis and its interpretation to the quotes of the players obtained in the recorded video and to the annotations collected in the field notebook.

Table 1. Data analysis instrument. Categories corresponding to mathematical and scientific content associated with artefacts, mentifacts, and sociofacts of each traditional board game of the playful microproject.

Area	Type	Category	Meaning Contextualized in the Microproject Activities
Mathematics	Artefacts: Game materials	1 Identifying flat shapes and three-dimensional bodies	Distinguishing regular polygons and polyhedrons and assigning them their name
		2 Situating oneself on plane and space	Distinguishing different positions with regards to some references (sides of the playing board and the outside)
		3 Making relationships of order	Sequencing elements spatially or temporally and/or numbering them with ordinals
	Mentifacts: Game objectives and challenges	4 Making classifications	Grouping objects that share one or more properties, separating them from those that lack them, forming subgroups or classes
		5 Making counts	Considering the discreet quantitative aspect of a group, assigning it a natural number (can be game pieces or phases)
		6 Recognizing regularities	Appreciating that patterns are repeated
	Sociofacts: Game rules	7 Giving exact and approximate measurements	Making measurements of magnitude with units already established or conceived by the players
		8 Posing numerical questions	Quantifying aspects that require communication, with the aid of numbers for explaining them
		9 Ascertaining geometric aspects	Posing questions on spatial situations and shapes

Table 1. *Cont.*

Area	Type	Category	Meaning Contextualized in the Microproject Activities
Sciences	Artefacts: Game materials	10 Recognising length	Understanding the linear distance between two points (a dimension of the board)
		11 Recognizing the surface area and volume of a body	Differentiating between two and three dimensions (flat board and pieces, respectively)
		12 Identifying properties of materials	Intuitively understanding approximate values of physical properties of materials (handled for making game board and pieces)
	Mentifacts: Game objectives and challenges	13 Exercising observation	Paying attention (visually and though hearing, without speaking simultaneously)
		14 Proposing hypotheses	Thinking about something that could be done and stating it
		15 Recognizing alternatives	Realizing that you can do something different to that already thought about or done
		16 Demonstrating logical reasoning	Ordering ideas with a cause-effect criterion (coming to relate moves made in the game)
		17 Designing strategies	Thinking about and expressing ways of acting (to win the game)
		18 Experimenting	Making tests before acting or doing various things to see their effects
	Sociofacts: Game rules	19 Evaluating results	Observing something that happened and making an assessment of it
		20 Drawing conclusions	Making inferences or other logical reasoning with a view to guidelines for the future
		21 Predicting	Anticipating something (that could occur in the game)

3. Results

3.1. Results of the Educational Study. Implementation of the Microproject

The playful microproject was implemented, with a total of 32 participants (16 girls and 16 boys) between 7 and 12 years old (Primary Education). Participating players were recruited: 16 in a non-formal education centre in the city of Granada (Spain), 12 in a non-formal education centre in Maracena, a city in the province of Granada, (Spain), and 4 in a group of children of neighbours of one of the researchers, in the city of Granada. The players participating were randomly selected by the heads of each non-formal education centre. The intention was not to have a homogeneous group of students, but to form play groups with students of various types and abilities. After receiving an explanation of the experiment, they volunteered to participate.

Each participant was assigned a code (Appendix A, Table A2).

The implementation was extended over four months, involving three 60-min sessions for each game, organized as follows:

Initial session: The players were grouped into pairs. Each pair was assigned a board game that was the exclusive basis for all activities. The Dog and the Goats was assigned to six pairs (12 participants), the Towers of the Alhambra to another six (12 participants), and Minjlieff to four (eight participants). The traditional board game assigned was presented along with its origin and elements of the culture it is related to, employing different materials (a ppt presentation, drawings, flash cards, and elements that can be handled). A story of our own creation was told, "The tale of Guanche", which involved the story of a shepherd from the Canary Islands passionate about board games whose wish was to create his own game, to which he travelled all around the world discovering different cultures and learning the games they played. After finding discovering the cultural origin of the game, the players dressed up as characters from the culture in the past, they themselves creating the costume with fabric, plastic, and card. To do so they made hats, shields, and other dress elements, taking measurements, drawing, and cutting out. Now in their costumes, the participants assumed the role of locals entrusted with making the game board and pieces. They used recycled materials (boxes, caps, and cartons) and decorated the board to taste with figures from the culture in question (Figure 5).

Figure 5. Construction of game materials for the traditional games selected. Top to bottom: The Dog and the Goats (top), The Towers of the Alhambra (centre), and Mijnlieff (bottom). (Source: Own creation).

Development session: The participants again entered into role play with the constructed material (board and pieces). The rules for their assigned games were explained to them, they familiarized themselves with the games and played them a number of times with help.

Closing session: The participants once again went through the role play process and played the board games in pairs, but this time without help, making their own decisions.

3.2. Research Results. Evidence of Activation of Mathematical and Scientific Content

The details of each player were taken, during interaction with partner or with the researcher, via video recording and field notes.

Even while being aware that a category can be repeated in the same player various times, for the data analysis, if a player stated a category, subsequent posterior evidence of that category was no longer counted. This is done in order to specify the content analysis, reducing it to a maximum of 672 pieces of data (32 players by 21 categories). We understand "evidence of a category" as being an action or verbal expression from the player (comment, response, or question), in which the content associated to the category manifests itself. Examples of evidence of each category for each game are shown in Tables 2–4. Both observations and the transcription of words expressed by the participants are included. The players who showed evidence, the situation in which the category was evidenced, and examples of evidence for each category are tabulated.

Table 2. Codes of the players who showed evidence, evidence situations, and examples of evidences of categories in the game "The dog and the goats".

Category	Player Code/Evidence Situation	Example
1. Identifying flat shapes and three-dimensional bodies	All players show evidence of this category. Making the game board and pieces	It is observed that they all recognise square and rectangle shapes when making the board.
3. Making relationships of order	Players showing evidence of this category: 1A9, 3A9, 4O12, 8A8, 9A9, 10A8, 11A9, 12O12. Making the game board and pieces and Playing	Establish a numerical order when placing the tiles while playing (1,2,3 ...). A player states the number of steps followed for making the board (12O12)
4. Making classifications	All players show evidence of this category. Making the game board and pieces	When looking for objects to make the pieces, they classify them by colour, creating the white and the black types. A player sort the chips by shape, quantity and colour (1A9)
5. Making counts	Players showing evidence of this category: 1A9, 2A8, 3A9, 4O12, 5O7, 7A7, 8A8, 9A9, 10A8, 11A9, 12O12. Making the game board and pieces	They count the white pieces
6. Recognizing regularities	Players showing evidence of this category: 2A8, 3A9, 4O12, 5O7, 8A8, 9A9, 10A8, 11A9, 12O12. Making the game board and pieces and playing	"I've taken 2 pieces in a row, then one and now another 2" Decorate the box, in which to keep the game, drawing a red flower, followed by a rose, repeating this pattern regularly (4O12).
7. Giving exact and approximate measurements	Players showing evidence of this category: 1A9, 2A8, 3A9, 4O12, 5O7, 6O8, 8A8, 9A9, 10A8, 11A9, 12O12. Making the board.	A player realises that the width of the board corresponds to a succession of various pieces in a row (12O12)
8. Posing numerical questions	Players showing evidence of this category: 1A9, 2A8, 3A9, 4O12, 5O7, 7A7, 8A8, 9A9, 10A8, 11A9, 12O12. Playing	"I've lost 5 pieces, only 3 of the ones I've got left can't be taken by the dog" "You'd take more pieces if you moved 2 rows forward"
10. Recognizing length	All players show evidence of this category Playing	They estimate distances between points during their turns playing
11. Recognizing the surface area and volume of a body	All players show evidence of this category Making the game board and pieces	When constructing the game materials, they distinguish flat figures (board) from three-dimensional bodies (pieces)
12. Identifying properties of materials	Players showing evidence of this category: 2A8, 3A9, 4O12, 9A9, 12O12. Making the game board and pieces	They identify hardness when selecting materials to make the board and pieces
13. Exercising observation	All players except one (4O12) show evidence of this category. Playing	They watch the game closely in order to know what to do while play
14. Proposing hypotheses	Players showing evidence of this category: 1A9, 2A8, 3A9, 10A8, 11A9, 12O12. Playing	"I don't think I'll win because wherever I move he can take me"
15. Recognizing alternatives	Players showing evidence of this category: 1A9, 12O12. Playing	"It's better to keep this piece for the end of the game"
16. Demonstrating logical reasoning	Players showing evidence of this category: 1A9, 2A8, 3A9, 4O12, Playing	"If I move them all together I'll trap it"
17. Designing strategies	Players showing evidence of this category: 9A9, 11A9, 12O12 Playing	"When there are fewer goats left, I'll move the ones in the corners"
18. Experimenting	Players showing evidence of this category: 1A9, 12O12. Playing	Only moves 2 pieces in order to avoid the rest being taken
19. Evaluating results	Players showing evidence of this category: 1A9, 9A9, 11A9, 12O12. Playing	"I played terribly"
20. Drawing conclusions	Players showing evidence of this category: 1A9, 3A9, 9A9, 11A9, 12O12. Playing	"I should have moved another piece that wasn't so close to the dog"

Table 3. Codes of the players who showed evidence, evidence situations, and examples of evidences of categories in the game "The towers of the Alhambra".

Category	Player Code/Evidence Situation	Example
1. Identifying flat shapes and three-dimensional bodies	All players show evidence of this category. Making the game board and pieces	They find the irregular shape of the board strange: "It looks like a rectangle with a square inside" (25O9).
2. Situating oneself on plane and space	Players showing evidence of this category: 13A7, 14O8, 21O9, 23A10. Playing	They begin on the initial starting squares and must move to adjacent squares, not diagonally and they do it correctly
3. Making relationships of order	All players show evidence of this category. Making the game board and pieces and Playing	They order temporally: they indicate that, firstly, you have to make the board and pieces and then, play
4. Making classifications	All players show evidence of this category. Making the game board and pieces and Playing	They classify the pieces by their colour or design
5. Making counts	All players show evidence of this category. Making the game board and pieces	They count how many pieces there are per player and in total. A player counts the tower battlements and how many towers have windows (23A10)
6. Recognizing regularities	All players show evidence of this category. Making the game board and pieces	They establish a pattern of various colours when decorating the board simulating marquetry. When cutting out the battlements, a player indicates that "you have to cut one then not cut the other" (18A11), along with colouring the board with two colours.
7. Giving exact and approximate measurements	A player show evidence of this category: 20O12. Making the game board and pieces	They measure with a ruler. A player calculates the measurements of the board counting the squares (20O12).
8. Posing numerical questions	Players showing evidence of this category: 15O8, 16O9, 17A10, 18A11, 19O11, 20O12, 23A10, 24A9. Playing	"If I move 2 pieces I can block you". "You're on square 4, you can't jump over me on 7"
9. Ascertaining geometric aspects	Players showing evidence of this category: 13A7, 15O8, 16O9, 17A10, 18A11, 19O11, 20O12, 23A10, 24A9. Playing	"If I squash the tower flat, it will look like another square". "I'm moving along the corners of the board, let's see what happens".
10. Recognizing length	All players show evidence of this category. Playing	They estimate distances between points during their turns playing
11. Recognizing the surface area and volume of a body	All players show evidence of this category. Making the game board and pieces	They differentiate flat shapes on a surface of three-dimensional bodies, as the pieces are parallelepiped towers. When they make them they ask questions and speak about it
12. Identifying properties of materials	Players showing evidence of this category: 13A7, 15O8, 16O9, 17A10, 18A11, 19O11, 20O12, 22O9, 23A10, 24A9. Making the game board and pieces	They identify hardness in the board material (box lid) and flexibility in the cartons they cut out to make the pieces
13. Exercising observation	All players show evidence of this category. Playing	They watch the games carefully
14. Proposing hypotheses	Players showing evidence of this category: 14O8, 15O8, 16O9, 17A10, 18A11, 19O11,20O12, 21O9, 22O9, 23A10, 24A9. Playing	"If you pass the middle of the board you've won, because it's easier to move forward". "If I move this piece, you can't move yours and I win on the next move".
15. Recognizing alternatives	Players showing evidence of this category: 18A11, 19O11, 20O12, 21O9 Playing	A player moves the piece he or she has moved incorrectly back, before ending the move (18A11).
16. Demonstrating logical reasoning	Players showing evidence of this category:15O8, 16O9, 17A10, 18A11, 19O11, 20O12, 21O9, 22O9, 23A10, 24A9. Playing	"If I jump over 3, I win". "If I go far enough past you, I win, because you're not going to get me moving one by one". "I move my towers together to make a barrier". "You can't draw"
17. Designing strategies	Players showing evidence of this category: 16O9, 17A10, 18A11, 19O11, 20O12, 21O9, 22O9, 23A10, 24A9. Playing	A player tries to leave a space to take two at a time. Another only moves the forward pieces. Another doesn't start from the initial squares, saying it's to prevent the opponent from getting there. Another player moves the pieces together.
19. Evaluating results	Players showing evidence of this category:7A10, 18A11, 19O11, 20O12, 21O9, 23A10. Playing	"I'm not going to do that anymore". "I'm not going to start anymore". "I should've moved another one". "I don't start first, that's why you always get there before".
20. Drawing conclusions	Players showing evidence of this category: 18A11, 19O11, 20O12, 21O9. Playing	"I'm going to think more in the next one". "I'll move them all together in the next one". "I'm not going to do that anymore". "I'm not going to start anymore".

Table 4. Codes of the players who showed evidence, evidence situations, and examples of evidences of categories in the game "Mijnlieff".

Category	Player Code/Situations	Example
1. Identifying flat shapes and three-dimensional bodies	All players show evidence of this category. Making the game board and pieces and playing.	They recognise circle, rectangle and square in the pieces and board
2. Situating oneself on plane and space	All players show evidence of this category. Playing.	When playing, they understand spatial situations represented by the symbols of the pieces
4. Making classifications	All players show evidence of this category. Making the game board and pieces and playing	They classify the pieces by the different symbols and colours while they make them.
5. Making counts	All players show evidence of this category. Making the game board and pieces	They count the total pieces in the game and the number of different symbols
6. Recognizing regularities	Players showing evidence of this category: 27O11, 28O12, 31A10, 32A9 Making the game board and pieces	They recognise the repetition of patterns in the designs of the pieces and different figures when drawing on the box (one player draws a mandala: 27O11)
7. Giving exact and approximate measurements	All players show evidence of this category. Making the game board and pieces	They measure well with the ruler. Only one player tries another measuring system, placing the pieces in a row to measure the width of the box (28O12)
8. Posing numerical questions	Players showing evidence of this category: 25A11, 26A11, 27O11, 28O12, 30O9, 31A10, 32-A-9. Playing.	One player establishes a number for each piece. Another calculates how many pieces the opponent has left after each move. Another player mentally divides the pieces when distributing them Another adds up the empty spaces to know how many moves he has left and to calculate whether he has enough pieces to win
9. Ascertaining geometric aspects	Players showing evidence of this category: 25A11, 27O11, 28O12, 31A10, 32A9. Playing.	A player creates a mandala combining shapes (27O11). Another uses the pieces as a means for calculating the sizes of the squares that make up the board. Another player relates the shape of the pieces to the squares.
10. Recognizing length	All players show evidence of this category. Making the game board and pieces	They take the measurements of the length of the board and the pieces, comparing them
11. Recognizing the surface area and volume of a body	Players showing evidence of this category: 25A11, 26A11, 27O11, 28O12, 30O9, 31A10, 32-A-9. Making the game board and pieces	They differentiate flat figures (pieces and board) and three-dimensional bodies, with volume (the box)
13. Exercising observation	All students show evidence of this category. Creating the board and pieces and playing	They closely observe the preparation of the materials by the other pairs and then their way of playing.
14. Proposing hypotheses	Player showing evidence of this category: 30O9 Playing.	"I'm going to play this piece, because with this other one X can't move to this square anymore and so I can move there afterwards" "If I place this piece first it's better, because it makes it difficult for X to be able to play hers"
16. Demonstrating logical reasoning	Players showing evidence of this category: 25A11, 26A11, 27O11, 28O12, Playing	"If you put the first piece in the centre it's more difficult for you to win because the other player has more space to put his pieces", "I'm not moving this piece because X only has one left and if I do he beats me", "If I play this piece, X wins because then I'm not going to be able to play the one I have left"
17. Designing strategies	Players showing evidence of this category: 25A11, 26A11, 27O11, 28O12, 30O9, 31A10. Playing	"I've done a good move because X hasn't been able block me", "If I move this piece, it's not good for my opponent". "I'm going to play this piece, because with this other one X can't move to this square anymore and so I can move there afterwards"
18. Experimenting	All students show evidence of this category. Making the board and pieces	They try out materials and designs on the construction of the pieces and the board.

Table 4. *Cont.*

Category	Player Code/Situations	Example
19. Evaluating results	All students show evidence of this category. Making the board and pieces and Playing	"This game really helps you to concentrate", "This game is more complicated than Three in a Row because it has symbols" "At the beginning I found it hard to understand it because I got confused with the symbols, but then it was easy because the picture looked like what you had to do".
20. Drawing conclusions	All students show evidence of this category. Creating the board and pieces and Playing	"I shouldn't have put that piece there", "I have to practice more", "I have good strategies which is why I always win"
21. Predicting	Player showing evidence of this category: 28O12. Playing	"The next game, I'll keep this piece for the end"

With "The dog and the goats" the players show great interest in Guanche culture, they ask why they played with stones, what games they played, and if it still exists. There has been observation of identifications of elemental flat shapes that intervene in the boards: square, rectangle, and triangle. Regarding relationships of order, various players initially placed their pieces following an order they named. Then, when playing, a player moves the pieces following the order of placement and not by game strategy.

They state their game strategies: "If I move along the corners it's more difficult for them to take me", and justify their actions, although they don't constitute a strategy: "I'm slow because if I think, I play better". Experimenting is interpreted by one as cheating when another tries to take two at a time as an experiment. They self-assess, trying to find the reasons for their mistakes, recognizing they have moved without thinking or have made a mistake when moving: "I should have made another more correct move", and conclude with ideas for improving. "Next time I'll wait to take" or "I need to pay more attention". All of the above shows that the participants have played in a conscious manner. A pair wanted to keep playing when time was up and said they would ask for the game when they returned to the playroom, and a player even said he would use it to teach his sister how to count, inventing a didactic application for this game.

In the game "The Towers of the Alhambra" it is observed that, in the construction of the board, the players recognize a rectangle and a square, making reference to its particular shape. In the pieces, which are clearly three-dimensional, they differentiate cube and straight prism. They make mistakes in the placement of the pieces, tending to move them diagonally along the square, as it is the direction that the starting squares go, when the rules require moving to adjacent squares. This makes them focus on directions on the plane that form straight angles. They design strategies trying to gain advantages (one moves all the towers together, another only when the opponent jumps over a piece), although other actions don't make sense (a player retreats from the opposing towers when they get near). Evaluating results at the end of the game is an exercise of reflection that they do quite competently. "I made a mistake because I moved too quickly", "I didn't play well", and from which they draw conclusions: "I'll pay more attention next time", "I need to listen more to your advice" or "I'm not going to start anymore".

It can be seen how the player of this game connected with the monument that it is inspired by. Some indicated that the real towers are harder than these, another made a reference to the towers of the monument as a defensive element, comparing it with its mode of play, another player explained she was Arabic and didn't know the Alhambra and another said: "Thanks to the game, when I go to the Alhambra I'm going to know what the towers are". Some parents present showed an interest in the game, as it was based on the monument in their city, expressing that it was very beautiful. This all favours social awareness and cultural knowledge.

With the game "Mijnlieff" there is a manifestation of the category of making classifications suggested by the pieces, which the players classify with two criteria: colour and symbol shapes. Counting is manifested when counting the total pieces and those for each player, along with the board squares. A participant counts the drawings made on his or her box, recognizing their regularity, and another draws a mandala, explaining what is repeated on it.

Proposing hypotheses is evidenced with expressions such as: "If I play this piece first its better". When playing, statements of logical reasoning occur, such as: "Because it makes it difficult for X to be able to play hers", "If I move this piece, it's not good for my opponent" or "I've done a good move because X hasn't been able block me", even "I can't win because I've got pieces that I can't play left". An alternative referring to a future play is demonstrated: "I'm going to play this piece, because with this other one, X can't move to this square anymore and so I can move there afterwards". Designing strategies is demonstrated with expressions such as: "If I put the pieces on the corners, I save 4 that won't be blocked", which requires thinking about their own move and that of the opponent at the same time. Experimenting has been evidenced in the making of the board and the pieces. The strategy of a player who stated that he was leaving a piece for the end, because this stopped the opponent from winning the game, stood out for its ingenuity. It is the piece that requires another piece to be placed near to it. As the game is at an advanced stage, this piece normally means that opponents cannot place their piece and lose their turn and even the game.

Once the registered evidence was commented on qualitatively, we completed the analysis with a quantitative analysis, providing the frequencies relative to the categories regarding the total number of players who interacted with each game (Table 5). As already indicated, the registry of the evidence has taken place considering each player, who has been counted only once per category manifested. We also provided the relative overall frequencies of the microproject, constituted by the three games as a whole, which have been calculated using the weighted mean of the relative frequencies of the three games.

Table 5. Relative frequencies of each category, evidenced with regards to the total players involved in each game (N) and overall relative frequencies in the microproject (weighted mean of the three games), expressed as a percentage.

Category	Relative Frequency (%)			
	The Dog and the Goats (N = 12)	The Towers of the Alhambra (N = 12)	Mijnlieff (N = 8)	Playful Microproject (N = 32)
1	100	100	100	100
2	0	33	100	37
3	67	100	0	63
4	100	100	100	100
5	88	100	100	96
6	75	100	50	89
7	92	8	100	63
8	50	66	88	88
9	0	74	63	43
10	100	0	100	63
11	100	100	88	97
12	38	84	0	49
13	92	100	100	97
14	50	92	13	56
15	16	33	0	19
16	33	83	50	56
17	25	75	75	56
18	16	0	95	30
19	33	50	100	56
20	42	33	100	53
21	0	0	13	3

The data from the microproject show that 15 categories have been evidenced with a mean frequency of over 50%, with those most manifested by the players being: identifying flat shapes and three-dimensional bodies, making classifications, recognizing the surface area and volume of a body, and exercising observation, with mean frequencies of over 90%, whereas the least evidenced, with 3%, is predicting, as only one player manifested it.

There is evidence of the three types of categories generated (artefacts, mentifacts, and sociofacts). On taking the arithmetic mean of the frequencies of the different categories included within each type we found that, in artefacts, the mean frequency is 65%, in mentifacts, it is greater, 80%, dropping to 48% in sociofacts. This downturn is due to the fact that some categories of this type have been evidenced in few participants. For example, predicting, with 3%, and experimenting, with 30%, as overall frequencies in the microproject. In contrast, there are categories grouped in the mentifacts with the maximum overall frequencies of the microproject.

4. Discussion and Conclusions

The results of this study indicate that it has been possible to design, create, and implement activities based on traditional board games, providing evidence that mathematical and scientific processes or concepts have been activated in the players via interaction with the selected games. It has also been reflected that this is possible by taking these games for the creation of a playful microproject of an ethnomathematical nature, in which such games stimulate mathematical and scientific thinking in the players in two situations: playing situation and situation of construction of materials of the game.

We have confirmed the power of these games for education, generally coinciding with other works [37–51] in the context of mathematical and science processes, concepts, and properties [35,36,52–60]. Likewise, less investigated STEAM aspects are examined, observing that the construction of the game materials also puts these contents into action, coinciding with another study [61].

We have confirmed the power of these games for education, coinciding in general with other works [37–51] within the context of the processes, concepts, and properties mathematics and science [35,36,52–60]. We also examine less investigated matters, observing that the construction of the materials of the games also brings these contents into action, coinciding with another study [61].

Furthermore, these gaming materials are cultural components that are highly valued in ethnomathematics as elements that manifest mathematical thought characteristic of a group. Thus, we verified the importance of artefacts in the knowledge of a culture and in the processes of mathematical and scientific enculturation [18–34].

We investigated games in two situations: from the perspective of their use as a playful activity as well as from the ethnomathematical standpoint of the artisan that makes them [98]. For this, the characteristics of the game must be understood, the materials must be selected and shaped, and the aesthetic form appropriate to the game must be applied. The merging of the two situations in the microproject activated the elements of mathematical, scientific, and STEAM knowledge.

Tables 2–4 show confirmation of the activities in relation to these contents in both situations of the experiment conducted by the players by examples of expressions and deeds faced by the players. The manifestations of certain categories in the situation of playing, and others in the crafts-engineering situation of making, proved more numerous.

It bears noting the categories that were manifested while playing more than while making, or vice versa, and analysing this circumstance qualitatively and quantitatively, as shown in Table 6.

Table 6. Frequencies of each category, evidenced in the situations of playing and/or making, in the three games.

Situations	**Playing**				**Making the Board and Pieces**			
				Total Evidence/Category				**Total Evidence/Category**
Games / **Category**	**The Dog and the Goats**	**The Towers of the Alhambra**	**Mijnlieff**		**The Dog and the Goats**	**The Towers of the Alhambra**	**Mijnlieff**	
1. Identifying flat shapes and three-dimensional bodies	X		X	2	X	X	X	3
2. Situating oneself on plane and space		X	X	2				0
3. Making relationships of order	X	X		2	X	X		2
4. Making classifications	X			1		X		1
5. Making counts		X	X	2	X	X	X	3
6. Recognizing regularities				0	X	X	X	3
7. Giving exact and approximate measurements	X			1	X	X	X	3
8. Posing numerical questions				0	X	X	X	3
9. Ascertaining geometric aspects	X	X	X	3				0
10. Recognizing length		X	X	2				0
11. Recognizing the surface area and volume of a body	X	X	X	3			X	1
12. Identifying properties of materials				0		X	X	2
13. Exercising observation				0	X	X	X	3
14. Proposing hypotheses				0	X	X		2
15. Recognizing alternatives	X	X		2				0
16. Demonstrating logical reasoning	X	X	X	3			X	1
17. Designing strategies	X	X	X	3				0
18. Experimen-ting	X	X		2				0
19. Evaluating results	X		X	2				0
20. Drawing conclusions	X	X	X	3				0
21. Predicting	X			1			X	1
Total game/evidences	15	13	12		8	9	10	

Quantitatively, 13 categories were found to be evidenced more in playing (62%), 7 (33%) were evidenced more in making, and 3 (14%) were evidenced equally in both situations (Figure 6).

Qualitatively, the categories most evidenced were 1 (Identifying flat shapes and three-dimensional bodies) and 5 (Making counts), which were evidenced in five options of the six possible, and this occurred more in making situations. These were followed the 3 (Making relationships of order) that proved equal in situations, 7 (Giving exact and approximate measurements) more in making, 11 (Recognizing the surface area and volume of a body) more in playing, and 16 (Demonstrating logical reasoning) more in playing. These data reflect consistency among the contents and situations in which they were manifested the most. It should be highlighted that these most evidenced categories form an essential part of the contents and competences of the curriculum of mathematics and sciences of Primary Education in Spain.

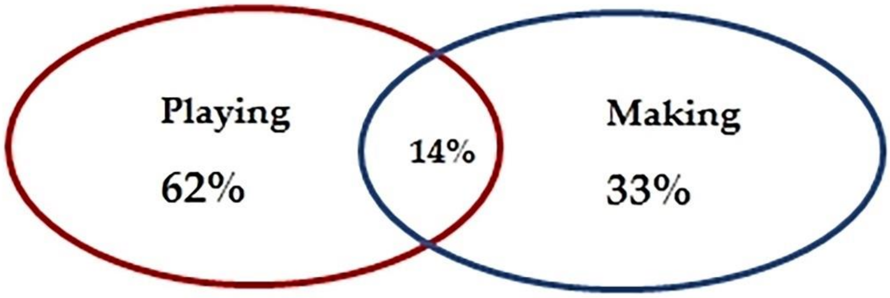

Figure 6. Comparison of the situations in which analytical categories were evidenced.

On the other hand, the playful microproject proved to be a successful didactic proposal in terms of its objectives. Thus, the contribution of this study to the field of Education is important because it shows that the microproject implemented ensures that activities in these games activate an essential part of the core of the curriculum, which should be completed by the student between 7 and 12 years of age.

The three games involved are equivalent in their quantity of manifestations. All the information gathered for each game is another contribution to Cultural Anthropology. This can be used in play centres and workshops for non-formal education, orienting the users on the learning implicit in these games. Therefore, we provide valuable information for cultural knowledge and for mathematical-scientific enculturation within settings of formal, as well as non-formal, education. Overall, a theoretic framework has been developed for ethnomathematics as a research program, and the results can be applied to practical socio-educational efforts with an intercultural focus. The contributions of the present work are presented in Figure 7.

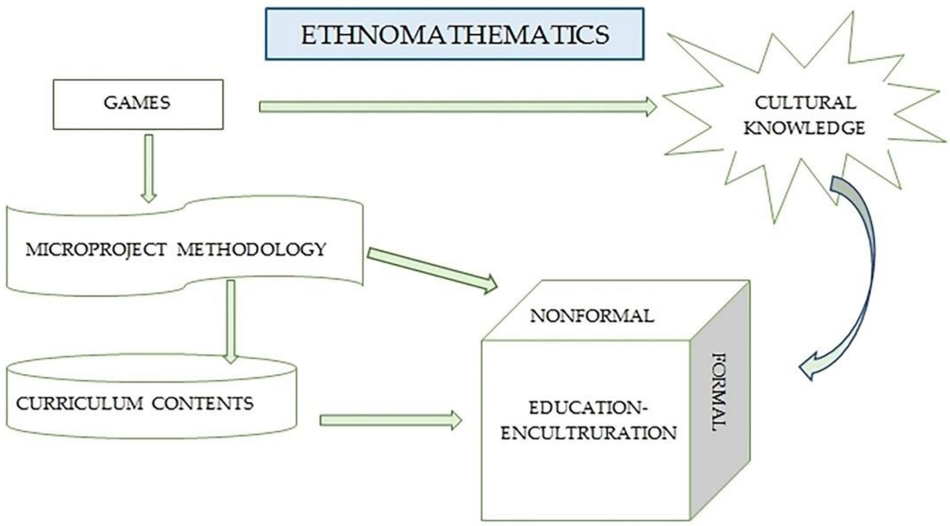

Figure 7. Contributions to cultural and educational fields with an ethnomathematical focus.

The limitations of the present study involve the setting and the interactions with the players since the making and use of these games could not be experienced in student surroundings of formal education due to the restrictions of the use of materials and relations with other people from outside the schools, due to the existing COVID-19 pandemic. Therefore, interviews could not be made with players after the implementation of the microproject. Both aspects, i.e., experimentation in a broader sample that includes schools (formal education) and interviews with the players included in the microproject to delve into the cognitive aspects, constitute perspectives for future investigation in this line.

Overall, the three traditional selected games have favoured the activation of mathematical and scientific content in a STEAM context, being appropriate as cultural signs for creating a playful microproject. When making their gaming materials and playing with them, 21 categories established a priori have been revealed. These categories were related to the concepts of artefacts, mentifacts, and sociofacts that characterize culture [97], forming three typologies. Evidence of these three types of categories was found, by means of a checklist [99] developed and applied to the players, with the mentifacts being the most evidenced.

They are important in mathematical and scientific learning; content related to the nature of scientific and mathematical thinking, such as the formulation of hypotheses, recognition of regularities, the establishment of relationships of order, strategy design, logical reasoning, and the evaluation of situations, with categories evidenced with mean percentages exceeding 56% of players.

In the playful setting and STEAM context in which the activities of the microproject have been developed, other mathematical content has been activated, such as: counting and putting forward numerical questions particular to arithmetic (mean frequencies over 85%), together with identifying the flat shapes and three-dimensional bodies particular to geometry (mean frequency of 100%). Scientific content has also been activated, such as: recognizing length, surface, and volume of a body (mean frequencies higher than 63%), giving exact and approximate measurements (mean frequencies over 56%) and identifying properties of materials (mean frequency of 49%). This all stimulates us to propose this games-based microproject for learning mathematics and science in a STEAM context, for non-formal and formal settings alike.

In addition, the implementation of the playful microproject has meant that attention has been drawn to traditional games of diverse origins, favouring respect and understanding towards all cultures, thus promoting key values of intercultural education.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Check-list to collect evidences of the categories activated in each player by the game.

Player Code (N°, Boy: O/Girl: A, Years. Example: 1A9 = 1°, Girl, 9 Year Old)	Evidence Captured with Recorded Video. Quote Player Phrases or Gestures (Sessions 1–3)	Evidence Gathered by Direct Observation and Written in the Field Notebook (Sessions 1–3)	Situation: Playing (put X if applicable)	Situation: Making the Board and the Pieces (put X if applicable)
Category (from 1 to 21)				

Table A2. Codification table of the players.

Game Pairs	Player Code	Gaming Place	Game Played
Pair 1	1-A-9	ALFA play centre	The dog and the goats
	2-A-8	ALFA play centre	
Pair 2	3-O-9	ALFA play centre	
	4-O-12	ALFA play centre	
Pair 3	5-O-7	Neighbourhood community room	
	6-O-8	Neighbourhood community room	
Pair 4	7-A-7	Neighbourhood community room	
	8-A-8	Neighbourhood community room	
Pair 5	9-A-8	Maracena play centre	
	10-A-8	Maracena play centre	
Pair 6	11-A-8	Maracena play centre	
	12-O-7	Maracena play centre	
Pair 7	13-A-7	ALFA play centre	Torres de la Alhambra
	14-O-8	ALFA play centre	
Pair 8	15-O-8	ALFA play centre	
	16-O-9	ALFA play centre	
Pair 9	17-A-10	ALFA play centre	
	18-A-11	ALFA play centre	
Pair 10	19-O-11	ALFA play centre	
	20-O-12	ALFA play centre	
Pair 11	21-O-9	Maracena play centre	
	22-O-9	Maracena play centre	
Pair 12	23-A-10	Maracena play centre	
	24-A-9	Maracena play centre	
Pair 13	25-A-11	ALFA play centre	Mijnlieff
	26-A-11	ALFA play centre	
Pair 14	27-O-11	ALFA play centre	
	28-O-12	ALFA play centre	
Pair 15	29-O-9	Maracena play centre	
	30-O-9	Maracena play centre	
Pair 16	31-A-10	Maracena play centre	
	32-A-9	Maracena play centre	

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