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Games as STEAM learning enhancers. Application of traditional Jamaican games in Early Childhood and Primary Intercultural Education

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ABSTRACT

Background: Despite its social importance, the learning associated with STEAM thinking (science, technology, engineering, arts, and mathematics) we consider is not fully developed in classrooms. **Objectives**: This research proposes to promote STEAM skills through game-based learning.. **Design**: These were used to design an integrated educational proposal, called the Micro Play Project (MPL), following the principles of game-based learning and an intercultural approach focused on Ethnomathematics. **Setting and Participants:** This MPL was implemented in a Spanish school with small groups of students from Pre-school and Primary Education, dedicating three sessions to each of the four games, which were recorded on video. **Data collection and analysis:** Studying the Jamaican culture, we discovered that the game is a relevant cultural sign in Jamaica, we compiled and analyzed its traditional games, generating a catalog, from which we selected four games, for their potential to develop STEAM learning at school **.**Qualitative-interpretive research was carried out through a case study and content analysis, using a proprietary tool. **Results**: they are diverse skills, artistic, scientific and mathematical manifested when playing, such as: musical sense, detection of similarities, ability to turn, identification of shapes, estimation of distances, formulation of hypotheses and establishment of relationships by criteria, which have confirmed the didactic potential of these games, in an environment of ethnomathematical intercultural education. **Conclusions**: The validity of the MPL as a didactic method to develop STEAM learning is deduced from the results. We hope to strengthen and spread this method by making new elaborations and applications of MPL.

Keywords: STEAM learning; Game-based learning; Traditional games; Early Childhood Education and Primary Education; Ethnomathematical Intercultural education.

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Juegos como potenciadores de aprendizajes STEAM. Aplicación de juegos tradicionales Jamaicanos en Educación Intercultural Infantil y Primaria

RESUMEN

Antecedentes: Pese a su importancia social, los aprendizajes asociados al pensamiento STEAM (science, technology, engineering, arts, and mathematics) consideramos no se desarrollan integradamente en las aulas suficientemente. **Objetivos:** Esta investigación propone favorecer las destrezas STEAM mediante el aprendizaje basado en juegos.. **Diseño**: Estos fueron utilizados para diseñar una propuesta educativa integrada, denominada Micro Proyecto Lúdico (MPL), siguiendo los principios del aprendizaje basado en juegos y un enfoque intercultural centrado en Etnomatemáticas. **Entorno y Participantes**: Este MPL se implementó en un centro escolar español con pequeños grupos de estudiantes de Educación Infantil y Primaria, dedicando tres sesiones a cada uno de los cuatro juegos, que fueron grabadas en vídeo. **Datos recopilados y análisis:** Estudiando la cultura jamaicana, descubrimos que el juego es un signo cultural relevante en Jamaica, recopilamos y analizamos sus juegos tradicionales, generando un catálogo, del cual seleccionamos cuatro juegos, por sus potencialidades para desarrollar en la escuela aprendizajes STEAM**.** Se realizó investigación cualitativa-interpretativa mediante un estudio de casos y análisis de contenido, empleando una herramienta propia**.** **Resultados**: son diversas destrezas, artísticas, científicas y matemáticas manifestadas al jugar, cómo: sentido musical, detección de semejanzas, capacidad de giro, identificación de formas, estimación de distancias, formulación de hipótesis y establecimiento de relaciones por criterios, que han confirmado el potencial didáctico de estos juegos, en un entorno de educación intercultural etnomatemática. **Conclusiones:** Se deduce de los resultados la validez del MPL como método didáctico para desarrollar aprendizajes STEAM. Esperamos afianzar y difundir este método realizando nuevas elaboraciones y aplicaciones de MPL.

Palabras clave: Aprendizajes STEAM; Aprendizaje basado en juegos; Juegos tradicionales; Educación infantil y primaria; Educación intercultural etnomatemática.

Jogos como Potencializadores de Aprendizagem STEAM: Aplicação de Jogos Jamaicanos Tradicionais na Educação Intercultural Infantil e Primária

RESUMO

Contexto: Apesar de sua importância social, o aprendizado associado ao pensamento STEAM (science, technology, engineering, arts, and mathematics) que consideramos não é totalmente desenvolvido nas salas de aula. **Objetivos:** Esta pesquisa propõe promover as habilidades do STEAM por meio da aprendizagem baseada em jogos. **Design:** Estes foram utilizados para projetar uma proposta educacional integrada, denominada Micro Play Project (MPL), seguindo os princípios da aprendizagem baseada em jogos e uma abordagem intercultural focada. em Etnomatemática. **Ambiente e participantes:** Este MPL foi implementado em uma escola de espanhol com pequenos grupos de alunos da Educação Infantil e do Ensino Fundamental, dedicando três sessões a cada um dos quatro jogos, que foram gravados em vídeo. **Coleta e análise de dados:** Estudando a cultura jamaicana, descobrimos que o jogo é um sinal cultural relevante na Jamaica, compilamos e analisamos seus jogos tradicionais, gerando um catálogo, do qual selecionamos quatro jogos, por seu potencial de desenvolver o aprendizado STEAM em escola .A pesquisa qualitativa-interpretativa foi realizada por meio de um estudo de caso e análise de conteúdo, utilizando uma ferramenta proprietária. **Resultados:** são habilidades diversas, artísticas, científicas e matemáticas manifestadas ao tocar, tais como: senso musical, detecção de similaridades, capacidade de girar, identificação de formas, estimativa de distâncias, formulação de hipóteses e estabelecimento de relacionamentos por critérios, que têm confirmaram o potencial didático desses jogos, em um ambiente de educação intercultural etnomatemática. **Conclusões:** A validade do MPL como método didático para desenvolver a aprendizagem STEAM é deduzida dos resultados. Esperamos fortalecer e disseminar esse método, fazendo novas elaborações e aplicações de MPL.

Palavras-chave: aprendizagem STEAM, aprendizagem baseada em jogos, jogos tradicionais, educação infantil e ensino fundamental, educação intercultural etnomatemática.

INTRODUCTION

Since the end of the last century, playful learning and gamification have been introduced in the educational and business fields, without sometimes making a clear distinction between the two learning methods.

Playful learning, coined by Resnick (2004), is "a generic term that, until now, consisted of free play and directed play" (Hassinger-Das, Toub, Zosh, Michnick, Golinkoff and Hirsh-Pasek, 2017, p.203). A more operational definition of playful learning refers us to play experiences to learn (Fisher, Hirsh-Pasek, Golinkoff, Singer, & Berk, 2010; Johnson, Christie, & Yawkey, 1999). The game is characterized by being playful-fun, voluntary, intrinsically motivated, with active participation and a certain inhibition of reality (Pellegrini, 2009; Sutton-Smith, 2001). Transmitting these characteristics to playful learning, "games make use of aspects such as fun, inhibition of reality and curiosity to attract children and maintain their interest. These elements reflect most of the key ingredients in playful learning" (Hassinger-Das, et al, 2017, p.206). Within playful learning we can include game-based learning, an optimal teaching methodology for the future according to the Horizon 2011 study (Johnson, Smith, Willis, Levine and Haywood, 2011).

There is extensive research on the effectiveness of games to produce behavioral, cognitive and metacognitive changes (Mc. Gonigal, 2011), but there is not as much research on games as a methodological alternative to instruction, that demonstrate its effectiveness in the development of learning in areas scientific and mathematical (Gee, 2013). In the review by Li and Tsai (2013) of 31 empirical investigations on science learning based on digital games, 27 raised the concept learning and few explored processes, affects, motivation and socio-contextual scientific learning. Some of these questions, such as the natural connection between games and the Jamaican cultural community, are transversal to the development of scientific-mathematical learning in the didactic proposal proposed in this research, whose key question is : Can STEAM learning be developed (Science, Technology, Engineering, Arts and Mathematics) through traditional Jamaican games?

As an answer we addressed the general objective of showing the use of traditional games as a valid methodology to develop STEAM learning, through an integrated instructive proposal with an intercultural approach. In details, we set ourselves two specific research objectives: to design and implement a didactic proposal focused on traditional games practiced in Jamaica, and to analyze its didactic potential to develop contextualized scientific-mathematical learning. We understand that a game has didactic potential to develop learning, when playing it there is an activated evidence in which certain knowledge (practical or theoretical) is required, which is modified towards greater mastery, producing learning.

Therefore, we started from the idea of STEM education (Science, Technology, Engineering, and Mathematics), (Furman, 2016; Martín □ Páez, Aguilera, Perales □ Palacios, Vílchez □ González, 2019), considering that the integration of the different areas of knowledge produces significant knowledge of the world, especially if it is articulated through learning based on games, taken as a sign of cultural identity, (which is provided by the A for Arts).

We want to explain that we understand intercultural education as the educational practice that is developed in a context in which diverse cultures are present in daily school tasks, as objects of study that we incorporate into the curriculum, valuing their ancestral or current knowledge, as well as the decontextualized knowledge recognized academically and present in textbooks. Knowing cultural signs of other cultures (for example, games) makes value others, respect them and desire to establish symmetrical relationships between all cultures (interculturality), considering multiculturality as a very enriching social value

Thus, in our research we relate play, interculturality and STEAM learning, from an ethnomathematical approach (Oliveras, 2005, 2006), designing and developing an educational proposal based on Jamaican culture, specifically in its games, to educate Spanish children in interculturality, at the same time that they develop their scientific-mathematical, technical and humanistic competences, helping to revalue the culture of Jamaica, whose values we are attracted to when studying their playful and respectful with diversity lifestyle.

THEORETICAL FRAMEWORK

Game and STEAM education

For Huizinga (1955, 2014), the game is free and voluntary action that occurs within space-time limits and under freely agreed rules. Furthermore, it is a meaningful activity that has a social function and creates its own social structure. Piaget (1964) establishes that play in childhood allows us to participate in the environment that surrounds us, understand it and assimilate reality, achieving learning. Vygotsky considers that the main function of the game is to allow the individual to realize their self, develop their personality and acquire social skills (Vygotsky, 1982; Vygotsky and Luria, 1994).

The educational possibilities of the game have also been raised by many other authors who have shown their impact on scientific-technological, social and humanistic knowledge (Bergen, 2009; Fernández-Oliveras, Molina-Correa and Oliveras, 2016; Hassinger-Das, Toub , Zosh, Michnick, Golinkoff and Hirsh-Pasek, 2017; Vázquez-

Alonso and Manassero-Mas, 2017). All are based on the multidimensionality of the game, considering it a regulatory element of human development in society. We share this idea, highlighting three dimensions: cultural, leisure and, especially, educational, where it has a compensatory power (Figure 1), since 'although children of low socioeconomic status tend to underperform on many tests, both they and their Higher level peers tend to use similar everyday math in their games', (Ginsburg, Wu & Diamond, 2019, p. 273).

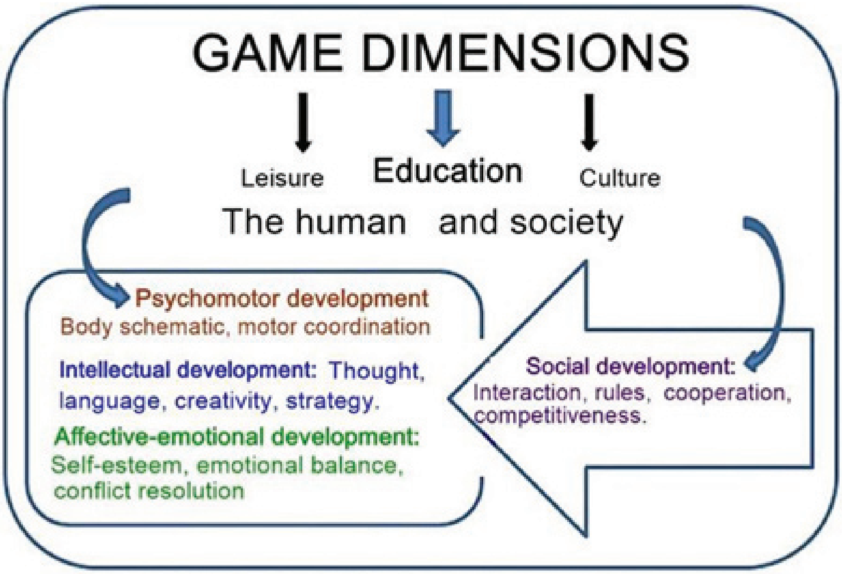

Figure.1 Dimensions of play and human development.

The connection between STEAM and game competencies was positively posed by Carr and Luken, (2014), indicating that boys and girls who learn academic concepts, participate in physical activities and research scientific principles through play, improve development in all domains. However, active teachers and also those in training, often doubt the value of play as a didactic method, especially for learning mathematics and science (Fernández-Oliveras & Oliveras, 2014).

We can define STEAM education as a more advanced model of STEM education (Páez, Aguilera, Perales - Palacios, Vílchez - González, 2019), where the arts and humanities, which include culture, are present in various facets, such as creativity, intuition and the development of the person in cognitive, physical, language, social, emotional and ethical domains (Chawla, 2013; Furman, 2016; Moore and Smith, 2014; Park and Ko, 2012; Sanders, 2009).

Further in depth the perspective of STEM and STEAM education, we turn to educational literature, concluding that one way to approach it is through the fact that all STEM disciplines offer opportunities to develop a set of common practices, such as: asking questions and design solutions, use models, design prototypes, investigate, analyze and interpret data, use computational thinking, generate arguments, evaluate and communicate information (Bybee, 2010; Stohlmann, Moore, & Roehrig, 2012). The STEM competence is characterized above all by providing solutions to everyday problems, relating to skills at all educational levels (Merrill and Daugherty, 2010; Moorehead and Grillo, 2013). On the other hand, the OECD (1996) indicates how cultural exchange patterns are necessary to educate flexible people with a global and intercultural mind, capable of creative work today. STEAM's full potential lies in including the arts and humanities, broadly understood, contemplating language, culture, history (Sullivan, Strawhacker, Umaschi Bers, 2017) and 21st century skills such as: creativity, intellectual curiosity, thinking critical, media literacy, cooperation, entrepreneurship, flexibility, intercultural interaction and social responsibility, (Ananiadou and Claro, 2009; Rotherham and Willingham, 2010). Furthermore, Park and Ko (2012) emphasize that STEAM education must include values and the promotion of skills related to ethics, leadership and empathy.

The principles of the STEAM educational approach base this research on teaching-learning of science and mathematics from an interdisciplinary perspective, in which the didactic methodology incorporates the artistic-humanistic part through cultural signs specifically of the game, through the practice of games. Traditional which additionally provides learning in values.

Game and culture. Ethnomathematic

The relationship between play and culture is based on Huizinga (1955), who posits play as a cultural element: "How much does culture have at stake?" (Huizinga, 2014, p. 20), and states: "Much of culture escapes being branded as a hypocrite for the mere fact of being part of the game. Society is saved, redeemed thanks to the game"(Huizinga, 2014, p. 22). Thus we intrinsically connect the game with culture and with intercultural education, an essential position in a global world.

All cultures play, since play is like mathematical and scientific thinking, are genuinely human physical or mental activities, intrinsically linked with culture, as Bishop (1988), expert in Ethnomathematics, indicates, affirming that there are six types of activities mathematics in which all cultural groups participate, the game being one of them. We conceptualize the sciences and mathematics following the approach of Ethnomathematics (D´Ambrosio, 2013), consisting of including both formal theories institutionalized in the academy, as well as the daily practices of micro-cultural groups, such as: groups identified by cultural signs, urban and rural communities, professional, ethnic, generational groups. Consequently, this research participates in a relativistic, sociocultural, ethnomathematical epistemology (Oliveras, 2006), which advocates interculturality in education (Oliveras, 2008). This implies accepting cultural diversity with respect and social equity, a perspective that all sectors of society have to assume (Rizvi, 2010, Walsh, 2005).

In the field of "school culture", Seckel et al. (2020), in their study of attitudes towards mathematics, indicate that teacher attitudes influence student attitudes (Seckel et al., P. 25); regarding the playful attitude, reflected in item 13 of the applied questionnaire: "I find it fun to study mathematics", show the following results: Totally agree: 15%, Agree: 24%, Neither agree nor disagree: 30% , Disagree: 24%, Totally Disagree: 7% (Seckel et al., P.31). That is to say, 39% have fun, 30% are perplexed by such a question and 31% do not have fun. Then only 30% of these teachers can transmit to their students the experience of a playful sense of mathematics. In turn, Burgos el al. (2019), affirm that the development of the knowledge and mathematical competences of the students is associated with the didactic-mathematical training of their teachers (Burgos et al., P.64), which shows the importance of introducing the playful perspective in mathematical training, both for teachers and for children, to improve their learning by enjoying their study.

Finally, within the focus of Ethnomathematics, to understand the approach of this research it is necessary to explain what a microproject is (Fernández-Oliveras & Oliveras, 2015). It is a curricular programming that does not start from content but from a relevant cultural axis or sign, which aims to develop competences in different subjects (sciences, techniques, mathematics), through integrated activities based on this sign. A microproject whose sign is the game contextualized in a culture, is a playful microproject (PMP). In this research, we selected traditional games in Jamaica as a cultural sign to develop an PMP.

METHODOLOGY

Phases. Methods and Techniques

The research in which this work is inserted, responds to the typology of Design-Based Research (DBR), or "*Design-Based Research*" (Confrey, 2006, Kelly, Lesh and Baek, 2008) and constitutes a single cycle of this methodology, which consists of three phases.

In the first phase, prior to this study, ethnographic techniques, curricular didactic analysis and content analysis applied to documents were used, carried out with a priori categories taken from scientific and mathematical epistemologies. Thus, the theoretical framework was developed and a "*Catalog of Jamaican cultural games*" was created, very useful for toy libraries (Fernández-Oliveras & Oliveras, 2019). The context for the initial anthropological study was Jamaica, where we find recreational activities as a sign of their cultural identity. We made the aforementioned catalog of about twenty traditional games and discovered that they are regulated. This type of games is characterized by rules to achieve a predetermined result in the game system, and its development varies depending on decisions or chance. We studied four games in the catalog as mediators of culturally contextualized mathematical-scientific thinking and enhancers of STEAM learning.

Second phase of the investigation, we designed an PMP, capable of developing mathematical and scientific learning, in a context such as the game that requires certain artifacts (engineering), aesthetic peculiarities (art), and interconnected values (respect for rules), activating STEAM learning. The aforementioned PMP was prepared, within the parameters of ethnomathematical interculturality and Spanish curricular regulations. The programmed PMP was also implemented and data on its development were taken, with the techniques: field notebook, audio recording and especially video, very suitable since it allows the spatial monitoring of the object of study (García, 2008). These recordings were taken directly, by someone outside the investigation. Data collection was carried out simultaneously with the performance of the PMP sessions. During the exploratory and initial sessions, one of the researchers carried out systematic, rational, direct and participant observation, taking field notes at the end of the sessions, changing to passive participant observation, in the final session. We show in this article the results of the second phase, whose obtaining process constituted the third phase, of which we also give all the most relevant information.

Third phase, a case study was carried out, considering as a case the activities carried out with each game, and integrating all the analyzes carried out on it. This research was carried out using a qualitative methodology, understood as that which produces descriptive data from observations (Taylor and Bogdan, 2000; Le Compte, 1995), and making contextualized interpretations, using Grounded Theory (Strauss and Corbin, 2002). For this, the videos were carefully visualized, the video segments were coded and analyzed with their own technique, registering them using tabular protocols prepared for the research (Figure 2):

Brown girl in the ring
Early Childhood Education (4 years)
Exploratory Session

C TO	Similarity detection		Detection of projective spatial relationships		Identification of flat shapes	Capacity rotation	Use of senses		Demonstration of balance	
TO	Imitate word said by the researcher	1:42	Forward shift	2:18 5:32 (slow) 6:03 (fast)	5:29 knows how to make a circle	4:30 transverse turn with the trunk	Ear	2:04 listen to the order and carry it out	Static	The whole session
			Scrolling down	6:31						
			Scrolling over an object	6:54						
	Mimics researcher or peer movement	1: 5 2:26 2:51 3:44 4:52	Shift left	7:27					Dynamic	4:04 jump
C	Mimics researcher or peer movement	1:58 2:49 3:47 4:47	Forward shift	5:35 (slow) 6.04 (fast)	7:15 position to form a circle		Ear	2:41 listen to the order and carry it out	Static	The whole session
			Scrolling down	6:24 6:30	8:18 identify rectangular shape					
			Scrolling over an object	7:03					Dynamic	1:54 and 2:24 scroll jump

Figure.2. Example of a protocol developed for data recording and analysis

In the data analysis and registration tables (one for each session) the categories associated with STEAM learning were reflected, some elaborated a priori through the analysis and initial classification of the games, and others emerging from the implementation, recording the data corresponding to each participant, in terms of temporal occurrence of actions or evidences that manifest each category (Figure 2). We show the set of 18 categories, and their relationships with each game, in Table 1. The creativity category was captured by the researcher and recorded in her field notebook, but not accounted for by video sequences.

Table 1.
Set of Categories for analysis and its relation to games

Games / Analysis categories	Brown Girl in the Ring	Dandy Shandy	Marbles	Domino
Identification of flat shapes or figures	X			
Identification of turning situations	X			
Similarity detection	X			
Detection of spatial topological relationships	X			
Use of the senses (music. Gesture, vision)	X			
Gross psychomotor activity: movement and balance	X	X		
Application of logical laws		X		
Detection of empty lengths or distance		X	X	
Specular laterality identification		X		
Offsets direction different from a path		X		
Detection of the three-dimensional plane-space relationship			X	
Identification of angles in hypothetical trajectories			X	
Sense of the force-speed relationship			X	
Hypothesis development			X	X
Establishment of relationships through criteria				X
Strategies development				X
Elaboration and perception of spatial structures				X
Creativity	X	X	X	X

This type of methodology allows showing evidences of various STEAM learning, activated when playing these games and through their records knowing the potentialities manifested by each game in this experience, collected in Figure 3.

In the previous sections, what was carried out in each phase of the research cycle was described. Qualitative research techniques such as case studies and content analysis were used to obtain evidence that supports learning through the design called PMP applied to Jamaican games, which will allow us to use it in a second cycle of research in other contexts.

RESULTS

The analysis of the implementation of the PMP is constituted by the interconnection of the four cases, first studying each case then together and what happened after analyzing the data.

The four games that make up the investigated cases were analyzed and have the following typological characteristics (Table 2) according to MTJ the authors' game classification model (Fernández-Oliveras et al, 2019):

Table 2.
Typologies of the games used in the research, according to MTJ

		Games used in research		
Type according to MTJ (Game Typing Model)	BROWN GIRL IN THE RING	DANDY SHANDY	Marbles	DOMINO
2 Social game	X	X	X	X
3 Regulated game	X	X	X	X
4 Functional and sensory coordination game	X	X	X	
5 Game of thought and creativity	X		X	X
6 Game of expression and emotional control	X			
8 Multiplayer game	X	X	X	X
9 Popular or traditional game		X	X	X
10 Outdoor set	X	X	X	X
11 Indoor set	X			X
12 Competitive Play		X	X	X
14 Cooperative play		X		
15 Non-competitive play	X			
17 Collaborative game	X			
19 Board Games				X
STEAM potential level				
Tall	X	X	X	X
Medium				
Low				

The high level of STEAM potential and the variety of types they collect, made these games were chosen for research.

Case A: Brown Girl in the Ring game.

Figure 3. First year students of Early Childhood education playing Brown Girl in the Ring

Brown Girl in the Ring is a circle game, where a participant located in the center of the circle makes a movement to the rhythm of the music and the rest of the participants must imitate it. (Jamaica Field Service Project, 2018)

Altogether, the participating researcher noted that this game activates the musical sense and the practice of balance-rhythm, along with the other six scientific-mathematical learnings, detected through video sequences and whose counts are shown in the graph in Figure 4. Results corresponding to the exploratory session show good levels of the students in the execution of the categories “Detection of similarities” and “Detection of topological notions”, the rest of the categories show lower rates. This could be due to the fact that during this session the players did not yet recognize a turn, nor were they aware that they possessed turning capacity as an ability.

In the initial session, when the participants start to play for the first time, they discover new skills that they were previously unaware of and increase the values in detecting similarities and especially in turning capacity. This is motivated by the characteristics of the second session, which further favors the development of motor skills. It also increases the “use of the senses”, as they respond to oral commands by changing their movements, using the ear and developing physical knowledge.

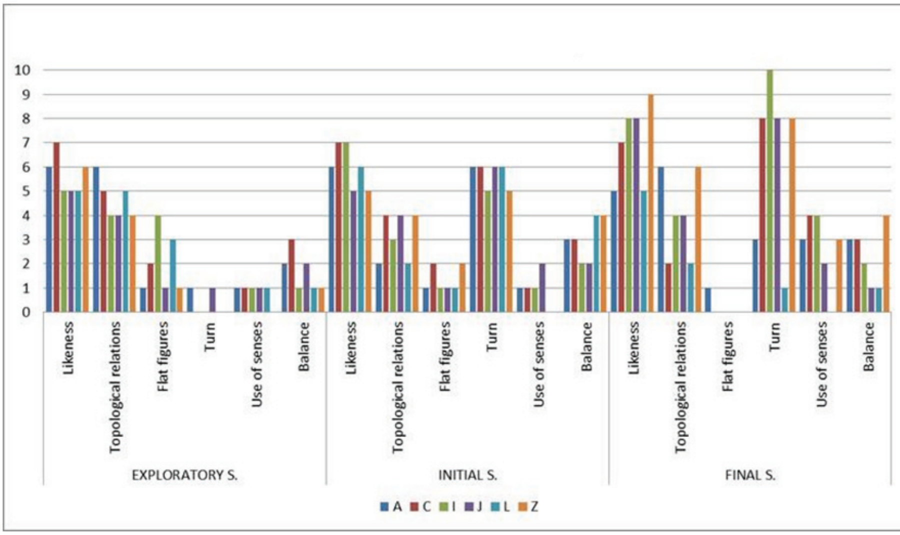

Figure 4. Graph with the results of the three sessions of Brown Girl in the Ring

This, combined with comprehensive language or social knowledge, leads to so-called logical-mathematical knowledge, through which relationships are established between the physical elements of the environment and the mental elements, such as concepts, properties, procedures, relationships in the form of guidelines or patterns and strategies of action and decision, which together configure, according to Piaget, (1964), human knowledge. We appreciate learning or changes in the knowledge of the participants, when the game instructor intervenes, since these skills are found in the "potential development zone" of these young children, which are activated by collaboration with another subject (Vygotsky and Luría 1994).

Regarding the last session, we can see how the levels of most categories (of participants C, I, J, Z) increase again, the highest being those of "Similarity detection" and "Turning capacity ", Which is remarkable for the correct development of this game. Finally, in "Identification of forms", the levels recorded suffer a general decrease due to the content of the sessions, in which no flat forms appear. Z and I are the most representative subjects of progress.

Case B: Dandy Shandy Game

Figure 5. Second year students of Early Childhood education playing Dandy Shandy

This game consists of forming two teams that must throw a ball or paper ball in order for it to touch an opponent and eliminate him from the game. The winning team will be the one that eliminates the last player from the opposing team (Mckenzie, 2011).

According to the field notes of the participating researcher, the game shows potentials such as: cooperation, respect for (social) rules; mathematical and scientific attitudes, using logic, appreciation of distances and use of laterality-position and displacements in space, (Figure 6).

In this case, during the exploratory session they were appreciated in the video as mathematical and scientific skills in the players, only the use of displacement. However, the researcher realized that they took into account the logical laws since they understood that they had to throw the ball with more or less force, depending on the distance at which their rival is. They also demonstrated a good use of displacement to prevent the ball from hitting them, the most used movements being displacement to the left and bending down. In the initial session, the participants demonstrated an improvement in the aforementioned use of displacement, as well as in the use of laterality. Both reflected in the players who had to dodge the ball. The team that was in charge of throwing the ball showed more potential in estimating distances, while the receiving team increased the categories of "Use of displacements" and "Laterality" when trying to dodge the ball.

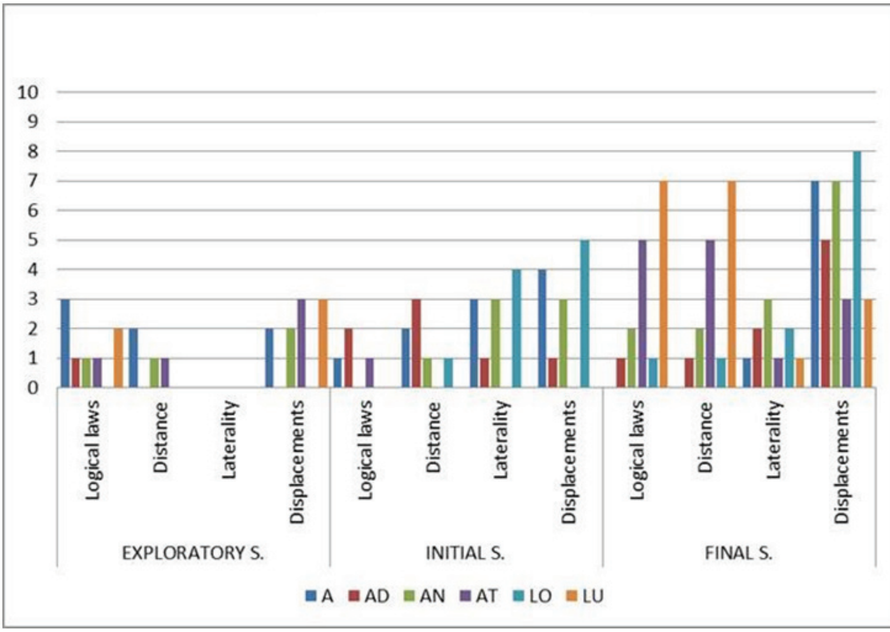

Figure 6. Graph with the results of the three sessions of Dandy Shandy

In the final session, there was an increase in all categories except for the laterality, which decreased a little, due to their more elaborate techniques of dodging the ball, since they already jumped, made turns or curls, observed emerging learning (Figure 6).

Case C: Marbles.

Figure 7. First year primary school student playing marbles

In this case, initially it was played in such a way that the students had to bring their marble closer to the established point. (Lucas, 2016).

The learning involved in this game, regarding the use of the senses, coordination of perspectives and psychomotor skills were tested in all sessions of the game along with the identification of shapes and the perception of the volume of the sphere, appreciating its influence on the increase in the other four learning elements, which were highlighted in the video and evaluated for their repeated occurrence. As can be seen in the graph (Figure 8), there was a significant increase in the analyzed mathematical and scientific skills over the course of the sessions.

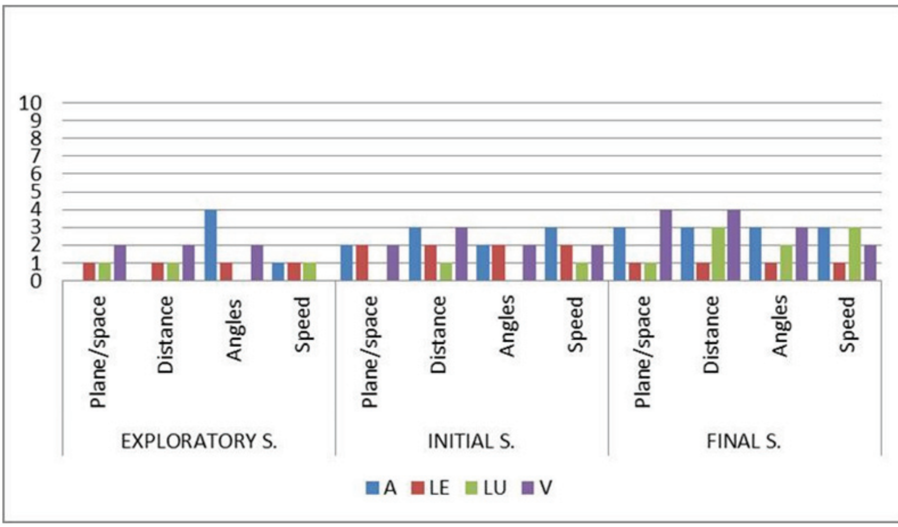

Figure 8. Graphic with the results of the three Marbles sessions

Meanwhile during the exploratory session the players demonstrated better results in the measurement of angles when making a throw, in the initial session there was an improvement in the distance estimation. Since the player first establishes the point at which he wants to launch the marble and the angle at which he must perform this launch, to later calculate the force (which they perceive as speed) with which he must launch, according to the distance from the point. Finally, during the final session, there was a considerable increase in all categories,

Highlighting the estimation of distance and launch speed. At the end of the third session, the players understood that they should launch with less force if the chosen point is closer to them, something that during the first session was barely reflected (Figure 8).

Case D: Domino-Domino Game.

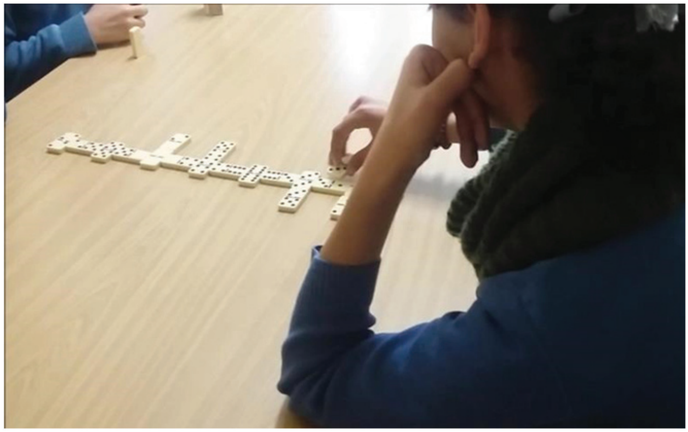

Figure 9. Sixth grade Primary School student playing Domino-Dominoe

The quintessential game of Jamaican society, in this case it was played in its "French" version where the placement of a chip is preceded by the previous chip, which must be twice the same value as this one. (Pineda, 2016)

During the exploratory session, only the formulation of hypotheses was stated, since the session was guided by a question, due to the researcher's interest in knowing the initial level of hypothesis development that the players had. This question was: "Why do they eat ackee fruit in Jamaica without suffering health problems, when it is highly toxic?" it is not toxic at its point of maturity (when it is open) or cooked, a change in properties that surprised them. They exercised scientific skills in this process, which are collected in the field notebook, but when they were analyzed in the video, they turned out to be of a low level (Figure 10). In the initial session, great progress was made in establishing relationships by criteria, especially in the two participants who had never played dominoes, but there was hardly any strategy, during the final session the players revealed numerous techniques to improve their game. Something similar occurs with the debate before the proposal of a hypothesis. During this session, the players were more participative and revealed a greater number of ideas when faced with the question posed by the researcher. It was also remarkable how as the sessions progressed they made more complex game structures, reflected in the video. In the final session, a great advance was demonstrated regarding the increase in STEAM learning, confirming the mathematical and scientific potential of the game and the didactic validity of the PMP.

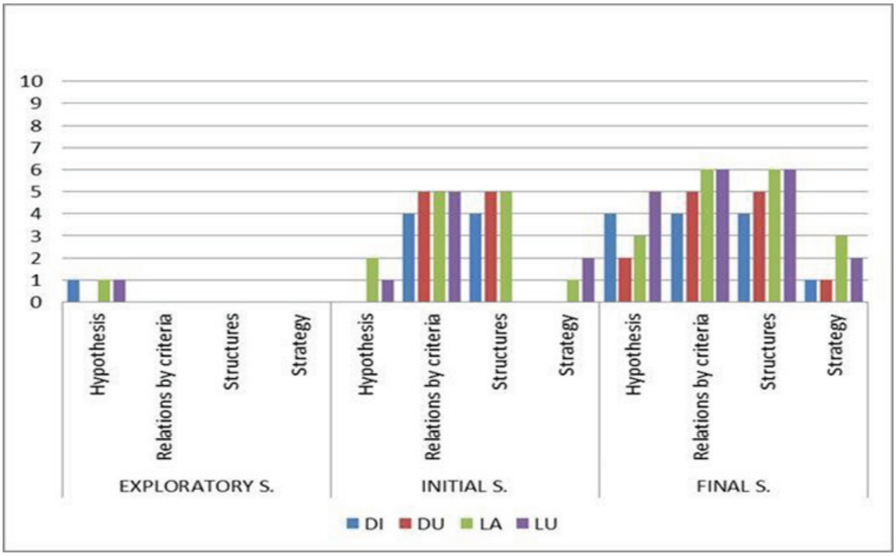

Figure 10. Graph with the results of the three Domino-Dominoe sessions

DISCUSSIONS

The cited studies by relevant authors affirm that children from all socioeconomic levels use mathematics in games: "they and their higher-level peers tend to use similar everyday mathematics in their games', (Ginsburg, Wu and Diamond, 2019, p. 273). In accordance with this, we conclude, from case A, that the game used shows sufficient evidence of activating the six mathematical and scientific learnings a priori categorized as possible and also develops the artistic musical sense as well as psychomotricity.

As we indicate in the framework of foundations, STEM competence is characterized above all by providing solutions to everyday problems, relating to skills (Merrill and Daugherty, 2010; Moorehead and Grillo, 2013). This has been verified in cases B and C. Case B has shown good evolution of the mathematical and scientific learning of the participants, and adds emerging spatial and psychomotor learning, thus affirming the potential of the game analyzed.

Case C presented material difficulties that were overcome, scientific learning that related force to speed was activated, space mathematicians and psychomotors who jointly developed everyday physical knowledge typical of the real world. The game involved shows good potential for learning.

In case D, it was possible to appreciate learning developed through a greater evolution of the logical and strategic elements, which also allow solving everyday problems. The version used, of French origin, has great mathematical and scientific potential, and provides interculturality, since, as the OECD (1996) indicates, patterns of cultural exchange are necessary to educate flexible people, capable of working creatively in the STEAM sense.

In all cases, rather than variations from one session to another, we are interested in highlighting the presence of evidence of the categories involved in each game, associated with STEM learning.

The study shows the 18 STEAM learnings activated with the four selected traditional games, with evidences registered by means of video recording and the elaboration of the field notebook, underlining the consequent potentiality of the games to develop such learning, which additionally provide learning in values , typical of component A understood broadly.

The case study as part of a design investigation and as such is contextualized and therefore what we can affirm is that what was discovered in the study is possible, although it cannot be generalized to all contexts or give it universal objective validity. . If it has been possible in these circumstances, it can be extrapolated to similar contexts and circumstances, in a second cycle of research, and always with a rigorous interpretation of its scope regarding the power of games as a STEAM learning method.

CONCLUSIONS AND EDUCATIONAL IMPLICATIONS

In the present study, we selected four games, from a catalog prepared through analysis and classification of popular games in Jamaica, which was carried out in an initial phase of the research design to which this work belongs. We select them for their a priori potentialities to activate aspects associated with mathematical and scientific thinking and other skills that generate STEAM learning.

Based on these games we designed an PMP, that was experimented with students from Early Childhood and Primary Education, discovering, through a case study. The curricular design is valid for working various subjects in an integrated way at school, through activities based on the games studied, whose educational potential STEAM is evident.

We can affirm this since, through the games involved in the PMP, evidence of activation has been collected in the ability players such as: elaboration of hypotheses, planning, detection of similarities, spatial sense, appreciation of the concept and ability to perform turns and spatial transformations. The participants also developed: logical-mathematical knowledge through which they established relationships between elements of the environment and built scientific learning about concepts, properties or procedures, in the form of guidelines or patterns, they won in developing strategies and choosing between alternatives.

The educational implications derived from this research point to the fact that given the suitability of the PMP design for the STEAM approach to education, since it takes as a nucleus to organize scientific and technical learning a relevant cultural sign in a social group, such as games employees, learning related to the artistic and humanistic aspects (musical and aesthetic sense, values and ethics) could also be developed.

In conclusion, through PMP, integrated game-based learning can be developed together with other positive values for coexistence in society, such as compliance with agreed rules, the ability to accept that one does not always win, companionship and cooperation.

Among the values that would be promoted, those associated with the intercultural educational conception stand out, such as respect for all cultures, as indicated in this case, materializes in the knowledge and practice of games typical of other parts of the world.

As a result, through this research cycle, it has been possible to demonstrate the educational value of the game as a methodology for the development of STEAM learning, and to state that traditional games are good mediators to disseminate values involving intercultural education.

AUTHORS ‘CONTRIBUTION STATEMENTS

MJE-G has contributed to the ethnographic study of the Jamaican culture, the analysis of the games, the design and implementation of the MPL and the analysis of the data. AF-O has directed the entire project, reviewed and corrected the design and analysis of data, collaborating in the writing of the final text; MLO has contributed in the implementation phase, advising on specific situations and collaborated in the revision of the data and the final text.

DECLARATION OF DATA AVAILABILITY

The data is in the authors’ files, the first author being in charge of their custody and consultation by those interested.

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