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# Contributions, Limitations, and Opportunities for the Development of Statistical Literacy with the Blue & Red Game

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***Abstract:*** This study aims to investigate the use of the Blue & Red game as a didactic tool in Statistical Education, highlighting its contributions, potentialities, and limitations in the development of statistical literacy. The methodology included the analysis of workshops with students from the Universidade Federal Fluminense, where the game was intentionally employed to promote statistical learning. Participant data were collected through questionnaires and qualitatively analyzed. The results demonstrate the game's effectiveness in creating conducive environments for teaching and learning in Statistics, encouraging discussions and critical reflections on the importance of using games in this teaching area. The game also proved valuable in the training of educators and students, with wild cards enriching the educational experience. It is concluded that Blue & Red is a pedagogical strategy that can assist in the development of statistical literacy, suggesting future research to investigate its applications in different educational contexts.

***Keywords:*** Statistical Education. Educational Games. Blue & Red Game. Statistical Literacy. Content Analysis.

# Contribuciones, Limitaciones y Oportunidades para el Desarrollo del Alfabetismo Estadístico con el Juego Blue & Red

***Resumen:*** Este estudio tiene como objetivo investigar el uso del juego Blue & Red como herramienta didáctica en Educación Estadística, destacando sus contribuciones, potencialidades y limitaciones en el desarrollo del alfabetismo estadístico. La metodología incluyó el análisis de talleres con estudiantes de la Universidade Federal Fluminense, donde el juego se empleó intencionalmente para promover el aprendizaje estadístico. Los datos de los participantes se recogieron mediante cuestionarios y se analizaron cualitativamente. Los resultados demuestran la eficacia del juego en crear ambientes propicios para la enseñanza y aprendizaje en Estadística, fomentando discusiones y reflexiones críticas sobre la importancia del uso de juegos en esta área de enseñanza. El juego también resultó valioso en la formación de educadores y estudiantes, con cartas comodín enriqueciendo la experiencia educativa. Se concluye que Blue & Red es una estrategia pedagógica que puede ayudar en el desarrollo del alfabetismo estadístico, sugiriéndose investigaciones futuras para explorar sus aplicaciones en

diferentes contextos educativos.

***Palabras clave:*** Educación Estadística. Juegos Educativos. Juego Blue & Red. Alfabetismo Estadístico. Análisis de Contenido.

## Contribuições, limitações e oportunidades para o desenvolvimento do letramento estatístico com o jogo Blue & Red

***Resumo:*** Este estudo tem como objetivo investigar o uso do jogo Blue & Red como ferramenta didática em Educação Estatística, destacando suas contribuições, potencialidades e limitações no desenvolvimento do letramento estatístico. A metodologia incluiu a análise de oficinas com discentes da Universidade Federal Fluminense (UFF), na qual o jogo foi empregado intencionalmente para promover o aprendizado estatístico. Dados dos participantes foram coletados por meio de questionários e analisados qualitativamente. Os resultados evidenciam a eficácia do jogo em criar ambientes propícios para o ensino e aprendizagem em Estatística, incentivando discussões e reflexões críticas sobre a importância do uso de jogos nessa área. O jogo também se mostrou valioso na formação de educadores e estudantes, com cartas coringa enriquecendo a experiência educativa. Conclui-se que o Blue & Red é uma estratégia pedagógica que pode auxiliar no desenvolvimento do letramento estatístico, sugerindo-se pesquisas futuras para investigar suas aplicações em diferentes contextos educativos.

***Palavras-chave:*** Educação Estatística. Jogos Educacionais. Jogo Blue & Red. Letramento Estatístico. Análise de Conteúdo.

### 1 Initial considerations

The incorporation of statistics into contemporary educational practices is not only a necessity imposed by social demands, but also a highly important pedagogical strategy. In this perspective, its implementation in Brazil, through the National Curriculum Parameters (PCN) and the National Common Curriculum Base (BNCC) (Brasil, 1997, 1998, 2000, 2018), normative documents that include Statistics as an essential area of the educational curriculum.

In particular, as can be seen in the PCN, the "Treatment of Information" block is incorporated into primary education and "Data Analysis" into secondary education. These guidelines seek to integrate aspects of Descriptive Statistics, Combinatorial Analysis and Probability, as well as providing an environment for students to build their knowledge anchored in everyday experiences.

The BNCC includes a series of skills and competences associated with the teaching of statistics, from primary to secondary school. The document emphasizes the importance of working with different representations of data, such as tables, graphs and statistical measures, in order to enable students to develop an in-depth and critical understanding of the information that is constantly presented to them in different formats.

Souza (2019) argues that the teaching of statistics in basic education should begin in the early stages of schooling, with the aim of enabling young learners to handle and interpret real-world phenomena. This approach aims for students to acquire the skills to read, understand, analyze and interpret statistical data in everyday situations, favoring a decision-making process based on capturing and understanding the variability intrinsic to data sets. From this perspective, the development of statistical reasoning skills from the Early Years of Primary School is essential for the construction of statistical literacy, an indispensable prerogative for the formation of critical and engaged citizens in society (Gal, 2002, 2019).

Initially, it is necessary to mention the definition of statistical reasoning postulated by

Garfield (2002), who conceptualizes it as the process by which an individual engages in thinking based on statistical ideas and interprets information of this nature in a meaningful way. This concept is distinct from, but complements, the notion of statistical literacy, which goes beyond statistical literacy, first proposed by Wallman (1993, p. 1), as the "[...] ability to understand and critically evaluate statistical results that permeate our daily lives along with the ability to recognize the contribution that statistical thinking can make to public and private, professional and personal decisions."

This definition is in line with an integrative and applied view of statistics, which emphasizes its importance not only in the academic field, but also in various aspects of everyday life. It involves conceptions of statistics that go beyond the mere ability to perform calculations or interpret data, as it incorporates a set of critical and evaluative skills (Giordano, 2020). In this sense, statistical literacy manifests itself in a variety of skills, from the ability to interpret information in graphical forms to the ability to question the validity and relevance of statistical methods used in studies and reports.

Furthermore, it is necessary to point out the concept of statistical literacy developed by Gal (2002), which has a broad and multidimensional scope. This definition is not just limited to the ability to read and interpret statistical information, but also encompasses the competence to produce it in a critical and informed manner. In the model he proposes, statistical literacy is structured around cognitive and dispositional components.

According to Gal (2002), the cognitive sphere includes literacy skills, statistical and mathematical knowledge, contextual understanding and the capacity for critical questioning. These elements are fundamental for the individual, in addition to consuming, to be able to generate statistical information in an assertive and critical manner. On the other hand, the dispositional aspect of the model encompasses beliefs and attitudes towards statistics, as well as the critical stance an individual takes towards statistical information and arguments. These dispositions affect the way a person interacts with statistical information, both in the academic context and in everyday life.

Gal's (2002) holistic view of statistical literacy has significant implications for the educational curriculum and for the pedagogical strategies adopted to teach statistics, as discussed by Giordano (2016). In this sense, it is not merely a question of inserting statistical content into the school curriculum, but of cultivating a complex set of skills, knowledge and dispositions that enable citizens to deal critically with statistical information and assist in decision-making.

According to Watson and Callingham (2003), statistical literacy plays a fundamental role in a citizen's life. By developing this skill, individuals develop a critical attitude that allows them to question information and data.

> Statistical literacy is important not only for our society as a whole; it is also relevant to individual members of society, as they make decisions in their personal lives based on information and risk analysis provided by others in the community. Decisions such as where to live, what kind of job to look for, buying a car can be influenced by data provided from outside their individual experience (Watson & Callingham, 2003, p. 4).

This observation by Watson and Callingham (2003) broadens the discussion beyond the academic and professional domains, pointing to the relevance of statistical literacy in everyday aspects and in decision-making at both an individual and collective level.

Coutinho (2013) points out that statistical literacy involves the skillful application of statistical concepts and procedures by the subject. In this way, statistical reasoning and literacy are important for citizens' ability to interact in a critical and informed way with a world full of data and quantitative information. This perspective suggests that the development of statistical literacy in basic education, as a complex educational task, requires an integrated and comprehensive approach that encompasses both the theoretical and practical training of mathematics teachers (Porciúncula, 2022).

Both concepts - statistical reasoning and statistical literacy - have profound implications for the teaching of Statistics and the training of citizens who are able to evaluate, interpret and question statistical information in multiple contexts. They reinforce the urgency of implementing statistics education from the early years of elementary school, corroborating the idea that a thorough understanding of statistics is indispensable for full citizenship in the 21st century.

Despite these relevant considerations, Gal (2002) emphasizes the need to promote statistical literacy in society. This process goes beyond the simple acquisition of technical skills, and involves the development of abilities to interpret and critically evaluate statistical information, as well as to articulate reasoned opinions about this data. In the same vein, Coutinho and Souza (2015) emphasize the importance of using methodologies that enable students to be active in the pedagogical processes involved in teaching and learning statistical content, which is necessary for exercising full citizenship.

It is essential that statistical literacy is promoted early on, through a gradual and systematic approach, starting from the first years of schooling. This facilitates the absorption and practical application of statistical concepts, while at the same time preparing individuals for the complexity of the social and professional demands they will encounter throughout their lives (Porciúncula, 2022).

As part of the ongoing effort to improve teaching methodologies in Statistics, the Teaching and Learning in Mathematics and Statistics Research Group (GPEAMATEST) at the Fluminense Federal University, recognized and registered with the National Council for Scientific and Technological Development (CNPq), has developed the didactic game “Blue & Red: a strategy and Statistics game”. This initiative is the result of a collaborative research approach aimed at deepening the theory and practical application of statistical concepts.

The creation of the game represents a significant milestone in the group's initiatives to innovate and enrich the learning process, as it offers students a playful tool that promotes both engagement and the development of statistical literacy in an interactive and challenging way. In view of this, the following research question emerges: How does the Blue & Red game influence the development of statistical literacy in primary school students and teachers in initial training, considering the perceptions of both groups about the effectiveness of playful methodologies in learning fundamental statistical concepts?

## 2 The use of games to teach mathematics

The incorporation of educational games as an active and varied approach to teaching mathematics in basic education is supported by both the National Curriculum Parameters (PCN) and the Common National Curriculum Base (BNCC). These guidelines emphasize the use of playful methods to enrich the mathematical learning process.

The PCN (Brasil, 1997, 1998, 2000) encourages the use of games as a way of making the teaching of mathematics more dynamic and meaningful for students. According to the

document, games can help develop skills such as logical reasoning, problem solving and understanding abstract concepts in a more applied and playful context.

The BNCC (Brasil, 2018) contains a more recent and detailed framework for the Basic Education curriculum, including the teaching of mathematics. In it, games are seen as pedagogical resources that can be used to achieve various competences and skills. They can be especially useful for promoting student engagement and for introducing or consolidating mathematical concepts in a contextualized and interactive way. For example, in the BNCC (2018), the use of games is suggested to explore concepts of Geometry, quantities and measures and Statistics, contributing to an integrated and applied teaching of Mathematics.

Both documents offer a foundation for teachers interested in incorporating games as part of a broad pedagogical strategy for teaching mathematics. The validation of these practices by national curriculum documents represents an institutional endorsement that can encourage more widespread adoption of these methodologies.

Educational games in mathematics are classified by Borin (2007) as: Training Games and Strategy Games. The former are designed to consolidate specific mathematical concepts. In this category, the game acts as a reinforcement vehicle, in which students practice and apply concepts learned in lectures or through other forms of instruction. The aim is not only to fix the content, but also to transpose theoretical knowledge into the practical domain. Strategy games, on the other hand, aim to improve logical-mathematical reasoning. Here, the emphasis is not so much on memorizing or directly applying formulas, but on the ability to think strategically, analyze patterns and make inferences. This type of game resonates with pedagogical approaches that emphasize the development of critical thinking, as pointed out in the regulatory frameworks for Brazilian education.

With this approach, Borin (2007) also notes that the use of games in Mathematics Education has the potential to lower the emotional and psychological barriers often associated with the subject. In this way, they can catalyze more positive attitudes towards mathematics, contributing to better academic performance and more effective learning. This phenomenon is confirmed by a variety of studies in Educational Psychology and Neuroscience that demonstrate the cognitive and emotional benefits of playful pedagogical approaches (Ramani & Siegler, 2008; Plass, Homer & Kinzer, 2015).

By proposing to work with educational strategy games, we hope to enhance the learning of the content discussed in Blue & Red in a playful way, since games are present in the social reality of children and adults. According to Gitirana et al. (2013), games can become an important way of introducing children to the world of school, as they help them to integrate into the group, promoting discussions about life in society, as well as having the potential to become a didactic element for teaching and learning different school skills.

According to Kishimoto (2017), games in education are privileged ways for students to appropriate, develop and acquire knowledge. They are important alternatives in pedagogical practice and curricular proposals. The game as a pedagogical resource produces conditions to maximize the construction of knowledge, by introducing elements such as pleasure, playfulness, active action and motivation. Games have the potential to contemplate various ways for students to represent their multiple abilities, contributing to learning, affective development, cognition, the manipulation of objects and exchanges in social interactions (Kishimoto, 2017).

For Gitirana et al. (2013), there are several games that enable the integration of different fields of knowledge. By becoming a player, the child is not just an observer, but becomes an

active element, getting involved in strategic decision-making, in the search for victory, which promotes problem-solving.

The characteristics of a pedagogical game and the motivation it provides can arouse the student's interest in learning in a pleasurable and joyful way, as well as stimulating creativity, curiosity, affectivity and sensitivity, making the learning process more dynamic (Luckesi, 2000). These aspects are related to playful learning, an important factor for quality education, which needs to be consciously planned.

> An education that takes playfulness into account is a broader human endeavor, which relates not only to the presence of games or playfulness, but also to a feeling, an attitude of the subject involved in the action, which refers to a celebratory pleasure as a result of genuine involvement with the activity, the feeling of fullness that accompanies meaningful and true things (Luckesi, 2000, p. 57).

## 3 Blue & Red: a strategy and statistics game

Initially, it is necessary to clarify some concepts about the game, given that Blue & Red offers challenges and problems to be solved. The experiences had by the participants can help develop self-confidence and offer important moments for the learning process. In this context, Gitirana et al. (2013) emphasize that games encourage the development of cognitive and affective autonomy, making it possible to change strategies in response to the objective of the game, looking for other ways to solve problems. However, it is necessary to reflect on the suitability of the game in relation to the age group, as failure can lead to frustration, which is not in line with the purpose of the game.

In his approach to educational games, Flemming (2004) points to the teacher's constant mediation during the course of a game and the care taken to insert this activity into the overall context of the class. The teacher needs to be attentive to relating the “before” and the “after”, ensuring that they can assess whether the game has achieved the planned didactic objectives. Thus, the use of games in the school environment requires a clear definition of the guiding objectives sought.

Based on this approach, a didactic-pedagogical proposal was drawn up centered on the use of an educational Statistics game, with the aim of incorporating elements of Descriptive Statistics, such as measures of central tendency and measures of variability. This approach offers an environment conducive to the development of statistical thinking, as advocated by Gal (2002) and Garfield (2002).

The first methodological validation of the Blue & Red game was conducted in 2013 by researchers from GPEAMATEST and a group of students from the Mathematics degree course at the Universidade Federal Fluminense, Santo Antônio de Pádua campus, in the northwest of Rio de Janeiro.

The Blue & Red game was presented at the XI Encontro Nacional de Educação Matemática (ENEM), in Curitiba, Brazil, as described in Souza, Tavares and Pereira (2013). It was also presented at the VII Ibero-American Congress of Mathematics Education (CIBEM) in Montevideo, Uruguay, as outlined in Souza (2013). Finally, it was presented at the International Association for Statistical Education (IASE) Satellite Conference in 2015 (Souza, 2015).

The relevance of this didactic game is not restricted to mastering the contents of Descriptive Statistics, as it also aims to promote the development of logical-mathematical reasoning. The playful activity was designed to provide an interactive platform on which

students can solidify the statistical concepts that have been introduced in their formal instruction, and also apply them in a contextualized way, promoting a deeper and more integrated understanding of the statistical content covered in the game.

Furthermore, the game seeks to create a pedagogical environment in which the cognitive processes necessary for logical-mathematical reasoning can be cultivated in a more intrinsic and engaging way. Therefore, by blending academic rigor with playful elements, this proposal aims to contribute to the formation of citizens who are not only technically competent in handling data and statistical information, but also capable of applying these skills critically and consciously in various everyday situations. Souza (2015) classified the Blue & Red game as a

> training and strategy, as it allows the concepts of measures of central tendency and dispersion to be established, avoiding mere memorization; in addition to providing deductive, inductive and logical reasoning; where each player makes their own choices and decisions, forcing them to elaborate and re-elaborate their hypotheses in each round (Souza, 2015, p. 2).

The didactic-pedagogical proposal of the Blue & Red game is outlined by a set of interrelated objectives that focus on promoting statistical and mathematical skills in accordance with the BNCC (Brasil, 2018). These objectives are articulated as follows:

- Consolidating the concepts of measures of central tendency: the game provides an environment conducive to establishing the fundamentals related to measures of central tendency, specifically the mean, mode and median;
- Broadening understanding of measures of variability: another purpose is to consolidate understanding of measures of variability, such as amplitude and standard deviation, which are fundamental concepts for analyzing and interpreting data sets;
- Reinforcement of complementary statistics: in addition to central and dispersion measures, the game also seeks to consolidate understanding of additional statistics, such as the maximum and minimum values of a data set;
- Fostering deductive, inductive and logical-mathematical reasoning: transcending the purely statistical sphere, the game aims to stimulate a variety of forms of reasoning, including deductive and inductive methods, as well as skills linked to logical-mathematical reasoning.

This pedagogical proposal therefore aims to provide a comprehensive education that encompasses both conceptual aspects and critical and analytical thinking skills, in line with the curriculum guidelines and the competencies provided for teaching Mathematics and Statistics.

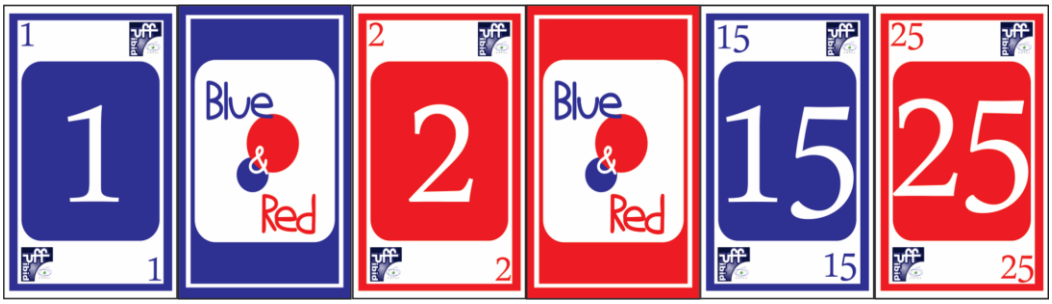
The Blue & Red game includes the following elements:

- 52 number cards: the cards are divided into two distinct groups, with 26 cards each. The set of blue cards contains positive values, and the set of red cards has negative values. The 13 cards in each set have the following values: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20 and 25;
- 18 joker cards: these cards have special functions within the game and are placed on the board in specific locations;
- Board: serves as a platform on which the cards to buy, wild cards and discards are placed;
- 12-sided dice (dodecahedron): used to introduce the element of chance and variability into the game, essential aspects for understanding statistical concepts. The number that comes up on the dodecahedron determines which statistic will be calculated in the round according to the

measurements predetermined before starting the game;

- Notebook: used to keep records of the statistical calculations made by each participant throughout the rounds, making it easier to check and analyze them later.

**Figure 1:** Some cards from the Blue & Red game

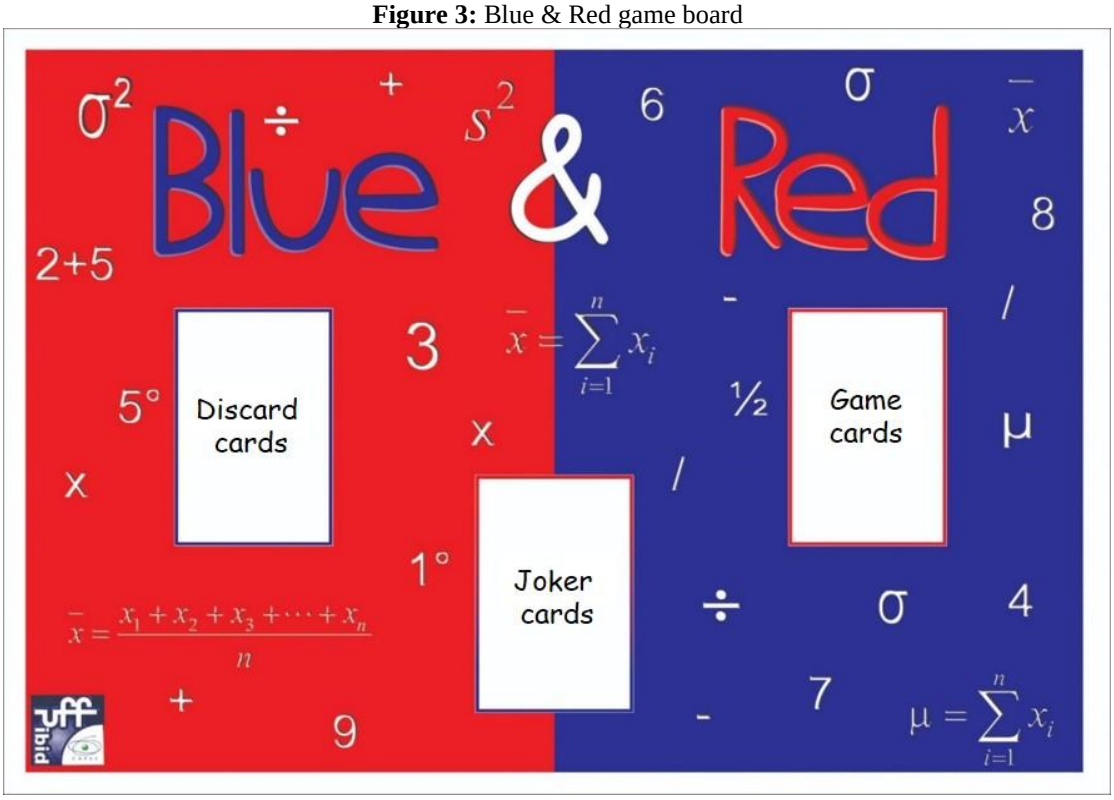



**Source:** Research collection.

**Figure 2:** Some joker cards from the Blue & Red game


**Source:** Research collection.

**Figure 3:** Blue & Red game board




**Source:** Research collection.

The versatility of the game also allows for adaptations using a conventional deck. In this case, black-suited cards (clubs and spades) can represent positive values, while red-suited cards (hearts and diamonds) represent negative values.

**Table 1:** Comparison between the cards in the Blue & Red game and a conventional deck

| **Blue & Red** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 15 | 20 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Common Deck** | A | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | J | Q | K |

**Source:** Souza (2015, p. 2).

**Figure 4:** Table of records, statistics and scores for the Blue & Red game

**Scoring Table - Blue&Red**

| Data Value | 1. Lowest Mean; 2. Lowest Mode; 3. Lowest Median; 4. Lowest Total Range; 5. Lowest Blue; 6. Lowest Red; 7. Highest Blue; 8. Highest Red; 9. Lowest Standard Deviation; 10. Highest Mean; 11. Highest Mode; 12. Highest Median. |
|---|---|

| Rounds/ Players | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 11th | 12th | Joker | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | | | | | | | | | | | | | |
| 2. | | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | | |

**Source:** Research collection.

The incorporation of a 12-sided dice (dodecahedron) to indicate the statistics to be used adds a relevant pedagogical and didactic complexity to the Blue & Red game. This game mechanic is in line with various educational theories and methodologies that emphasize the importance of chance (Coutinho, 1994, 2007; Gal, 2005) and decision-making in learning (Ignácio, 2010). Each side of the die represents a statistical measure or procedure: 1. Lowest Mean; 2. Lowest Mode; 3. Lowest Median; 4. Lowest Total Range; 5. Lowest Blue; 6. Lowest Red; 7. Highest Blue; 8. Highest Red; 9. Lowest Standard Deviation; 10. Highest Mean; 11. Highest Mode; 12. Highest Median.

The dice allow a wide range of statistical concepts to be addressed, going beyond measures of central tendency to include other aspects of data analysis. The introduction of chance through the dice stimulates strategic thinking, as students must adapt to different statistical scenarios and make decisions based on unpredictable results.

It should also be noted, for the purposes of this paper, that the inclusion of *outliers* in the set of numerical cards is a notable design feature of the Blue & Red game, which underscores the game's pedagogical commitment to addressing more advanced and realistic aspects of statistics. *Outliers* are elements that deviate significantly from the average of the data set, and their presence in data sets is often a real phenomenon in various scientific disciplines (Becker, 2015). The introduction of these cards adds a layer of complexity to the game and offers educational opportunities, such as:

- Conceptualization of variability: the resource allows students to directly experience how outliers affect measures of variability such as amplitude and standard deviation;
- Critical thinking: the presence of outliers requires students to employ a higher level of discernment and analytical skill, given that they must decide how to deal with these outliers in their statistical analysis;
- Real-world applicability: the inclusion of outliers brings the game closer to real-life data collection and analysis situations, where the presence of outliers is common and often informative;
- Reading and interpreting data: given the influence of outliers on statistical measures, students are encouraged to be more cautious when reading and interpreting data, an essential skill for statistical literacy.

This didactic strategy is in line with the PCN and BNCC guidelines, which emphasize the development of analytical skills and the practical application of mathematical and statistical concepts. Therefore, the inclusion of discrepant cards can be seen as a significant improvement in the pedagogical approach of the Blue & Red game.

### 3.1 Blue & Red game rules

- Participants and card distribution: the game is designed for a group of two to eight participants. Each participant will receive, in a clockwise distribution, a set of five number cards;
- Initiation and order of play: to determine the order of play, each participant will throw a numbered dodecahedron. The participant with the highest value on the dice will start the game, and the subsequent ones will go clockwise. In the event of a tie, the dice will be re-rolled by the tied participants until a single maximum value is obtained;
- Rounds and statistics: the total number of rounds will be equal to the number of participants plus one additional round (use of the joker card). In each round, a specific statistical aspect, corresponding to the value thrown at the dodecahedron, will be the focus. Each participant must calculate the corresponding statistic based on their cards and record their calculations on an appropriate sheet. A statistic cannot be repeated in the regular rounds;
- Scoring and verification: after all the participants have done their calculations, the verification takes place.If the statistical aspect of the round is, for example, “Highest Average”, the participant with the highest average, and whose calculations are correct, will be awarded three points. In situations of a tie, the tied participants will receive one point. Miscalculations will result in a penalty of one less point;
- Extra round and wild cards: in the additional round, each participant will receive a wild card and must comply with the instructions on it, performing additional calculations if necessary. Note: players must continue with their cards;
- Strategy and adaptations: from the second regular round onwards, participants can choose to discard one of their cards and draw a new card from the central pile after the dice roll.If the pile is exhausted, the discard will be shuffled to create a new pile;
- Conclusion of the game: the winner will be the participant who has accumulated the most points at the end of all the rounds (including the extra round with the joker card).

Pedagogical adaptations can be made to accommodate the educational level of the participants, especially in relation to more advanced concepts such as standard deviation, which may not be appropriate for elementary school. This reformulation aims to clarify and formalize

the rules for the pedagogical effectiveness and statistical rigour of the game.

## 4 Results and discussions of the Blue & Red game implementations

The Blue & Red game is a didactic-pedagogical tool that aligns theory and practice in the teaching of statistics. As well as encouraging the calculation of measures of central tendency and dispersion, it also stimulates fundamental reasoning and decision-making skills. The diversity of possible strategies, combined with the uncertainty inherent in chance, requires players to adopt a considered approach to analyzing variability, the concepts involved in statistics and the relationships between variables.

In line with Borin (2007), the game demands a series of cognitive skills that go beyond mathematical calculation per se. It stimulates aspects such as organization, attention, concentration and deductive reasoning, which are crucial for the development of logical-statistical thinking. It is worth noting that these skills are transferable and have applicability in a variety of academic and professional contexts.

According to Batanero and Godino (2005), Statistics Education should provide robust methodological tools that enable individuals to analyze variability, establish relationships between variables, conduct experiments and improve predictions to inform decisions in contexts of uncertainty. This methodological approach goes beyond mere quantification and computation to include a richer and more contextualized understanding of the role of Statistics in various practical applications.

It is in this context that the Blue & Red game effectively aligns itself with the guidelines proposed by Batanero and Godino (2005), serving as a pedagogical tool that goes beyond the simple calculation of statistical measures. It creates a simulated environment for deep engagement with concepts such as variability and decision-making under uncertainty. In doing so, the game transcends mere mathematical formulation and promotes a richer understanding of Statistics as a critical tool for analyzing data and complex situations, thus stimulating critical and analytical thinking skills in participants.

In 2012, the first empirical implementation of the didactic-pedagogical proposal was carried out with twelve scholarship holders participating in the Institutional Teaching Initiation Scholarship Program (PIBID), complemented by the participation of two supervising teachers from Basic Education and under the supervision and guidance of the university's area coordinator. The group was subdivided into two distinct groups and the Blue & Red game dynamics were carried out in five different sessions. This experimental design aimed not only to familiarize the participants with the mechanisms and rules intrinsic to the game, but also to deepen their understanding of the statistical concepts and decision-making strategies inherent in it. Repeating the game sessions makes the subsequent analysis more robust, allowing for more precise observations about possible pedagogical impacts. In this respect, Macedo, Petty and Passos (2007, p. 20) point out that “it is important to know the game materials and to promote all kinds of situations that enable them to get to know and assimilate the rules”.

At the end of each game, the groups discussed the decisions made during the game, as well as the strategic opportunities presented to each participant, based on their individual records. This exploratory phase, coordinated by the main researcher of this study and a member of the PIBID Mathematics team at the Fluminense Federal University (UFF), generated promising results that fostered discussions and reflections on the effectiveness of games as pedagogical tools for teaching descriptive statistics content. In addition, there was a notable increase in the level of motivation of the participants, who expressed positively inclined attitudes towards their respective learning processes. The Blue & Red game therefore acted as

a catalyst for the exercise of cognitive skills and the development of problem-solving strategies, corroborating its potential as an important didactic resource for teaching statistics.

The qualitative implementation of the Blue & Red game was carried out with two PIBID fellows, both members of GPEAMATEST, who helped develop the game with two 9th grade classes at a municipal PIBID partner school in Santo Antônio de Pádua-RJ, in 2012 and 2013.

The empirical results of the experiment showed an increase in the students' level of motivation in relation to statistical content. It was possible to observe a consensus among the students about the importance of reasoning before making decisions in each round, transcending the mere calculation of statistical measures. However, the study also brought to light some gaps in the students' statistical and mathematical understanding, especially related to the interpretation of specific statistics such as maximum and minimum red and amplitude. This was exacerbated by the duality of the cards - positive and negative - and the time pressure to respond, leading to errors in their answers. We emphasize the need for conjecture and reflection before formalizing answers, especially in the context of calculations and statistical processes. In addition, a lack of mastery of basic mathematical concepts was diagnosed, including the appropriate use of the number line and operations with whole numbers, indicating gaps for future pedagogical intervention.

The relevance of the Blue & Red game has also been demonstrated in academic settings. Specifically, workshops were held as part of Mathematics Day, organized by UFF's Mathematics Education Laboratory (LABEM), located in the Faculty of Education, in May 2013. The event was attended by 23 students and seven primary school teachers in Niterói-RJ. In addition, a second workshop was held in May 2014 at the Instituto do Noroeste Fluminense de Educação Superior (INFES), in Santo Antônio de Pádua-RJ, for 21 students from the first period of the Mathematics degree.

The continuity of the application of the Blue & Red game in the academic and pedagogical context was solidified by a third workshop held in 2018. This workshop involved 24 scholarship students participating in UFF's Institutional Mathematics Pedagogical Residency Program (PIRP), as well as three preceptor teachers from Basic Education.

The implementation and evaluation of the Blue & Red game in different educational contexts shows a continuous and adaptive expansion of its application. After the end of the Covid-19 pandemic, the resumption of face-to-face activities at UFF made it possible to hold a new workshop in December 2022. The session was attended by 24 scholarship holders and three supervising teachers linked to the PIBID in Mathematics.

In 2023, the game was significantly incorporated into the curriculum, specifically in the subject Educational Research and Practice IV (PPE IV), a compulsory subject in the final term of the Mathematics degree course at UFF. The course is taught by the first author of this study.

At the current stage of the research, the need for a more structured evaluation system for the game has been identified. Initially, the researchers developed a data collection instrument, including an Informed Consent Form (ICF), which clarifies the nature of the evaluation as part of a research project linked to a group at UFF, the objectives, the rights of the participants and the guarantee of anonymity. It is important to mention that, at the time the instrument was drawn up, the university did not have an ethics committee to evaluate it. A questionnaire was also created with 12 questions, two open and the others closed, receiving 43 responses in all. Of these, 25 were from PIBID scholarship holders and the remaining 18 were from students enrolled in two PPE IV classes, both in the first and second semester of 2023. The use of this instrument seeks to deepen the understanding of the didactic-pedagogical

effectiveness of the game and capture the perceptions and impacts among future education professionals and practicing educators.

The game was also used by two researchers and the authors of this paper in the context of the Laboratory for Cognitive Studies and Technologies in Statistics Education (LabEst) at the Federal University of Rio Grande (FURG), and will be incorporated into its collection. This represents an important stage in the partnership between the researchers, which lays the foundations for future research. Subsequent work will be developed, including a new evaluation instrument, which will be duly approved by the university's ethics committee, reinforcing the commitment to excellence and integrity in educational research.

### 4.1 Analysis of responses to the Blue & Red game evaluation tool

The set of data obtained through the evaluation instrument provides very enlightening information about the participants' perception of the effectiveness of the workshop and their level of knowledge in Statistics. On the first question, which dealt with the quality of the game's implementation, the data suggests a highly positive evaluation, with 35 of the participants giving it “grade 10” and six “grade 9”, i.e. 81% of the respondents, and only two giving it “grade 8”. This result can be interpreted as an indicator of the pedagogical effectiveness and, by extension, the relevance of the Blue & Red game as a didactic resource for teaching Statistics.

In the second question, which focused on the participants' self-assessed knowledge of statistics, the data showed a more heterogeneous distribution. There was considerable variation in the self-assessments, ranging from “grade 4” to the highest grade. This range of results could be interpreted in several ways. Firstly, the diversity in responses could reflect a real variation in the statistical skills of the participants. Secondly, these results could also suggest uncertainty or lack of confidence on the part of the participants about their own mastery of the statistical content involved.

The data on academic background in primary and secondary school can provide an important contextual view for interpreting the results obtained. The predominance of students from private schools in elementary school (29 responses) and the almost equal distribution between public (21 responses) and private (24 responses) in secondary school could be explanatory variables at various levels of analysis, such as self-efficacy, prior statistical knowledge or even confidence in applying strategies during the game.

With regard to perceptions of the Blue & Red game, the data collected is positive, corroborating the idea that the pedagogical approach adopted is successful in terms of engagement and positive evaluation of the learning experience. The majority of participants (33 responses) rated the game as “Very Good”, which is a very promising indicator of the activity's pedagogical effectiveness. However, it is worth noting that a considerable proportion (10 responses) of respondents did not use strategies during the game.

**Table 2:** Pedagogical aspects discussed and presented at the workshop

| Pedagogical aspects (Categories) | Very Good | Good | Regular |
|---|---|---|---|
| 1. Information on the field of Statistics Education | 34 | 9 | 0 |
| 2. Possible didactic situations for teaching Statistics | 32 | 11 | 0 |
| 3. Discussions and reflections on the importance of statistical literacy | 29 | 13 | 1 |

| | | | |
|---|---|---|---|
| 4. Relevance of the topic to the present day | 29 | 10 | 4 |
| 5. Perspective of use in the classroom | 38 | 5 | 0 |
| 6. The approach taken by teachers | 32 | 11 | 0 |
| 7. Contribution to their training | 37 | 5 | 1 |

**Source:** Research collection.

The table 2 provides a comprehensive overview of the participants' perception of the different pedagogical aspects of the workshop's implementation. Most of the categories have very positive evaluations, which suggests an alignment between the workshop's objectives and the participants' expectations and needs. With regard to categories 1 and 2 of the respective table, there are indications that the workshop met their needs very well, as the participants left the workshop with concrete and applicable ideas for teaching Statistics.

In category 3, although the majority still rated the workshop as “Very Good” (29 responses), the presence of a “Fair” evaluation suggests that this may be an aspect for greater attention and refinement in future iterations of the workshop. Category 4 was rated “Fair” with four responses, suggesting that while many see the relevance, there is room for improvement in the way this importance is communicated or demonstrated.

Regarding the category “Perspective of use in the classroom”, the results indicate that the participants felt that the content of the workshop was directly applicable in their teaching contexts. The approach taken by teachers during the workshop was generally well received. Finally, category 7 provides support for stating that the workshop was seen as potentially beneficial for the participants' professional development, but also indicates the need to investigate what may have led to the “Fair” evaluation. The data presented here, referring to Table 2, can generally be considered positive indicators of the workshop's effectiveness in meeting its pedagogical objectives.

**Table 3:** Pedagogical aspects of the Blue & Red game presented at the workshop

| Pedagogical aspects (Categories) | Very Good | Good | Regular |
|---|---|---|---|
| 1. Possibilities for didactic situations for teaching statistics | 35 | 8 | |
| 2. Discussions and reflections on the importance of the game for teaching statistics | 33 | 9 | 1 |
| 3. Relevance of the theme to the present day | 30 | 12 | 1 |
| 4. Perspective of use in the classroom | 36 | 7 | |
| 5. Potential of the Blue & Red Game | 40 | 3 | |
| 6. Contribution to their development | 36 | 7 | |
| 7. Contribution to the student's development | 38 | 5 | |

**Source:** Research collection.

Table 3 shows relevant data on the reception and pedagogical effectiveness of the Blue & Red game, as assessed by the workshop participants. The categories covered are fundamental to understanding both the practical applicability and the theoretical relevance of the game in the context of statistics teaching.

Categories 1 and 2 indicate a positive perception of the game's versatility in providing multiple teaching situations and stimulating critical discussion and reflection on Statistics

Education. Category 3 is an indicator of the current relevance of the subject.

Regarding the perspective of use in the classroom, the results indicate that the participants see a direct applicability of the game in the educational environment. Regarding the potential of the Blue & Red game, the highest rate of "Very Good" responses (40) in this category indicates that the participants recognize the game as a pedagogical tool with high potential.

As far as category 6 is concerned, the workshop and the game seem to have a significant impact on the participants' teacher training. This also occurs in category 7, which may be a reflection of the game's perceived potential to positively affect student learning. In this sense, the proposal, to a certain extent, reinforces the effectiveness of the Blue & Red game as a potential pedagogical tool in the teaching of Statistics. It was also noted that the game is seen as a useful innovation, both in terms of its applicability in the classroom and its contribution to teacher and student training.

Regarding the answers to the open question "What strategy(ies) did you use in the game?", we used the participants' answers and analyzed the content using categories, with the aim of understanding how the players approach the game and what types of strategies they used. Several answers focus on "swapping cards" as a primary strategy, either to maximize or minimize certain statistical variables (mode, mean, median, etc.). Some players choose to keep or exchange cards based on their color (blue or red), which can affect the statistical variables of their hand.

The "statistical analysis" category involves strategies that explicitly mention the use of statistical concepts such as mode, mean, median, range, etc. In the "observation and adaptation" category, players base their strategies on the cards they have or the cards they believe the other players have. They can adapt their actions depending on previous rounds or the other players' moves.

A notable category is "no strategy", in which players explicitly say they haven't used one. On the other hand, there is the emergence of the "complex strategies" category, which are strategies that combine multiple elements, such as observation of the other players and statistical analysis. Some answers indicate an element of luck or faith rather than a well-defined strategy.

The instrument's other open question asked whether the player had any difficulty with any of the game's statistics, and if so, which statistic(s). The category of analysis that appeared most often in the answers was "no difficulties", i.e. answers that indicate the absence of any difficulty in relation to the statistics involved in the game. Examples of textual records: "no"; "I didn't"; "of those we had the opportunity to do, no". The majority of respondents had no difficulties with the statistical concepts involved, which may suggest that the game was effective in its educational objective, at least in terms of accessibility.

The second category was "difficulty with standard deviation", i.e. answers that explained challenges with the concepts of standard deviation in the game. Examples of textual entries: "yes, because I didn't know what variance and standard deviation were"; "I couldn't remember the standard deviation formula"; "standard deviation calculation". This category stands out as the main area in which players faced challenges. This suggests that future game interactions or support material could focus on explaining these concepts more clearly.

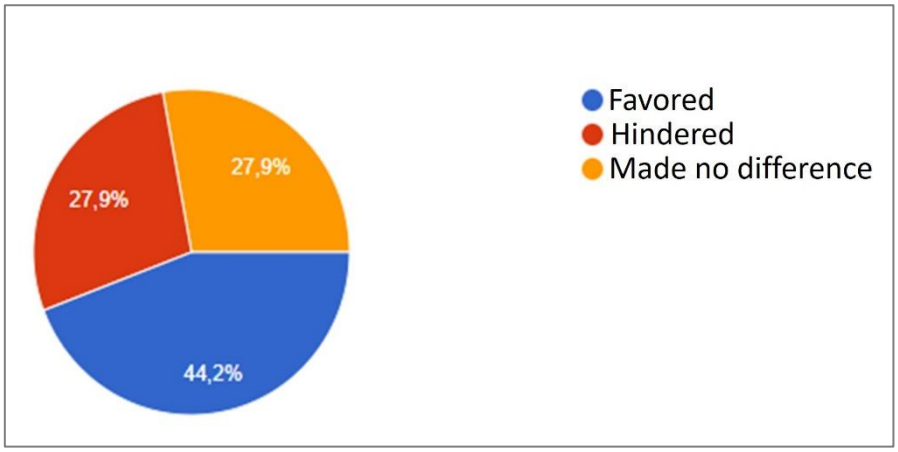
On the other hand, there is the category "initial comprehension problems", which groups together answers that point to initial difficulties in understanding the dynamics of the game, but not necessarily related to a specific statistical concept. Examples of records: "the initial

difficulties were only when it came to understanding the dynamics of the game"; "at the beginning, choosing the wrong color card to exchange". A smaller proportion of players faced challenges at the start of the game, which may imply that the learning curve is relatively short or that the instructions are clear.

The "review of concepts" category refers to answers that indicate the need to revisit statistical concepts, although they do not specify which ones. Examples of textual entries: "remembering the concepts"; "I had to remember how to calculate the standard deviation". This category suggests that, for some players, the game served as a useful reminder of statistical concepts they hadn't revisited for some time. On the other hand, the category "other statistical concepts" groups together answers that mention statistics or concepts other than standard deviation or variance. Examples: "amplitude"; "maximum and negative minimum". Although fewer in number, difficulties with other statistics, such as amplitude, were mentioned. This may offer clues for expanding or adjusting the educational material associated with the game. The analysis suggests that the game was largely effective in pedagogical terms, although areas for improvement and focus in future versions or support materials were identified.

Finally, the last closed question was about the joker card, in which it was asked whether it "favored", "hindered" or "made no difference".

**Figure 5:** Did the joker card favored, hindered or made no difference?




**Source:** Research collection.

The "favored" category had 19 responses, suggesting that the joker card, in the view of most players, adds a positive element to the game. This may indicate that the joker card increases the dynamics, interest or strategy of the game. The categories "hindered", with 12 responses, and "favored" may indicate that the wild card introduces an element of imbalance or perceived unfairness into the game for some players. Finally, the last category "made no difference", with 12 responses, suggests that some players did not perceive the joker card as a critical factor in the game. This may indicate that its inclusion can be seen as neutral or that its effect varies depending on other factors, such as the player's skill or the specific dynamics of a match.

The analysis also shows that the existence of varied opinions on the impact of the joker card on the game suggests that it is an element with complex pedagogical and strategic implications. In future iterations of the game or research, it would be interesting to investigate further how the wild card affects different aspects of the game, such as engagement, learning and fairness.

In any case, the insertion of random elements, such as the joker card, can have the

pedagogical effect of shifting the focus of the game from the purely competitive domain to a more educational one. By introducing a random factor, the game implicitly recognizes that skill alone is not the sole determinant of success, which can be an important cross-curricular teaching (Gitirana *et al.*, 2013). This approach can facilitate the engagement of all participants, regardless of their level of statistical skills, by reducing the pressure of performance and focusing more on the learning process (Luckesi, 2000; Kishimoto, 2017).

## 5 Final considerations

In this paper, we aim to answer the following research question: "How does the Blue & Red game influence the development of statistical literacy in primary school students and teachers in initial training, considering the perceptions of both groups about the effectiveness of playful methodologies in learning fundamental statistical concepts?"

To answer the question, we sought to understand the potential impact of the game not only on student learning, but also on the training of future math educators. This implies highlighting the relevance of using teaching resources focused on the educational process of both students and teachers, whether in their initial or continuing training.

It is also important to note that the potential of the Blue & Red game was presented and explored as a pedagogical resource in the field of Statistics Education, in the construction of statistical literacy. The game emerges as a potentially effective didactic-pedagogical tool for teaching and learning Descriptive Statistics content, as evidenced by the mostly positive responses from the participants in various pedagogical aspects. The game not only offers possibilities for versatile teaching situations, but also encourages discussions and reflections on the importance of using games to build statistical literacy.

With regard to the training of teachers and students, the game appears to be a valuable contribution, providing both the opportunity for active engagement with statistical concepts and the possibility of critical reflection on the application and interpretation of these concepts.

It should also be noted that the association of aspects such as schooling, perception of the game and use of strategies can offer a rich layer of understanding about the mediating or moderating effects that previous academic training and self-perceptions could have on the learning experience and engagement with didactic activities such as the Blue & Red game. Thus, the data collected can serve as a starting point for more in-depth research that seeks to understand not only the effectiveness of the intervention in terms of satisfaction and engagement, but also in terms of the development of statistical and strategic skills.

Therefore, the Blue & Red game not only meets the pedagogical criteria for being an effective teaching and learning tool in Statistics Education, but also presents potential for future iterations and research, which can further explore its effectiveness and applicability in different educational contexts.

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