

## Science board games: what do the creators say?

### RESUMO

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In this article, we outline the perspective of board game creators with a scientific theme. We seek to understand the intentions of the creators for the developed games and evaluate whether the expectations were met. The qualitative-quantitative research was conducted with eight producers of three educational games, "Batalha de Micróbios", "Imune –Serie Virus," and "Microvilões em Ação". The intentionality in idealization was investigated through content analysis of semi-structured interviews and application of the theoretical-methodological tool "Indicators of Scientific Literacy" concerning the three games. The content analysis, carried out from the perspective of Scientific Literacy in comparison with Scientific Communication, allowed us to identify the presence and absence of relevant attributes in these materials. We found a tendency to prioritize scientific knowledge and different forms of interaction – physical, aesthetic-affective, and cognitive – in all games. The social interface was also a present attribute, mainly to present the impact of Science in society. On the other hand, the institutional role, influence of the economy and politics on Science, historical context, and science promotion were neglected. This result and the detailed analysis of other attributes can contribute to a change in the scenario of educational game production. We have shown that it is necessary to plan the production of games with a scientific theme in a way that comprises other aspects of Scientific Communication, such as the role of Brazilian institutions and researchers, all relevant in the context of Scientific Literacy and Communication. In addition to directing creation, this article can contribute to the use of Science games in a meaningful and effective way with educational intentions in formal and non-formal education environments. Finally, we conclude that the games analyzed in this article were developed to stimulate the understanding and discussion of scientific topics related to the players' daily lives and therefore present educational and pedagogical potential in Scientific Communication actions in formal and non-formal education environments.

**PALAVRAS-CHAVE:** Scientific Literacy. Indicators of Scientific Literacy. Educational Game. Science Game. Scientific Communication.

## INTRODUCTION

The relation between games and toys and education is not something recent and the reflections concerning this combination remain in the academic scope up to these days (KISHIMOTO, 1990; MIRANDA, 2002; GRÜBREL; BEZ, 2006; LIRA-DASILVA *et al.*, 2007; HUIZINGA, 2010; ZAPATEIRO *et al.*, 2017). In Brazil, we started appreciating the use of educational games as an ancillary instrument in the teaching-learning process around the decade of 1980, with the arrival of toy libraries and the commercial interest from some business managers (KISHIMOTO, 1990). The recreation, the playfulness and the games are the first social elements that children have contact with, mediating their relation and the culture of the society in which they are included, presenting cultural symbols and exerting great influence in their social and education background (KISHIMOTO, 1990; HUIZINGA, 2010; ALVES, 2013).

David Elkind (2007) states that it is through games and playfulness, crucial learning forms, that children create new experiences and develop social, emotional, creative and intellectual abilities. Hromek and Roffey (2009) evidence that games can be highly motivational and can present potential to induce learning by means of social interaction and cooperation with other children and adults. Linares and López (2021) address games that include child interaction with school spaces. Alves and Bianchin (2010) emphasize that the game, when included in pedagogical practice, can promote physical, mental and emotional development for the child. Dartigues *et al.* (2013) argue that *board games* players present smaller cognitive decline and smaller cases of depression than non-players, indicating that board games have a beneficial effect in the cognition and mental health. As shown, the games used with the purpose of social, psychological and intellectual development are theme of research in several groups.

The increase of scientific production in the games and education area defines the acknowledgement as a potentially promising field. The games are considered target resources for educators and for scientific communicators, once the concept of education is enhanced for beyond formal education (GASPAR, 2002). In literature, researchers relate the different types and genres of games used in education with the construction of collective meaningful knowledge and the possibility of development of the human being in multiple perspectives: cognitive, social, cultural, creative, emotional, affective, scientific and physical (ELKIND, 2007; HROMEK; ROFFEY, 2009; ALVES; BIANCHIN, 2010; DARTIGUES *et al.*, 2013; PARK; LEE, 2017; ZAPATEIRO *et al.*, 2017; RAMOS; DOS SANTOS; LABURÚ, 2017; CODÁ; DA SILVA; DE VASCONCELLOS, 2021).

The premise of Scientific Literacy (SL) in the context of Scientific Communication is that the obtaining of scientific knowledge expands on social, political, moral and economic decisions (CASTELFRANCHI; FERNANDES, 2015; MARANDINO *et al.*, 2018). This makes the individuals express more critical attitudes based on information and analysis on the grounds of Science under

everyday issues (CHASSOT, 2003; SASSERON; CARVALHO, 2011; LORENZETTI, 2017).

The scientific and technological knowledge is present in different scopes of society, showing infinite applications in the social, political, environmental and economic scope. Even if some purposes and applications of scientific knowledge are not clearly evident, they are, absolutely, present in the population routine, influencing in a distinguished way the individuals of all social levels (CONCEIÇÃO, 2010). Although people not always understand or are completely aware of all dimensions of technology and Science that appear in their routine, they are compelled to make decisions by means of complex combinations between economic rationale, political values, religious beliefs, cultural capital, scientific knowledge and so on (AIKENHEAD, 1985). The Covid-19 pandemic, for example, showed the presence of technical and scientific knowledge in the area of health and politics, demanding several attitudes and macro perceptions from the population concerning the subject, including the risk awareness and Science controversies, as well as the identification of false affirmations (SERPA *et al.*, 2021).

The SL process is not restricted to formal education environments; it also occurs in non-formal education spaces, such as: museums, Science centers, libraries, botanical gardens, aquariums, zoos and others (ROGERS, 2004; FALK; DIERKING, 2012; MARANDINO *et al.*, 2018; ROCHA, 2018). The non-formal education spaces use multiple approaches for the constant SL development with the visiting public that promote the growth of general culture. In case of education games, these materials produced by professionals from educational institutions or specialized companies also take part as instruments of mediation between the players and the knowledge, with the possibility of direct or indirect intervention in the SL development (PRADO, 2018). This way, it is important to show the perspective of the Science board games creators, allowing a better understanding of the education potential of different games and the planning of the pedagogical work, as well as the most captivating and effective Scientific Communication actions.

Regarding the Science board games, in particular about Microbiology, this article has the purpose to explore the context of production of three board games with scientific theme; to understand the intention of the creators for the games developed and to assess if the expectations were met, by using semi structured interviews and the theoretical and methodological "SL Indicators" tool. Who are the creators of the games? What do the creators aim to achieve with the creation of Science games? What are the places the creators apply the games? What characteristics are prioritized during the creation of the games? These questions guided our research.

## **METHOD**

The qualiquantitative character research (CARMO; FERREIRA, 2008) was carried out with eight creators of three board games having a Microbiology theme, from different institutions. Amongst these eight creators, three were

involved in the “Batalha de Micróbios” game, organized by Universidade Federal do Rio de Janeiro; three were the creators of the “Imune – Série Vírus” game, organized by Fundação Oswaldo Cruz; and two created the “Microvilões em Ação” game, organized by Universidade de São Paulo, and they all participated in semi structured interviews. Three participants of each initiative were selected, except for the “Microvilões em Ação”<sup>1</sup>, in order to contemplate the production chain of each game, to prevent possible distortions and to assure a result validation by means of data triangulation (CARMO; FERREIRA, 2008).

The interview, as a data collection technique, is intended for obtaining information and creating a base on a determined theme (DUARTE, 2006; GIL, 2010). This way, we use it as a tool to raise data, concerning the production processes and to understand the expectations that led the creators to think of the object education materials.

Eight semi structured interviews guided by 23 previously established questions, of flexible character however, were performed from November 2019 to April 2020, following the list of topics adapted from the thesis of Lourenço (2017)<sup>2</sup>. The representatives for the creation of the games “Batalha de Micróbios” and “Imune – Série Vírus” were interviewed in person, while two creators of “Microvilões em Ação” were interviewed via phone call. The interviews lasted, on average, 32 minutes. All the interviews were recorded in audio, and then transcribed. The transcripts were included in the platform Dedoose®, an on-line software developed to help the qualiquantitative analysis (DEDOOSE, 2020).

The transcript of the interviews was codified and investigated using the content analysis (BARDIN, 2016). In compliance with the Bardin theoretical reference, we followed the thematic analysis method, once it allows the detection of significance units of the interviews by means of categories. This method favors the frequency of themes extracted by the group of interviews, considering the targetable, comparable and quantifiable data (BARDIN, 2016).

After an initial reading of the transcribed interviews, it was possible to create the categorial board with the main themes and subthemes (Table 1), developed in inductive form (MAYRING, 2014). The creation of categories was made as the themes emerged in the pre-analysis of each interview. This way, we created exclusive codes for this analysis. These codes are the themes and subthemes contained in Table 1 (BARDIN, 2016).

With the purpose of enhancing the different investigation contexts to which the theme analysis is proposed, we also used the theoretical and methodological “SL Indicators” tool (MARANDINO *et al.*, 2018) as a reference for the creation of the category board.

After the construction of the category board, the interviews were completely analyzed and each register unit, herein understood as sentences of the interviews, was categorized one single time in each theme and subtheme (BARDIN, 2016). Finally, the data were measured quantitatively, using the *Analyse* tool of the Dedoose® software (DEDOOSE, 2020).

Together with the content analysis, we explored the interviews by observing the occurrence of the indicators and attributes that compose the theoretical and methodological “Scientific Literacy Indicators” tool (MARANDINO *et al.*, 2018) concerning the presence of interaction, production of scientific knowledge, social interface, institutional issues, and otherwise.

The theoretical and methodological “SL Indicators” tool was developed and improved in view of the need to systematize the assessment of different activities in non-formal education spaces and in Science public communication actions (MARANDINO, 2018). The indicators and attributes are appropriate to the development of the SL and of Education of Science, Technology, Society and Environment. The indicators are classified as: (1) “Scientific indicator”, with the following attributes (1a) “Scientific knowledge and concepts, scientific researches and their results”, (1b) “Scientific knowledge production process” and (1c) “Role of the researcher in the knowledge production process”; (2) “Social interface indicator”, presenting the attributes (2a) “Impacts of Science in society”, (2b) “Influence of economy and politics in Science” and (2c) “Influence and participation of society in Science”; (3) “Institutional indicator” with the attributes (3a) “Institutions involved in the production and communication of Science, their roles and missions”, (3b) “Financing Institutions, their roles and missions” and (3c) “Political, historical, cultural and social elements related to the institution”; finally, the (4) “Interaction Indicator” presents the attributes (4a) “Physical interaction”, (4b) “Aesthetic and affective interaction” and (4c) “Cognitive interaction” (ROCHA, 2018; MARANDINO *et al.*, 2018).

During the investigation, the interviews were completely analyzed using the theoretical and methodological “Scientific Literacy Indicators” tool. The indicators and attributes of the tool were activated for each register unit one single time in compliance with its presence.

After all the interviews were analyzed using the theoretical and methodological “Scientific Literacy Indicators” tool, the data were analyzed by using the *Analyse* tool of the qualiquantitative analysis software Dedoose® (DEDOOSE, 2020). With the purpose of reinforcing the reliability of the data, the analysis of the interviews using the Scientific Literacy Indicators was discussed with the group, which is also familiar with the theoretical and methodological tool used.

It is important to emphasize that the project was submitted and approved by the Institutional Review Board (CAAE number: 16798919.8.0000.5241)<sup>3</sup>. We also emphasize that the data presented in this article are part of the thesis O potencial dos jogos educativos com temática científica: “Batalha de Micróbios”, “Imune - Série Vírus” e “Microvilões em Ação” no processo de Alfabetização Científica (LYRA, 2020) in the post graduation program in Communication of Science, Technology and Health at Casa de Oswaldo Cruz, of the Oswaldo Cruz Foundation.

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## RESULTS AND DISCUSSIONS

The content of the three interviews with the creators of the games brought, as a result, issues concerning the response for the creation of the materials, as well as the perceptions related to the game, the assessment forms and the participation in the development of the material and in the distribution of tasks among the team members.

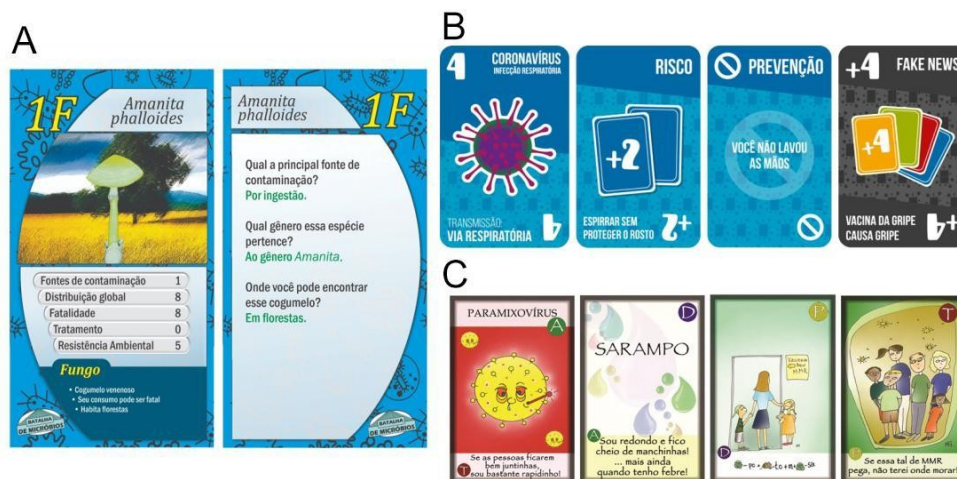
Therefore, in this section, we present the results obtained by the analysis of the content in comparison to the theoretical and methodological “SL Indicators” tool. The amount of times the themes and subthemes were mentioned appeared from the content analysis and is quantitatively registered in Table 1. Figure 1 presents some cards of the games “Batalha de Micróbios”, “Imune – Série Vírus” and “Microvilões em Ação”. Chart 1 presents the analysis of the interviews with the creators using the theoretical and methodological “SL Indicators” tool, highlighting the occurrence of the indicators and its attributes in every interview of each game.

Table 1 – Content analysis of the interviews with the creators of the Science games “Batalha de Micróbios”, “Imune – Série Vírus” and “Microvilões em Ação”, category board.

Themes	Subthemes	Interviews		
		Batalha de Micróbios	Imune - Série Vírus	Microvilões em ação
Participation in the development of the game	Coordination	2	1	1
	Designer	1	1	3
	Content	5	1	2
Game production stimulus	Science Communication	5	5	3
	Education	4	3	12
Objective of the game	Scientific content and concepts	18	36	8
	History of Science	0	3	0
	Identifying the researcher	0	13	0
	Identifying the institution	5	5	0
	Language adaptation	4	1	8
	Relation to the routine	11	6	8
	Scientific knowledge production process	4	0	0
	Involvement of the public with the institution	0	6	1
Applied places	Formal education space	9	5	21
	Non-formal education space	0	5	1
	Scientific Communication events	3	8	3
	Scientific events	0	5	2
Target public	Children	4	0	0
	Teenagers	1	4	0
	Adults	2	1	1
	School	2	2	4
	Non-specific	3	0	2
	Non-planned target public	0	4	0
Game assessment forms	Gameplay	0	3	1
	Content	1	0	4
	Experience	2	0	1
	Preview	5	2	2
	Absent	0	1	5
	Undefined	0	1	1
Game perception	Physical interaction	2	3	3
	Aesthetic affective interaction	3	12	3
	Cognitive interaction	9	9	12

Source: Self authoring (2020).

Figure 1 – Examples of cards of the games analyzed. (A) “Batalha de Micróbios”, (B) “Imune – Série Vírus” and (C) “Microvilões em Ação”.



Source: Self authoring (2020).

The theme “Participation in the development of the game” concerns the role performed by the respondent at the moment of development of each game, either in the card content or in the aesthetics of the game. This way, we identify the contribution of each respondent for the production of the materials, once they might be responsible for the coordination, for cards design and/or for the research and production of the scientific content of the game.

The content analysis showed that there is a balance in the distribution of tasks among the team members of education material “Imune – Série Vírus”, including a professional in design. The education materials “Batalha de Micróbios” and “Microvilões em Ação”, on the other hand, had a team focused in the content production with a team member who shared functions in the design of the game and in the creation of content, with no member dedicated to each task.

The theme “Game production stimulus” concerns the motivation and justification expressed by the creators during the interview for the material production, which may have education or Scientific Communication purposes. The analysis showed that rationale for the production of “Batalha de Micróbios” may be considered both for Scientific Communication and education purposes, once it presents similar frequencies in the category board, Table 1, as exemplified by respondents 1 and 2, respectively, in the highlighted segments:

*My main intention with this game was to show a little of Microbiology reality to people in a lighter way, in a cooler way (Respondent 1 – Batalha de Micróbios).*

*We had this idea so that we could present in the first moments of education for these children, who are in pre-school, in primary school, to have access to micro-organisms, which is*



*something they do not see in school on a regular basis (Respondent 2 – Batalha de Micróbios).*

Concerning the main stimulus expressed by the creators of "Imune - Série Vírus" for the production of education material, the Scientific Communication is the most emphasized, as explained in the highlighted segment:

*I mean, most recently, we are investing, hypertrophying, as I always mention, with the Scientific Communication part, considering that we have to "dismantle" ourselves; I use this expression because of the wonderful castle we have here. Because, actually, there is no use in having knowledge kept only among our pairs, right?! So the game itself is the result of this view of leaving the four walls of an institution (Respondent 4 – Imune – Série Vírus).*

The interviews with the creators of the game "Microvilões em Ação" reveal that the greatest stimulus for the development of the game was in education itself and in formal education. The stimulus to the production caused by the Scientific Communication comes with little reference, different from the two other materials analyzed.

*Look, XXX (name omitted to safeguard anonymity) was always very involved with education, in all areas, but I believe that, in this case, we had the intention to reach the primary education, right? (Respondent 8 – Microvilões em Ação).*

The theme "Objective of the game" encompasses the purposes of development for each game, expressed both in explicit or implicit ways by the creators during the interviews. This category is directly related to the "Scientific Indicator", "Social Interface Indicator" and "Institutional Indicator" and their respective attributes of the theoretical and methodological "SL Indicators" tool. According to the analysis of the interviews with the creators, the material "Batalha de Micróbios" has as main focus the Microbiology oriented approach of scientific content and concepts, given the occurrence of the subtheme "Scientific content and concept", as we can observe in the segments:

*This is the main purpose, right, to show that Microbiology is not boring and show them a little more about this reality, to show a little of what each thing is and, sometimes, what is involved in each disease, for people to gain consciousness and be more aware of things (Respondent 1 – Batalha de Micróbios).*

*[...] that people would understand that it causes disease, how pathogenic that is, how fatal that is, how do we do to make you understand the real risk we run concerning a pathogen and, effectively, know they exist, right? And the names of the viruses, bacteria and fungi (Respondent 3 – Batalha de Micróbios).*

Analyzing the interviews, we observed the transmission of scientific content and concept as the main goal of the “Imune – Série Vírus”; similar to what was found in the analyzed interviews with the team responsible for creating the material “Batalha de Micróbios”, as the segment highlighted:

*[...] these are basic concepts, necessary for the understanding of the layperson, right? So, from the form of transmission, prevention, what form of clinical manifestation occurs, these are really very basic because, also, you neither can verticalize it nor should, right? (Respondent 4 – Imune – Série Vírus).*

The interviews also show the intention to value the figure of the researchers as one of the goals of the game “Imune – Série Vírus”, highlighted by the subtheme “Identifying the researcher”. This subtheme, which occurs only in this game, not observed on the other two, is directly related to the attribute “Role of the researcher in the knowledge production process” of “Scientific Indicator”. The segments highlighted from respondents 4 and 5, evidence this aspect:

*[...] reinforcing the need to promote the researchers we have in the country (Respondent 4 – Imune – Série Vírus).*

*[...] then, we ended up thinking “why not talk about the researchers too?” (Respondent 5 – Imune – Série Vírus).*

The education material “Microvilões em Ação” is different from the others. One of the things found by analyzing the interviews was the equal emphasis given to the subthemes “Language adaptation”, “Relation to the routine” and “Scientific content and concepts”. The segments highlighted evidence the presence of these subthemes:

*So, I thought it was necessary to bring out the information contained in the educational book in a way that would make more sense, that they could compare the colors, the things (Respondent 7 – Microvilões em Ação).*

*[...] yes, very much, because the situations characterized there as prevention, transmission, are situations that are really part of the routine. There you have: wash the greens, dog and cat defecating in the school sandbox, all of that. The images, I think the images are very similar to the routine situations (Respondent 7 – Microvilões em Ação).*

The influence of Science in the economic, cultural, political and historical aspects, as well as possible solutions to social questions, are present as the second main purpose due to the subtheme “Relation to the routine”, in the game “Batalha de Micróbios”. This subtheme is related to the attribute “2a – Impact of Science in the society” of the “Social Interface Indicator”. The people responsible for the concept of the education material related the importance of the presence of microorganisms existing in different spheres of our routine:

*That's because this is where people start to connect the dots, you know?! "Oh, this is that thing", "Oh, I have seen this, but can't remember where", that's where the connections are made (Respondent 3 – Batalha de Micróbios).*

*So, bringing the (microorganism) closer, something you would easily find day-by-day and present it to the children (Respondent 2 – Batalha de Micróbios).*

The subthemes "Relation to the routine", "Involvement of the public with the institution" and "Identifying the institution" appear in a third group of objectives in the "Imune – Série Vírus". In accordance with our analysis, the game was used, mostly, in Scientific Communication events, such as the "Science and Technology National Week" and the "Fiocruz para Você", confirming the results that stimulate the game production. The subtheme "Science Communication Events" is related to "Institutional Indicator":

*This is now going to be presented at Cinelândia, at the Secretary of Health of the State (Respondent 6 – Imune – Série Vírus).*

*[...] we have, basically, been using it in the events to which we are invited, for example, the Fiocruz para Você (Respondent 5 – Imune – Série Vírus).*

The content analysis of the interviews highlights the subtheme "Scientific content and concepts", which emerge in the background as the purpose of the game "Microvilões em Ação". This aspect is shown differently in the two other materials analyzed, which had the subtheme as the main highlight. Finally, the objective "Involvement of the public with the institution" frequently appears in the analysis, the other subthemes are not very significant or were not observed, as presented in Table 1. The subtheme "Scientific Content and Concepts" is directly related to the attribute "Scientific content and concepts, scientific researches and results". And the subtheme "Involvement of the public with the institution" is connected to the attribute "Influence and participation of society in Science" of the "Social Interface Indicator" from the theoretical and methodological tool.

The results presented indicate that, in general, the creators prioritize the scientific knowledge transmission as the purpose during the creation of Science games with Microbiology theme. This theme is directly related to the "Scientific Indicator" from the theoretical and methodological tool.

The priority of scientific knowledge, even in a non intentional way, is related to the Science and Technology Public Communication deficit model, which intend to solve the problem of lack of communication by assuming that the "laypeople" do not have this content (LEWENSTEIN, 2003; CASTELFRANCHI *et al.*, 2013).

Other studies that use the "Scientific Literacy Indicators" to explore education actions and materials also identified the significant presence of the "Scientific Indicator" in their analysis (CERATTI, 2014; MINGUES; MARANDINO,

2014; LOURENÇO, 2017; NORBERTO ROCHA, 2018; MARQUES; MARANDINO, 2019).

The category “Places applied” brings the perspective of using the materials analyzed, which can be formal education environments, non-formal education environments, scientific events or Scientific Communication events. This category is related to the “Institutional Indicator” of the theoretical and methodological tool, once they can present and indicate the institutions involved in supporting, producing and communicating Science, their historical aspects and institutional mission. Some institutions, where the games were produced, perform actions and events of Scientific Communication, such as the “Science and Technology National Week” and “Fiocruz para Você”.

Out of the interviews, the emerging education material “Batalha de Micróbios” was applied mainly in environments of formal education, such as schools and universities, while Scientific Communication events remained in the background:

*When we went to the school to play with the children (Respondent 1 – Batalha de Micróbios).*

*[...] it was already communicated; there are events here in the university until today, in the institute itself, in extensions that bring the children to know UFRJ (Respondent 2 – Batalha de Micróbios).*

*Here, when we have the extension event called “Hoje a universidade é nossa escola”, we put it in some of them. (Respondent 3 – Batalha de Micróbios).*

This datum goes against the main stimulus for the production of material shown in the interviews with the creators, once they state that the will to promote Microbiology was the main purpose that led them to produce the material, the application places reflect a different reality. Besides, the subtheme “Non-formal education environments”, proper places for the Scientific Communication activities are not informed during the analysis of the interviews, identical situation appears with the subtheme “Scientific events”.

The game “Imune – Série Vírus” was most used in Scientific Communication events, such as the Science and Technology National Week and the Fiocruz para Você, confirming the results of game production stimulus. The subtheme “Scientific Communication Events” is related to the “Institutional Indicator”:

*This is now going to be presented at Cinelândia, at the Secretary of Health of the State (Respondent 6 – Imune – Série Vírus).*

*[...] we have, basically, been using it in the events to which we are invited, for example, the Fiocruz para Você (Respondent 5 – Imune – Série Vírus).*

The subcategories “Formal education spaces”, “Non-formal education spaces” and “Scientific events”, related to the “Institutional Indicator”, are places that showed the same frequency of material use, according to the analyzed in the interviews.

The application place of the material “Microvilões em Ação” with higher distinction was formal education spaces. This finding confirms the creators’ incentive for production focused in formal education.

*This game is, today, in several public schools here in SP (Respondent 7 – Microvilões em Ação).*

*[...] in the present curriculum the Microvilões was put there to be used from, if I’m not mistaken, the seventh grade on (Respondent 7 – Microvilões em Ação).*

*[...] I was invited to teach in a university of the third age at USP and I took Microvilões as one of the activities to the ladies and gentlemen who were there and it was very cool (Respondent 8 – Microvilões em Ação).*

*[...] but, as I recall, what happened the most was people going to schools (Respondent 8 – Microvilões em Ação).*

The non-formal environment spaces, Scientific Communication events and scientific events appear with low frequency in the category, opposing to the results of the analysis of interviews for the other two games.

The “Target public” theme contemplates the public considered or not in the moment of creation of each game. Our analysis indicate, as of the interviews, that the material “Batalha de Micróbios” was produced to be used mainly by children, although the subtheme “Non-specific” also appears with a similar frequency. The adult and teenager public appear with low frequency, showing that the game does not aim these age groups. The same occurs with the school public considered, emphasizing that the material was not meant for this public segment, although the interviews show that they were very explored in formal education environments, such as schools.

*Look, our target is children up to 12 years old, right? (Respondent 3 – Batalha de Micróbios).*

*[...] from 4-5 years old on, which is indicated, the person can play (Respondent 1 – Batalha de Micróbios).*

Our analysis identified that the priority public of the game “Imune – Série Vírus” is the teenagers, from 12 years old on. The school and adult publics were also mentioned, however, in a lower frequency. Children under 12 years old were not considered as possible public.

We also figured out that the creators of the game “Imune – Série Vírus” say that the material reached a target public that was not initially planned. Possibly,

because of the application in Scientific Communication events, in which there is no strict control over the public, which may vary in age groups, education and social issues.

*[...] people are enjoying it a lot, even for the age group lower than the one we estimated, smaller children, sometimes, are more interested than the teenagers. The teenagers play it like this and the interest is lost in the third round (Respondent 6 – Imune – Série Vírus).*

The school public is emphasized in the target group analysis, reaffirming the results that indicate that the game “Microvilões em Ação” was developed for the application in formal education. The non-specific planning and adults’ orientation also appear in the analysis, in lower frequency, though.

*Basically, primary school students from ... I don’t know how it is now, but before they start talking about microorganisms, at least my son, on third grade, start talking about prokaryotic and eukaryotic cell (Respondent 7 – Microvilões em Ação).*

*And, despite being a little childish, they can be used in YAE, I don’t know if you have YAE, which is Young and Adult Education (Respondent 7 – Microvilões em Ação).*

The category “Game assessment forms” is related to the presence of some game assessment method before, during or post production. It is shown in the interviews that “Batalha de Micróbios” went through previous assessments, from player experience to content assessment, as exemplified in the statements:

*So there was a previous test with the members of the extension (Respondent 3 – Batalha de Micróbios).*

*When we were developing the game, these cards were given to different experts, then... For us to choose a protozoan or for us to choose a fungi, to choose a virus we sent to different researchers who worked with that class of microorganism, specially for us not to make any mistake concerning the game punctuation, what gives more points and what gives less. So, the game was assessed by different professionals and it was only final when we received their endorsement (Respondent 2 – Batalha de Micróbios).*

In compliance with the interviews with the people in charge of the production of the game “Imune – Série Vírus”, there were few forms of product assessment, probably because it is a new product, released few months before the interviews were made. In just a moment, the respondents stated the absence of assessment. Amongst the assessment forms, we can emphasize the game play tests, previous assessment and indefinite assessments.

*[...] then there is that vaccine card and so on, which was later included because we saw the need to better adapt to the game (Respondent 5 – Imune – Série Vírus).*

*We are having assessment now, the first assessment was our own, with a lot of fun and criticism (laughs) considering it was a product that was not ready, considering that a product that I identified some things that are not, you know... That won't derail its use, but considering it is a prototype and, the more assessed it is, the better (Respondent 4 – Imune – Série Vírus).*

In compliance with the content analysis, the absence of a systematized assessment form of the game “Microvilões em Ação” is emphasized:

*[...] but it is something that could have been done, I agree, I think we could have done a more systematic game assessment and made it in a more formal way. No, not that I remember we didn't do it, I don't know if XXX (name suppressed to safeguard the anonymity) made and never told us (Respondent 8 – Microvilões em Ação).*

*[...] with the students I don't have any formal assessment (Respondent 7 – Microvilões em Ação).*

*[...] the game has always been very well accepted and the teachers have always considered using it in classroom. “It brings benefits”, “the material is good”, anyway... well assessed (Respondent 7 – Microvilões em Ação).*

*In fact, there is a list of some diseases that are out there: zika virus, chikungunya virus, back then, there was just dengue fever; that would be a form of updating the game (Respondent 7 – Microvilões em Ação).*

In the category “Game perception” the intention is to understand how the creators of the education material perceive the interaction of the public with the game after the material is produced. The subthemes “Physical interaction”, “Aesthetic and affective interaction” and “Cognitive interaction” (Table 1) can be associated to the attributes of theoretical and methodological “Interaction Indicator” tool.

According to our analysis, the creators of the game “Batalha de Micróbios” understand that the material has a great potential to raise encouragement to questioning and promoting cognitive and learning abilities, once the subtheme “Cognitive interaction” is the one most frequently appearing during the interview, as exemplified:

*If the child, from an early age, receives this encouragement, even if in the simple form of a game, this child will grow with a different mindset (Respondent 2 – Batalha de Micróbios).*

As follows, the subthemes “Aesthetic and affective interaction” and “Physical interaction” are the ones appearing. The low frequency of these two subthemes, in comparison to the “Cognitive interaction” subtheme, might be related to the fact that the game development is centralized in the production of scientific content, giving low value to emotions, feelings that might appear during the game, besides the physical manipulation of the cards.

The subtheme “Aesthetic and affective interaction” is the group that stands out in the category “Game perception” during the analysis of the interviews with the creators of the game “Imune – Série Vírus”, while the physical interaction appears with a low frequency. This subtheme is related to the attribute with the same name as the “Interaction Indicator”. Our hypothesis is that the presence of a design professional exclusively dedicated to the chart and aesthetic aspects of the education material has considerably increased the understanding of the importance of such elements, making the material aesthetically appealing.

*[...] because it is also colorful, because it draws attention, because it is a, a, the images are unique, so, they were remade, etc (Respondent 5 – Imune – Série Vírus).*

*[...] the biggest concern is to spread information in a playful manner, in a pleasant, seductive way (Respondent 4 – Imune – Série Vírus).*

*So, it is an appealing, colorful, seductive game and spreads knowledge (Respondent 4 – Imune – Série Vírus).*

The subtheme “Cognitive interaction” stands out as the second element in the game “Imune – Série Vírus”, different from the appearing in the material “Batalha de Micróbios”, which presents a central role in cognitive interaction.

*At least I saw. In my case, because I played the games with one of the children, I saw it produces questioning, and... In children, it produces this will to question, you know?! Which they don't have, most times (Respondent 5 – Imune – Série Vírus).*

The perception of the creators of “Microvilões em Ação” that appear most frequently from the content analysis is the “Cognitive interaction”, which reaffirms the results found in the encouragement to the production towards education. This subtheme is related to the attribute “Cognitive interaction” of “Interaction Indicator”. Considering that the education material was produced with the purpose of being used in formal education, the presence of processes related to education, reflection over concepts, theories and scientific ideas is necessary and important, as pointed out in the selected segments:

*So, in the short term, I would say that there is this playful context that includes this knowledge that, at first, we can assume that makes learning meaningful to that child or even to that teacher (Respondent 8 – Microvilões em Ação).*



*[...] the student, or any person who is playing, must associate to something, make an operation, besides memorizing; I believe it brings some contribution (Respondent 7 – Microvilões em Ação).*

*I think it all contributes a lot to autonomy, autonomy, I mean, because they see they are capable of comparing things that are not a simple intellectual operation. They can compare, they can obtain information on their own, where they put beside the information they get in the material, right? (Respondent 7 – Microvilões em Ação).*

On the background, the subthemes “Physical interaction” and “Aesthetic and affective interaction” appear with the same frequency. Such results are similar to the analysis of the interviews with the team of the material “Batalha de Micróbios” which, by centralizing the main goal in the transmission of scientific knowledge and also be made by Life Sciences professionals, present a greater perception of the cognitive aspect to the detriment of physical and aesthetic and affective interaction. We have observed the opposite in the education material “Imune – Série Vírus”, which presents an interdisciplinary team and a balance in the design and scientific theoretical reference, resulting in a greater perception in the aesthetic and affective aspects in the material produced.

The results presented indicate that the creators prioritize two types of interaction during the creation of Science games with Microbiology theme: “Cognitive interaction” and “Aesthetic and affective interaction”.

The “Cognitive interaction” is related to the *minds on* interaction concept, put out by Wagensberg (2001) with the mental interactivity, essential to museums and education materials. This attribute is present when they have the opportunity to promote cognitive processes and the development of abilities relevant to critical analysis, to scientific investigation and to learning. Besides, it allows and stimulates a dialog relation among the other participants; it stimulates questionings and the reflection over the knowledge spread.

According to our analysis, this is the type of interaction which is more present in the analyzed interviews given by the creators of the education material in question. The perception from the creators that the education material has potential to exercise the mind and stimulate reflections and dialogs with other players is explicit in the interviews and reflects in the content and form of presentation of the games.

The “Aesthetic and affective interaction” uses the *heart on* concept (WAGENSBERG, 2001). This kind of interaction involves stimuli concerning knowledge that might be created by feelings, emotions, affection, by the reconstruction of several scenarios that allow the contextualization or immersion of knowledge through the appreciation of aesthetics, besides its motivating potential. Such feelings might be appreciation, pleasure, repulsion, fear, affection, outrage, surprise, motivation, satisfaction, joy among others (NORBERTO ROCHA, 2018).

The two types of interaction are expressed as important aspects in the game, especially in games with educational character. One of the main challenges during game production, whether digital or analog, is the conception and creation of aesthetic elements, creating a sensorial and cognitive richness, capable of seducing the public (VASCONCELLOS *et al.*, 2017).

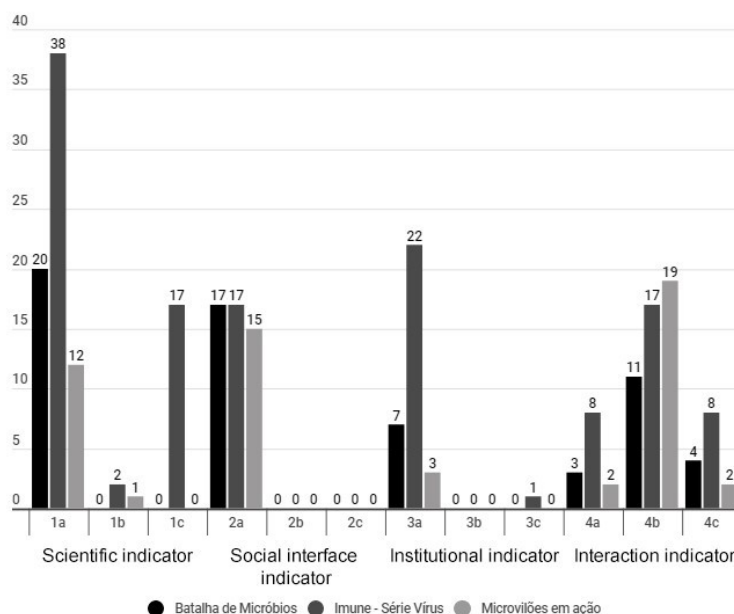
The academic formation of the team members has influenced the game development. The presence of researchers and students in Life Sciences area and the absence of a Design professional listed in the production of the games “Batalha de Micróbios” and “Microvilões em Ação” may justify the favoring in presenting more characteristics of the subthemes “Cognitive interaction” and “Scientific content and concepts” opposing to “Aesthetic and affective interaction” or other objective of the game. We noticed the opposite in the game “Imune – Série Vírus”, in which the presence of a designer in the team holds knowledge and the necessary techniques to the development of an aesthetically elaborated product has increased the presence of the subtheme “Aesthetic and affective interaction”.

In most cases, the education games are planned and developed by researchers, teachers and students that do not have the technical knowledge in Game Design, Graphic Design and Science Communication areas (BATTISTELLA; VON WANGENHEIM; FERNANDES, 2014). This fact leads to the production of games and education materials that prioritize the transmission of knowledge in traditional formats of formal education and in the deficit of Public Communication of Science and Technology model (LEWENSTEIN, 2003), presenting games such as Nine Men’s Morris or questions and answers. Yet, putting the aesthetic aspects to the background, creating materials with visual features less captivating and eye-catching, leading to limitations in creating interest and motivation from players (VASCONCELLOS *et al.*, 2017; CARMO; XEXÉO; ARAÚJO, 2019).

Together with the content analysis, we have explored the occurrence of indicators and attributes that compose the theoretical and methodological tool “Scientific Literacy Indicators” (MARANDINO *et al.*, 2018) concerning the presence of interaction, production of scientific knowledge, social interface, institutional issues and others.

The investigation of the interviews using the “SL Indicators” created a chart including the results of the games “Batalha de Micróbios”, “Imune – Série Vírus” and “Microvilões em Ação” (Chart 1).

Chart 1 – Result of the analysis of the interviews with the creators using the theoretical and methodological tool “SL Indicators”. The appearance of indicators and their attributes are highlighted in every interview for each game.



Source: Self-Authoring (2020).

In compliance with the analysis of the interviews made using the theoretical and methodological tool, we can observe that the education material “Batalha de Micróbios” shows occurrences in the attribute “1a – Scientific knowledge and concept, scientific researches and results” and “2a – Impacts of Science in the society”, coherent to the results of interview content analysis, Table 1. We also observed that the attribute “4b – Aesthetic and affective interaction”, in the “Interaction Indicator”, is the attribute with most emphasis, different from the content analysis result, which enhances the subtheme “Cognitive interaction”.

Observing the results of the education game “Imune – Série Vírus”, we noticed that it shows expressive occurrences in attribute “1a – Scientific knowledge and concepts, scientific researches and results” and “1c – Role of the researcher in knowledge production process”, confirming the results of the interview content analysis, Table 1. The attribute “3a – Institutions involved in Science production and communication, their roles and missions” appears in a very expressive way during the interview analysis using the tool; however it does not reflect in the content analysis. In the “Interaction Indicator”, the attribute “4b – Aesthetic and affective interaction” is emphasized, confirming the content analysis data.

Finally, we see in the analysis of “Microvilões em Ação” that the attribute “2a – Impact of Science in society” is highlighted, confirming the results of content analysis, Table 1. The attribute “4b – Aesthetic and affective interaction” has strong expression when analyzed using the tool, however, we observe that the subtheme “Cognitive interaction” is the highlight of the content analysis of the interviews.

The results allow the identification of the absences in the planning by the creators, which unravel the development of the three materials analyzed. As shown in the chart 1, out of the 12 attributes composing the indicators, seven are present in an expressive way, two are superficially present and three are absent, the last ones being: “2b – Economic and political influence in Science”, “2c – Influence and participation of society in Science” and “3b – Financing institutions, their roles and missions”.

The prioritization of the “Scientific Indicator” emphasizes aspects of concepts, ideas, laws, naming of objects and living beings, results of researches and scientific advances in games. Therewith, other aspects are chosen to be absent, which are: incentive the promotion of aspects related to the mission, institutional role, historical dimension and political and social aspects of the institutions involved in the financing, communication and production of the researches and scientific knowledge. These omitted characteristics are also considered relevant in the SL and Science Education, Technology, Society and Environment perspective (CHASSOT, 2003; SASSERON; CARVALHO, 2011).

Comparing our results with other works using the theoretical and methodological “SL Indicators” tool, to analyze other education materials, we observe the presence of a similar profile. In the study over the contributions of the education materials used in activities at Parque Zoológico Municipal Quinzinho de Barros, in São Paulo, considering the SL perspective (LOURENÇO, 2017), Márcia Lourenço has identified the presence of four indicators of the tool in 27 education materials<sup>4</sup>. The “Scientific Indicator”, “Social Interface Indicator” and “Aesthetic/Affective/Cognitive Indicator” (currently “Interaction Indicator”) rates are the most expressive<sup>5</sup>. The “Institutional Indicator”, although is present, is only found in one attribute.

The theoretical and methodological “SL Indicators” tool was also applied to the toy library of Laboratório de Brinquedos e Materiais Pedagógicos from Faculdade de Educação at Universidade de São Paulo (MARQUES; MARANDINO, 2019). The researchers analyzed three areas in this space: hospital, play house and market, and observed the presence of the indicators regarding the “Scientific Indicator”, the “Social Interface Indicator” and the “Interaction Indicator”, while the “Institutional Indicator” was not present, once again.

## CONCLUSION

Our objective, with this research, was to investigate the context of production of three different board games with scientific theme, to understand the intention of the creators for the developed games and to assess if the expectations were met by using semi structured interviews and the theoretical and methodological “SL Indicators” tool.

Although the education materials have different origins in relation to the people responsible for their production, the belonging institutions, the main goals, whether for education or for Science Communication, we could identify the tendencies that influenced the production of the materials studied. We identified two general tendencies: strong potential for the promotion of “Scientific

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Indicator” and “Interaction Indicator”, and little potential for the promotion of the “Social Interface Indicator” and “Institutional Indicator”.

The analysis of the interviews with the creators of the three education games, from the SL perspective, has potential to contribute to the improvement of this kind of education material. The analysis made is capable of methodologically assist the creation of games with scientific theme that promote and value the role of Brazilian institutions and researchers. Games that are capable of approaching Science risks and benefits, political and economic factors involving Science; games that discuss the historical character of Science, that deals concepts and methodologies in a contextualized way, without failing to approach the interactive aspects, present in board games, however. Besides, the results direct the application of Science board games in non-formal education, indicating attention to possible gaps in the SL context.

Anyway, the results obtained cannot be generalized for all the education games with Microbiology theme. We believe that discussions allow the growing of understanding about the development of education and Scientific Communication. That way, we can refine strategies that value the education perspectives and the SL adopted during the conception of the games, as well as the ones that were discarded.

## Jogos de tabuleiro de ciência: o que dizem os idealizadores?

### ABSTRACT

Neste artigo, delineamos a perspectiva dos criadores de jogos de tabuleiro com temática científica. Buscamos explorar o contexto de produção de três jogos, compreender a intencionalidade dos idealizadores para os jogos desenvolvidos e avaliar se as expectativas foram alcançadas. A pesquisa de caráter qualiquantitativo foi realizada com oito produtores de três jogos educativos: “Batalha de Micróbios”, “Imune – Série Vírus” e “Microvilões em Ação”. A intencionalidade na idealização foi investigada por meio de análise de conteúdo de entrevistas semiestruturadas e aplicação da ferramenta teórico-metodológica “Indicadores de Alfabetização Científica” nos três jogos. A análise de conteúdo das entrevistas, feita na perspectiva da Alfabetização Científica em cotejo com a Divulgação Científica, permitiu identificar presença e ausência de atributos relevantes nestes materiais. Constatamos a tendência à priorização do conhecimento científico e diferentes formas de interação – física, estética-afetiva e cognitiva – em todos os jogos. A interface social também foi um atributo presente, principalmente para apresentar o impacto da Ciência na sociedade. Por outro lado, o papel institucional, influência da economia e política na Ciência, contexto histórico e de fomento à Ciência foram negligenciados. Este resultado e a análise detalhada de outros atributos podem contribuir para uma mudança de cenário na produção de jogos educativos. Mostramos que é necessário planejar a produção de jogos com temática científica de forma a compreender outros aspectos da Divulgação Científica, como o papel das instituições e dos pesquisadores brasileiros, todos relevantes no contexto da Alfabetização e Divulgação Científica. Além de direcionar a criação, este artigo pode contribuir para a utilização de jogos de Ciência de forma significativa e eficiente com intenções educacionais em ambientes formais e não-formais de educação. Por fim, concluímos que os jogos analisados neste artigo foram desenvolvidos de forma a estimular a compreensão e a discussão de temas científicos relacionados ao cotidiano dos jogadores e, portanto, apresentam potencial educativo e pedagógico em ações de Divulgação Científica em ambientes formais e não-formais de educação.

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## NOTES

1. The difference in number of respondents of the game “Microvilões em Ação” is justified, once only two creators took part in the development of the game, as informed by the coordinator.
2. The semi structured interview script was adapted from the thesis by Márcia Lourenço (2017) and can be found in her dissertation (Lourenço, 2017).
3. Under CAAE (Certificate of Presentation for Ethical Consideration) number: 16798919.8.0000.5241 with the purpose of attending the Resolutions of the Conselho Nacional de Saúde (CNS – National Health Council - 196/96, resolution Nr. 466, as of December 12, 2012). To this end, the volunteers admitted their participation in the research by means of the Informed Consent (Registro de Consentimento Livre e Esclarecido).
4. Each material consists of specific sets with objects (preserved animals and plants, models and replicas), booklets, pictures, illustrations, instruction manuals, multimedia material, among other objects.
5. Figure 30 of Márcia Lourenço thesis (2017).
6. Aline da Silva Vianna [alinev14nn4@gmail.com](mailto:alinev14nn4@gmail.com) responsável pela tradução.

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