

Research on memes in the teaching of Natural Sciences

ABSTRACT

Digital information and communication technologies have been corroborating the (re)significance of the teaching and learning process in Chemistry, Physics, and Biology. The multimodal meme genre is the result of this technological advance and has contributed to the construction of knowledge in Science by a multifaceted audience. In this sense, this article aims to analyze how memes have been used in the field of Natural Sciences through a systematic literature review. It is an exploratory, descriptive, and bibliographic research, with a quali-quantitative approach, which uses articles from Qualis A1, A2, B1, B2, and B3 journals in the field of Teaching as a corpus of research. Data analysis took place in the light of content analysis proposed by Laurence Bardin. The systematic review enabled the identification of six articles including the use of memes in both formal and informal settings, such as Elementary schools and universities, as well as social media and museums. The findings indicate that memes are of great relevance to the learning of Natural Sciences. Because they act as catalysts in the dissemination of Science, they are widely accepted, rich in meanings, dynamic and current, in addition to corroborating with the participants' formation of scientific knowledge. However, studies in this field of research are incipient, revealing an emerging need to promote research and reflections on this digital resource.

KEYWORDS: Memes. Multimodal Resources. Systematic review. Natural Sciences.

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1 INTRODUCTION

In contemporary times, Digital Information and Communication Technologies (TDIC) have assumed an essential role in the way society has been relating, generating information and learning (SCHUARTZ; SARMENTO, 2020). With the advances that emerge in the 21st century, the teaching and learning process has been through different (and significant) changes, in view of the digital didactic resources that are presented and that are part of the context of the students, as well as the pedagogical work of primary education schools.

The role of cyberspace allows communication through the worldwide interconnection of computers, through which a range of information is being elaborated and accessed by individuals who navigate and feed in it (LÉVY, 1999). To the detriment of this process, cyberculture develops, which, in turn, integrates the “set of techniques (material and intellectual), practices, attitudes, ways of thinking and values that are involved together with the growth of the cyberspace” (LÉVY, 1999, p. 17).

Undoubtedly, the advent of technological advances has re-signified the means of communication, as well as the modes of production and sharing of information. According to Cani (2019), communication in the digital space involves the use of texts, audio and video material, words and images, with or without movements. Furthermore, Cani (2019) highlights that the insertion of technologies in language practices favored the emergence of discursive genres, such as memes, tweets and gifs.

Accordingly, Lara (2016) points out that the school is an environment of personal change and possibilities and, it is necessary to consider the use of different resources available. According to the author, the teaching units provide an adequate context for the use of social media, so it is necessary to understand these environments and mobilize them in favor of the knowledge-construction process. However, “this must be continuous at school, science is not immutable, with the change in science new technologies emerge and school environments must adhere to these changes and follow them” (LARA, 2016, p. 23). Furthermore, it is understood that social media can favor interaction between students, the construction of meanings, as well as the monitoring and exploration of various themes that circulate in cyberspace.

In this sense, memes stand out, as they are important elements for scientific dissemination, corroborating the elaboration of knowledge and the dissemination of Science. Memes have drawn the attention of students and teachers, as well as researchers. Through humor, texts and images that permeate this multimodal genre allow various subjects to be favored by way of a critical analysis of information. Consequently, its use as a learning object has been defended by different authors (ARNEMANN; OLIVEIRA; SANTOS, 2018; FELCHER; FOLMER, 2018; OLIVEIRA; PORTO; ALVES, 2019; LUCENA, 2020).

According to Arnemann, Oliveira and Santos (2018), meme:

[...] appeared in 1976 with the work “The selfish gene”, by Richard Dawkins. Based on Darwin and his theory of natural evolution, Dawkins developed what he called memetics. According to the author, “meme”, related to cultural evolution, is analogous to “gene”, referring to genetic evolution. The term “meme” has historical roots in the Aristotelian meaning of imitative representation, since Aristotle initially claimed that art proposed to

imitate reality (ARNEMANN; OLIVEIRA; SANTOS, 2018, p. 76, emphasis added).

Regarding the pedagogical possibilities of memes, these originate from collective/individual constructions, which have been shared in an expressive way in different virtual spaces, considering the last decade, with significant acceptance and repercussion by the public, it becomes pertinent to consider them as learning objects in the teaching of Natural Sciences.

The National Common Curricular Base (BNCC, in Brazil) proposes that the area of Natural Sciences in primary education should corroborate with a contextualized knowledge base, which provides conditions for students to “make judgments, take initiatives, elaborate arguments and present alternative propositions, as well as making judicious use of various technologies” (BRASIL, 2017, p. 537). Therefore, BNCC points out that the pedagogical practice needs to consider the other areas of knowledge, the role of digital technologies assume in contemporary times, in order to encourage the development of critical thinking in the face of issues that come up inside and outside the school sphere.

In this context, Oliveira and Porto (2020) highlight that memes involving Science:

[...] have gained notoriety in the public debate, as a mode of expression by internet users and a critical representation of the scientific scenario, which demonstrates a form of democratization of science through involvement and digital mobilization about it, even if in an indirect language, although effectively propositional in its aesthetic composition and questioning of everyday life and its place in it (OLIVEIRA; PORTO, 2020, p. 99).

This genre, which enables the dissemination of content at different levels and for different agents of educational action, can and should be used in the classroom. In this direction, Felcher and Folmer (2018, p. 1) emphasize that “the work with memes bets on the importance of integrating technologies, methodologies, modifying the way of teaching, taking a visual and written language with a humorous bias, present in the lives of students.”. That said, with regard to the use and advantages of memes to address Science topics, Oliveira, Porto and Cardoso Junior (2020) show that these:

They make the non-specialized public have a critical view of Science (according to their way of reading and interpreting); They can combat pseudosciences, problematizing major issues under debate; They can show the processes, characters and controversies involved in scientific activity and scientific facts; They promote a rapprochement between science and society, especially through comic mediation (OLIVEIRA; PORTO; CARDOSO JUNIOR, 2020, p. 11).

As a result, working with such resources goes beyond its humorous aspect, since, when well explored, it can contribute to the scientific training of students, the implementation of innovative digital didactic resources in the classroom, as well as the improvement of teaching and learning process in Natural Sciences.

Furthermore, Oliveira, Porto and Cardoso Junior (2020) state that:

[...] memes, as units of information about Science, or [...] as science disseminators, can become learning objects that carry in themselves

statements, feelings, and cultural expressions of our time (OLIVEIRA; PORTO; CARDOSO JUNIOR, 2020, p. 10).

Although these are artifacts with a high degree of acceptance, sharing and popularity, there are few studies that discuss the potential of memes in the educational process, as Oliveira and Porto (2020) point out.

Regarding the low number of research on the subject, Oliveira and Porto (2020) emphasize that the few existing investigations have led to the deconstruction of pre-established stereotypes, which corroborates the objective of this research, that is, to discuss and highlight the potential of the multimodal meme genre in the teaching of Natural Sciences. For this, a systematic review was carried out involving scientific articles published in the last 10 years (2011 and 2020) in national journals.

Through this investigation, we sought to analyze how memes have been used in the areas of Natural Sciences (Chemistry, Physics and Biology), as well as their contributions to the teaching and learning processes of students in these areas of knowledge.

2 METHODOLOGY

In conformity with the objectives proposed for this research, a Systematic Literature Review (SLR) was conducted involving the use of memes in the field of Natural Sciences. In this sense, it is worth mentioning that the SLR “[...] aims to identify, select, evaluate and synthesize the relevant evidence available” (GALVÃO; PEREIRA, 2014) on the topic under investigation. According to the authors, that review is a secondary study based on primary research, thus allowing progress in the development of original productions with scientific impact.

In this context, this systematic review went through the following steps: definition of objectives; preparation of research questions; literature search; definition of inclusion and exclusion criteria; keywords; selection of papers; data extraction and synthesis; in addition to writing and publishing the results (BOTTENTUIT JUNIOR; SANTOS, 2014; GALVÃO; PEREIRA, 2014; REIS; LEITE; LEÃO, 2017; LEITE, 2018; OKOLI, 2019).

This research is classified as exploratory, considering the promotion of greater familiarity with the theme; descriptive, considering the establishment of relations between variables and the description of characteristics; as well as bibliographical, since it was developed from materials already prepared – scientific papers (GIL, 2002). Therefore, it started from the following questions: 1) How have memes been used in the field of Natural Sciences? 2) What are the contributions of memes to the learning process? Such questions also led to the following developments: 3) What are the methodologies employed by the authors when approaching the multimodal meme genre? 4) What is the profile of the target audience? 5) What contents were contemplated?

From this, data were collected through a search in the Qualis Periódico of the Sucupira Platform of the Coordination for the Improvement of Higher Education Personnel (CAPES), thus following these inclusion criteria: articles published in journals belonging to the Quadrennium 2013-2016, in the Teaching area, from

strata A1, A2, B1, B2 and B3; productions written in Portuguese released in the last 10 years (2011 to 2020); regular or special editions involving the multimodal meme genre; and, finally, unpublished or review studies.

In the list of exclusion criteria, there are articles not related to the contents of Natural Sciences; journals with publications (scope) in the areas of Languages (Languages, Arts, English, Spanish and Physical Education), Mathematics, Humanities (History, Geography, Philosophy, Sociology, and Law), Health (Medicine and Nursing); international journals; as well as printed journals. The exclusion of international journals is justified by the fact that the research seeks to understand, in general, the use of memes in Brazilian journals. The keywords used during the survey were: memes; Natural Sciences; Chemistry teaching; Physics teaching; Biology teaching; Science. The words meme and Chemistry teaching, meme and Physics, etc were also crossed. Furthermore, that process was based on reading the title, abstract, keywords, as well as the body of the text, thus seeking coherence between the information obtained and the focus of the research.

After collecting data, this study took into account the quality-quantitative approach, since “[...] it involves obtaining both numerical information (for example, in instruments) and text information (for example, in interviews) [...]” (CRESWELL, 2007, p. 35), thus enabling a greater significance of elements in the results presented.

The method adopted for analyzing the data obtained was the content analysis proposed by Bardin (2011). According to the author, the process in question integrates three extremely important stages, namely: (i) pre-analysis, in which (a) floating reading will be carried out, (b) choice of documents, (c) formulation of hypotheses and of the objectives, (d) referencing the indices and the elaboration of indicators, in addition to (e) preparation of the material; (ii) the exploration of the material, in order to go through the “coding, decomposition or enumeration operations” (BARDIN, 2011, p. 131); (iii) treatment of the results obtained and interpretation, this with a view to treating the information in a meaningful and valid way, relying on statistical operations (simple or complex), making inferences and interpretations in favor of the proposed objectives (BARDIN, 2011). In view of this, the categories of analysis were defined *a posteriori*.

Throughout this work, to facilitate the identification of articles from the survey, they were coded as PN, where P means the publications and N the number of the article that is referred to. The next section presents the results and discussion of the information treated and interpreted in this investigation.

3 RESULTS AND DISCUSSION

Regarding the survey of journals with Qualis A1, A2, B1, B2 and B3 in the Teaching area, 373 journals were analyzed (with scope in the area of interest), this quantitative result from the application of the aforementioned inclusion and exclusion criteria, which resulted in the identification of 6 articles on the subject (Chart 1).

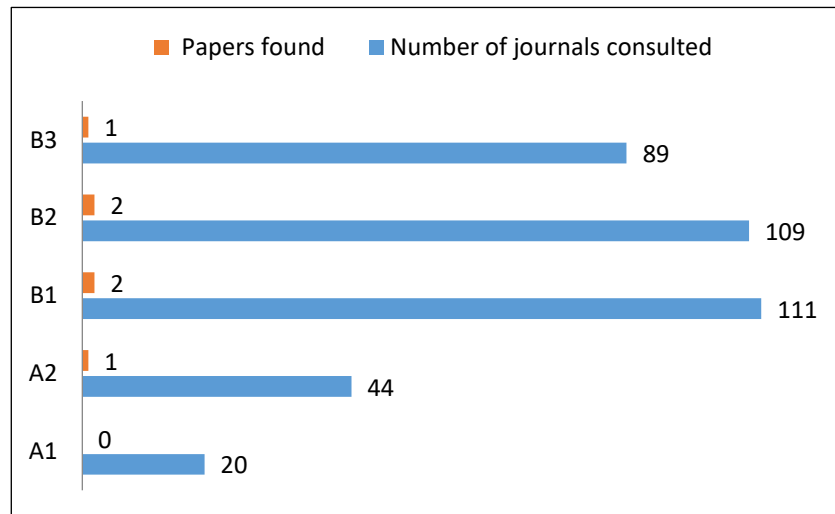
Chart 1 – Survey papers identification

Assigned code	Publication title	Authors	Qualis	Journal	Year
P1	Memes about science and the reconfiguration of the language of science communication in cyberculture	Oliveira; Porto; Cardoso Junior	A2	Acta Scientiarum	2020
P2	Science, opinion and fake news in times of coronavirus: conceptualizations in memes under the linguistic approach cognitive	Almeida; Santos	B1	Pensares em revista	2020
P3	Interdisciplinary teaching in undergraduate courses through integration with digital technologies: the case of techno-teaching	Lima; Loureiro	B1	Revista Tecnologia e Sociedade	2017
P4	The use of memes as a pedagogical resource in chemistry teaching: the chemistry teachers view	Santos <i>et al.</i>	B2	Research, Society and Development	2020
P5	Coronavirus in memes: pedagogical potentialities of reading Science	Simplicio <i>et al.</i>	B2	Revista Prática Docente	2020
P6	Museum education in cyberculture: the use of memes in the “young scientists club” project of the teaching assistance section (SAE) of the national museum/UFRJ	Marti; Costa; Miranda	B3	Periferia	2019

Source: Research data (2021)

The search filters considered in this research, for journals in the field of Teaching, reveal a little expressive production, in which the first published article, judging by the range considered, is from 2017, while the most current ones (another four) were published in 2020. Therefore, such information reveals a recent scenario of discussions and concerns regarding the focus element. With regard to the number of journals analyzed and the articles found during the survey, Graph 1 summarizes the distributions according to Qualis.

Graphic 1 – Papers found according to Qualis CAPES in the Teaching area



Source: Research data (2021)

Journals in strata B1 and B2 gather the largest number of consulted journals (111 and 109, respectively), as well as being the ones that enabled the identification of 4 productions suitable for appreciation (66.6%), with two each. During the analysis, it was identified that, in the last decade, the journals with Qualis A1 had not published any article on the subject, which represents a need to promote research in the area of this study in journals considered of high impact. However, the 44 journals in the A2 stratum, as well as the 89 in the B3 stratum, published only 1 article over a 10-year period.

Thus, it can be inferred that this is an incipient number of studies that address the relationship between meme and Science, and that pervades its educational potential. This scenario was addressed by Santos et al. (2020) when discussing the few existing research in Chemistry teaching involving memes and the need to investigate their use and contributions. It is understood, therefore, the importance of advancing in investigations and reflections around the use and advantages of the meme in the area of Science, since it is a dynamic, current and easily accepted resource, in which different themes can be addressed simply and efficiently.

The treatment and appreciation of the results from the six productions enabled the definition of two main categories. The first comprises the use of memes in formal and non-formal spaces; the second focuses on the potential of memes in the field of Natural Sciences.

3.1 The use of memes in formal and non-formal spaces

This category is the result of the grouping of papers that deal with the presence of memes in formal spaces, such as primary education schools or universities, and non-formal spaces, such as museums and social media. Regarding the creation of a category, Bardin (2011) points out that it brings together a group of elements (registration units) due to common characteristics. That said, the same seeks to elucidate how the implementation of memes has been; which spaces and agents are contemplated; in addition to the process of obtaining and producing such resources.

The interest in new ways of discussing and perceiving themes in the field of Science has caught the attention of several researchers. In this sense, memes emerge as a possibility to attract and awaken different audiences to the issues that are present in their environment and that have (or have not) generated great repercussions in different social media.

The implementation of the memes multimodal resource has taken place in different ways and with different objectives, judging by the data obtained by the surveys analyzed in the present review. In this context, P1 takes into account issues within the scope of scientific dissemination, since the meme can be used in a decentralized way and in digital spaces, in an unformatted and not recommended way, based on different spaces and audiences. To this end, the research carried out in P1 analyzes the production and reproduction of the genre of Science, thus covering the digital language (OLIVEIRA; PORTO; CARDOSO JUNIOR, 2020).

A current look at the use of memes is provided in P2, as it discusses Science and fake news in productions from internet pages, more specifically, on social networks. Such a scenario leads to a direct confrontation between the range of information that has been propagated, and that departs from common sense, without scientific proof, and the role of memes that, in a relaxed and highly visible way, demonstrates the impact of Science in the face of the fake news. An example achieved by the authors involving the new coronavirus (SARS-CoV-2), the subject of numerous unfounded information (ALMEIDA; SANTOS, 2020).

One of the characteristics of memes concerns their integration with phenomena that are having repercussions in the social sphere, and just as in P4, which addresses the virus that has plagued the planet since 2020, P5 also provides new perspectives on the use of digital resources to approach coronavirus theme. In view of this, P5 seeks to analyze the role of memes with regard to “[...] aspects of language and scientific information addressed, in order to establish means, [...] so that students develop the ability to 'Reading in Science' [...]” (SIMPLÍCIO et al., 2020, p. 1199). This perspective corroborates what is proposed by the BNCC, since reading in Science makes it possible to create conditions for participants to make judgments, present alternative propositions, or even elaborate arguments about the content studied (BRASIL, 2017), making possible the continuing the scientific formation of the target public

The meme has also gained space in degree courses, as well as presented by P3. This investigation, through the discipline of Techno-teaching, brings an interdisciplinary view between different courses (Biological Sciences, Mathematics, English, and Geography), in which undergraduate students took the movie **Ice Age** to the classroom and, in the sequence, explored the contents involved so that the high school students could make use of online tools in the process of creating the multimodal digital resource. Thus, the study presents, in some moments:

[...] actions centered on the students, mainly when thinking about the creation of memes, using images and texts that contemplate the integration of the contents addressed in class (LIMA; LOUREIRO, 2017, p. 129).

It is also worth pointing, in this scenario involving education professionals, what is presented by P4, as it addresses an investigation with 400 teachers,

emphasizing that 67% of respondents have already made use of memes in their Chemistry classes, also revealing the views about the potential of the resource. Its approach happened through:

[...] videos and/or posts on social networks (168 teachers); in extra class activities such as exercises (125 teachers); in tests (121 teachers) and in the development of content in the classroom (173 teachers) (SANTOS et al., 2020, p. 13-14).

In the research carried out in P6, it is possible to observe that the use of memes can occur in different spaces, not only in social media, schools, or universities but also in museums. This investigation was developed with primary education students, at the elementary level, through educational activities in the Teaching Assistance Section of the National Museum of Rio de Janeiro. In this research, we sought to narrate the experience of creating memes by students through the experience of a workshop, as well as to discuss the knowledge and meanings resulting from the process. The term elucidated was adopted by the authors - from P6 - inspired by Alves (2008). It is, therefore, a proposal that intertwines Science, museum education, cyberculture, and the production of memes. In summary, the research aimed to favor the interaction between students and the museum's exhibition based on digital resources and the production of multimodal texts, taking into account semiotic and linguistic aspects (MARTI; COSTA; MIRANDA, 2019).

In order to understand the methodologies used by the authors of the articles analyzed when addressing the multimodal genre in the field of Science (question 3), Chart 2 presents a synthesis involving elements of methodological development, containing the type of research, approach and origin of memes used.

According to Chart 2, in the methodological development item, there is a predominance of analyzes of memes resulting from social media (P1, P2, and P5), that is, materials that are being shared/appreciated daily on different pages and by different consumers. On the other hand, P3 understands the experience of a lesson plan, this one elaborated by undergraduates, in which the target audience is public high school students, mobilizing, for this, the TDIC. In P4, in turn, there is an interview, through the application of a questionnaire with 18 semi-structured questions, aimed at teachers of basic and higher education. Finally, the study proposed by P6, unlike the others, describes the experience of a meme-making workshop in a museum with students from the municipal public network, with the use of tablets and the internet throughout the process.

Chart 2 – Methodological paths taken by the authors

	Methodological development	Research type	Approach	Origin of memes used
P1	Analysis of the production and replication of memes extracted from virtual pages	Exploratory	Qualitative	Facebook
P2	Selection and study of memes from social networks	Exploratory, descriptive and interpretive	Qualitative	Facebook, Twitter and Instagram
P3	Experience of a lesson plan with high school students using DICT	Case study	Qualitative	Produção autoral
P4	Questionnaire application (semi-structured) with teachers	Survey	Quantitative	Facebook, Instagram, Blogs and authorial production
P5	Analysis of scientific articles and memes (shared on social networks).	Bibliographical	Qualitative	Facebook, Instagram and WhatsApp

Source: Research data (2021)

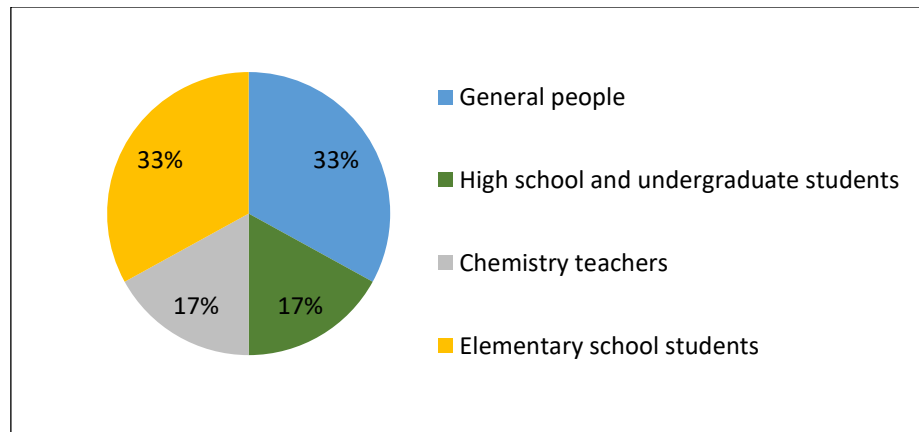
With regard to the type of each research, differences were observed between the proposals, since they include surveys (P4), bibliographic (P5), and case studies (P6), in addition to exploratory investigations (P1 and P2). Furthermore, it is convenient to explain the item origin of the memes used, since this appears from the need to highlight the sources of extraction or production of the memes worked on in the research. In this sense, Facebook was the most used social network for collecting the multimodal genre, followed by Instagram. In addition, the process also included the elaboration of authorial material, which indicates a significant advance in the learning of the participants, as they assume the role of creators and protagonists of the process.

It is evident that the predominant approach among the analyzed works is of a qualitative nature, representing 83.33%, which allows for greater richness in the provision of information that cannot be quantified. Only the studies of P3 and P6 allowed the production of memes by the students, considering that the others extracted their data from social media. Student participation in the process preparation is extremely important, as it arouses interest, mobilizes the public and catalyzes the construction of knowledge, in addition to bringing a sense of belonging to what is being proposed in the classroom, not of something distant, done by others, but by the students themselves. It is necessary to point out that in P4, other than using memes obtained from the media, of the 400 participants (teachers) interviewed, only 33 created their own memes, 24 others highlighted that the elaboration was carried out by the students and occurred in the classroom (SANTOS et al., 2020).

Regarding the profile of the public responsible for the use or production of the memes (questioning what is the profile of the target public?), Graph 2 allows

us to identify the involvement of people who differ in terms of education or occupation. The participation of the general public, as well as elementary school students, together represent about 66% of those involved who consumed this type of resource.

Graphic 2 – Target audience profile



Source: Reasearch data (2021).

High school and undergraduate students, in addition to Chemistry teachers, make up, together, 34% of those who were favored with the meme genre. Graph 2 makes it clear that the digital element is within everyone's reach, and that it is possible to disseminate themes in the field of Natural Sciences to a specific public or not. Thus, it is necessary to launch new perspectives on the use of DICT in the classroom, based on the fact that it “[...] allows the elaboration, circulation, sharing of data and information, as well as the production of knowledge about the certain area” (SCHUARTZ; SARMENTO, 2020, p. 436). In Natural Sciences, for example, DICT can corroborate the formation of a scientifically and digitally literate society (LEITE, 2015), when taking into account a critical implementation, with well-defined goals, collaborative and investigative, with the teacher as a mediator of the educational process.

Regarding the first question of this research (How are memes being used in the field of Natural Sciences?), it is observed that the process of using memes has occurred spontaneously, multidisciplinary and contextualized, in schools, museums, universities and social media. The data reveal that memes assume the role of learning objects, mobilizing numerous contents (be they from the school curriculum or from the current scenario) by and for a multifaceted public that, directly or indirectly, is interested in science and multimodal resources.

3.2 The potential of memes in the field of Natural Sciences

This second category brings together elements present in the 6 elaborations, that permeate the potential of the multimodal genre in terms of student learning. In this sense, it comes up from identified common data, in accordance with the proposed objectives, as well as an attempt to explain the real contributions that configure the process of construction of scientific knowledge.

The meme does not require high aesthetic or artistic quality. An example is its amateur and informal character. Reading it is not passive, as it allows moving

towards debates on Science and the construction of meaning (OLIVEIRA; PORTO; CARDOSO JUNIOR, 2020). In P1, the digital genre is considered capable of becoming a learning object, as it carries statements, feelings and cultural expressions of the emerging scenario, stimulating scientific knowledge. According to the authors:

Memes about Science are full of ideological values and intentions, as well as representations of the intention of those who produce them. Thus, the literacy practices inherent to their interpretation may or may not lead the subject to a posture of discernment, questioning, and critical awareness in the face of the images read (OLIVEIRA; PORTO; CARDOSO JUNIOR, 2020, p. 10).

Research P2 proposes a critical look at memes, which interconnects important aspects of the areas of Languages and Science. The authors consider that the use of these resources supports discussions and critical reflections on important topics (ALMEIDA; SANTOS, 2020). In this sense, the need to invest in Science emerges, as well as in the training of subjects capable of mobilizing scientific knowledge by reading the environment in which they are inserted (and beyond it) so that they can identify the dissemination of false news.

Among the contributions highlighted in the analyzes of P3, the following stand out: the possibility of contextualizing knowledge; working together; the use of digital technologies by high school graduates and students; the elaboration of copyright resources (memes); and the construction of knowledge from experiences (LIMA; LOUREIRO, 2017). Such elements seek to contribute to the improvement of the teaching and learning process. Accordingly, P4 highlights the pedagogical use of memes in Chemistry classes, due to their potential to articulate content in the area with the reality of students, stimulating and arousing interest in understanding the discipline in question (SANTOS et al., 2020).

The data analyzed in P5 show that that:

[...] memes have a transversal and interdisciplinary character that, through humor, address information of a scientific nature as well as related to language, generating critical and reflective thinking (SIMPLÍCIO et al., 2020, p. 1191).

For them, another significant possibility in the classroom includes the development of scientific literacy indicators, such as reading in Science, which “comprises the ability to interpret texts or images and knowing how to relate new knowledge to that which already exists, thus contributing to digital literacy” (SIMPLÍCIO et al., 2020, p. 1200).

The contributions of memes to the learning provided by P6 are described through the experience carried out in the research. The positive aspects of P6, arising from the realization of a meme production workshop with elementary school students, integrate the stimulation of creativity with the public's interest and sensitive look at the objects on display in the museum (MARTI; COSTA; MIRANDA, 2019). For these authors, this:

[...] indicated a production of meanings based on the social and historical contexts experienced by its authors, thus helping us to reflect on the context

of museum education in cyberculture and the relationship between Science and society (MARTI; COSTA; MIRANDA, 2019, p. 90).

Therefore, the experiences lived by the public were reflected in their productions, so that the genre worked allowed valuing existing knowledge, as well as the production of meanings about museum education.

With regard to question 5 (which contents were covered?), the data obtained from the six articles point to the existence of different contents in the field of Natural Sciences being addressed in activities involving memes (Chart 3). It should be noted that memes from other areas (Languages, Geography, Geology, and Mathematics) were also identified during the analysis. These memes were approached in a multidisciplinary way, that is, they were related to the contents of Chemistry, Physics, or Biology (Natural Sciences).

Chart 3 – List of contents addressed in memes

	Contents	Subjects
P1	Periodic table: elements, symbols, mass and atomic number.	Chemistry
	Newton's three laws of motion.	Physics
P2	The new coronavirus (SARS-CoV-2).	Biology
P3	Biological evolution	Biology
P4	Solution, mixtures, periodic table, physical states, concentration, solubility, organic functions, polarity, etc.	Chemistry
P5	The new coronavirus (SARS-CoV-2), morphology and spread of the virus, personal hygiene.	Biology
P6	Natural history: Zoology and Paleontology.	Biology

Source: Research data (2021).

Chart 3 shows the contents addressed in the research, as well as the subjects to which these subjects are related. The data reveal that Biology was the most mobilized subject through memes, allowing us to infer that researchers agreed to consider that this genre has shown considerable potential for approaching relevant topics, as presented in P2, P3, P5, and P6. This context confronts the proposal of traditional teaching when considering the multimodality in the process of building scientific knowledge, as it opens space for (re)signification of didactic resources inside and outside the school environment, with a view to a critical look at perceiving and implementing elements of DICT.

These possibilities are extended to the areas of Chemistry and Physics, since the virtual genre made it possible to discuss content from the macro and microscopic world, in order to facilitate its understanding, as well as exposed by the studies of P1 and P4. There is, therefore, the presence of playfulness and humor facilitating scientific dissemination and training; the construction of meanings; language, and participation in digital culture (OLIVEIRA; PORTO; CARDOSO JUNIOR, 2020).

Concerning Question 2 (What are the contributions of memes to learning?), among other elements already exposed, the versatility that permeates the genre when approaching themes of the Natural Sciences is highlighted. Thus, it is not limited to subjects or contents, considering that, regardless of the degree of

complexity involved in the subjects, the resource allows it to go beyond the school contents. Therefore, the list of identified contributions includes the: exploration of already elaborated knowledge and the construction of new ones; development of indicators of doing and scientific thinking; participation in digital culture; diffusion of Science; mood involvement; creativity; accessibility; playfulness; easy adhesion; as well as the critical and reflective training of students, in which they can assume, depending on how the genre is implemented, the condition of being the protagonist of the educational action.

4 FINAL CONSIDERATIONS

This article sought to present a systematic literature review of research involving the use of memes in the teaching of Natural Sciences, analyzing their contributions. During the review, 373 journals in the area of Education were investigated, which resulted, after a thorough reading of the texts, in only 6 papers that met the criteria established in this research.

Multimodal resources, especially the meme genre, contribute directly and significantly to the implementation of new strategies, in addition to allowing dissemination, perception, and discussion of Science in different spaces, on different contents, and for a very heterogeneous public. Therefore, working on Chemistry, Physics, or Biology subjects inside and outside the classroom using DICT can be a promising strategy, which ends up corroborating what the BNCC advocates.

The approach of memes in formal and non-formal environments has been considered due to the pedagogical potential that these elements present. It is a learning object of digital culture that has gained notoriety in the XXI, through social media but has little research in the field of Natural Sciences. Thus, this research points to the need for studies involving the multimodal meme genre in the teaching of Chemistry, Physics, and Biology, in formal and non-formal education spaces, as well as in national and international journals, in order to contribute to the construction of the knowledge in a playful and participatory way.

PESQUISAS SOBRE MEMES NO ENSINO DE CIÊNCIAS DA NATUREZA

RESUMO

As tecnologias digitais de informação e comunicação vêm corroborando com a (re)significação do processo de ensino e aprendizagem em Química, Física e Biologia. O gênero multimodal meme é fruto desse avanço tecnológico e tem contribuído com a construção de conhecimento acerca da Ciência por um público multifacetado. Nesse sentido, este artigo tem como objetivo, por meio de uma revisão sistemática da literatura, analisar como os memes vêm sendo empregados na área de Ciências da Natureza. Trata-se de uma pesquisa exploratória, descritiva e bibliográfica, de abordagem quali-quantitativa, considerando como *corpus* da pesquisa artigos publicados em periódicos de Qualis A1, A2, B1, B2 e B3 da área de Ensino. A análise dos dados ocorreu à luz da análise de conteúdo proposta por Laurence Bardin. A revisão sistemática possibilitou a identificação de 6 artigos envolvendo o uso de memes em espaços formais, como escolas da educação básica e universidades; e não formais, tais como mídias sociais e museus. Os resultados apontam que os memes têm se mostrado de grande pertinência à aprendizagem em Ciências da Natureza, uma vez que atuam como catalisadores na difusão da Ciência, são de grande aceitação, ricos em significados, dinâmicos e atuais, além de corroborar com a formação científica dos participantes. Todavia, são incipientes os estudos nesse campo de investigação, o que revela uma necessidade emergente em se promover pesquisas e reflexões sobre esse recurso digital.

PALAVRAS-CHAVE: Memes. Recursos Multimodais. Revisão Sistemática. Ciências da Natureza.

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