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The influence of animations on what is and who does science

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ABSTRACT

One of the first types of entertainment that children have contact with is animated films, which are rich sources of information, learning, and influence for this audience, presenting educational potential and can impact the professional choice of future generations. However, scientist characters are often represented full of stereotypes, and many productions do not commit to approaching science with seriousness nor reflect true events. Therefore, this research aimed to analyze how science and the representation of a scientist are displayed in animated films, released between 2010 and 2020, by digitizing the synopses/plots cataloged in the Google search website and on the Internet Movie Database (IMDb) website, followed by the search for keywords related to Science, in addition to comparison with data obtained by ChatGPT, to identify animations with scientist characters. According to Google, during the evaluated period, 405 animated films were released, presenting the most popular ones as a result. ChatGPT showed no widely known science-related animated films from the same period. The IMDb website presented 3246 results, involving productions from different countries worldwide. Of the total, only 34 films demonstrated at least two keywords referring to science, of which only one production committed to portraying science in an educational fashion. Therefore, despite being a useful learning approach, there are still obstacles to effectively transforming this strategy into a scientific literacy instrument inside or outside the classroom.

KEYWORDS: science; scientist; animation; stereotype; classroom.

A influência das animações sobre o que é e quem faz ciência

RESUMO

Uma das primeiras modalidades de entretenimento que as crianças têm contato são os filmes de animação, os quais, por serem fontes ricas de informação, aprendizado e influência para esse público, podem apresentar potencial educacional e, inclusive, impactar na escolha profissional das futuras gerações. Entretanto, muitas vezes os personagens cientistas estão repletos de estereótipos, além de muitas produções não se comprometem a abordar a ciência com a devida seriedade e nem refletir eventos verídicos. Por isso, esta pesquisa buscou analisar como a ciência e a representação de um cientista são retratadas em filmes de animação, lançados entre 2010 e 2020, pela digitalização das sinopses/enredos catalogadas no buscador *Google* e no site *Internet Movie Database* (*IMDb*), seguida da busca por palavras-chave relacionadas a Ciência, além da comparação com dados obtidos pelo *Chat GPT*, para identificar animações com personagens cientistas. Segundo o *Google*, no período estudado, foram lançados 405 filmes de animação, exibindo, como resultado, os mais populares. O *Chat GPT* retornou que não existem filmes de animação relacionados à ciência amplamente conhecidos no mesmo período. Já o site *IMDb* apresentou 3246 resultados, envolvendo produções de diversos países do mundo. Do total, apenas 34 filmes exibiram pelo menos duas palavras-chave referentes à ciência, dos quais apenas 1 produção mostrou-se comprometida em representar a ciência de forma educativa. Portanto, apesar de ser uma abordagem de aprendizado valiosa, ainda persistem diversos obstáculos para a efetiva transformação dessa estratégia como ferramenta de alfabetização científica dentro ou fora da sala de aula.

PALAVRAS-CHAVE: ciência; cientista; animação; estereótipo; sala de aula.

INTRODUCTION

Since its invention, television has revolutionized how knowledge is acquired and entertainment is accessed. Nowadays, this is still the main source of information related to science for Brazilian citizens (MCTI&CGEE, 2015) and other Latin-American countries. Amidst the various programs and channels available, it is reasonable to believe that the content displayed influences learning. In that sense, children search for patterns to help them understand the world around them and that's why the stereotypes portrayed by characters can have a significant impact on the perceptions of the professions shown and consequently on the professional choices of future generations (Dos Reis, 2013). However, divulgation for children in Brazil is scarce, indicating that, although science is present, it does not catch this public's attention, as well as being not very representative for girls, which can reduce female participation in science, invalidating lack of aptitude as a reason for this scenario (Petropauleas & Rached, 2018).

Considering the access to television programs and the existence of several free and subscription-based streaming platforms, according to a survey done by Eurodata TV Worldwide and published by Folha de São Paulo (2005), Brazilian children spend on average 3,5 hours a day watching television. During this period, they are exposed to information that is not always appropriate for their age, which is why 82% of the parents of children between 2 and 10 years old who participated in a survey done by Pesquisa Globo in 2021 (GLOOB, 2021), on a national scale, related being concerned about their children being negatively impacted by inappropriate content on free streaming platforms and 83% fear that their children might be exposed to advertisement inappropriate for their age.

Taking into consideration the wide films and series catalog available on streaming, it is expected that children will be in contact with animated films, which are socialization agents, since they are the bridge that connects different cultures and knowledge (da Silva; da Cunha, 2017). Moreover, animation is defined as the action of creating movement perception (life) around what is static (inanimate) (Denslow, 1997). With that, animation refers to animated films, in which cartoons come to life, presenting motivation, soul and mind (Routt, 2007) and, therefore, can awaken children's interest in science and the scientific profession by bringing science closer to their everyday lives (Siqueira, 2006).

Several television stations invest in children's content and, especially, in animations for their regular schedule, however, there is a very big economic gap between public and cable channels in the country. For this reason, the stations with fewer resources invest in "recipes that work", i.e., they innovate less and more slowly, keeping the same standard of content so as to not lose their audience (Siqueira, 2006). Furthermore, teaching conveys views of science, technology and scientists which are very distant from the way scientific and technological knowledge is built and transformed (Cachapuz et al., 2005). Even though recent studies have indicated that the Brazilian population has broadened its vision of a scientist as a regular person with special training (CGEE, 2019), it is important to remember that the form in which science and scientists are represented in fiction is one of the main influences in public perception of these social actors (Pansegrau, 2008). On the other hand, streaming services present a

more diverse catalog, in general, without ads, but which is not accessible to the general public, because not everyone has the resources for it. That is why we question who these animations are created for – for the general public as a way to democratize knowledge or as a tool of profit?

OBJECTIVE AND PROBLEM QUESTION

This research has sought to identify how Science and scientist characters are represented in animated films released between 2010 and 2020 by analyzing the synopses and plots found in different search engines (Google search, IMDb – Internet Movie Database and artificial intelligence with ChatGPT). Additionally, this study also has the objective of identifying the stereotypes present in these representations, with special attention to gender inequality.

MATERIALS AND METHODS DESCRIPTION

To prepare this research, qualitative methodology was used through systematic mapping, with consultations to scientific articles aimed at analyzing animations with approaches and/or scientific characters as a pedagogical tool and discussion of stereotypes found in the years prior to the analysis.

For data collection, the Google search engine was used with the prompt “animated films 2010”, for instance, changing only the year searched. On the Internet Movie Database (IMDb) platform, an online cinema, television, games and music database which currently belongs to Amazon, a survey of all animated films released during the studied period was carried out. Finally, messages were exchanged with ChatGPT in its free version 3.5, which presents information up to 2021 in its database. Thus, questions such as “Was there any animated film with a scientist character in 2019?”, “Was there any unpopular animated film with a scientist character in 2010?” and “Is there another animated film released in 2020 that portrays a character as a scientist?” were asked.

After that, the synopses and/or plots of all animated films released between 2010 and 2020 found on IMDb were digitized, in which the synopses were normally written by the animations' producers and the plots were written by IMDb users. It was noted that, in many cases, the synopses and plots found were identical.

Finally, a search was carried out in both synopses and the plots, using keywords such as “science, scientist, laboratory, chemistry, physics, biology, experiment, research, researcher(s), investigation, scientific, invention, invent, invented, inventor, biologist, sociologist, anthropologist, psychologist and political scientist” and their respective English translations. From this search, animated films with at least two keywords were selected to be watched and analyzed, according to an analysis script model (Tables 1, 2 and 3), which had been previously elaborated using criteria adopted by other authors such as Berk et al. (2018), Reznik et al. (2019), Rosa, Maria et al. (2003) and Tomazi et al. (2009). Among the analyzed criteria, the potential for animated productions to be used as scientific dissemination and construction of social stereotypes was used.

Table 1

Model of technical sheet used in the analysis of each animation

Name	Image from the animation
Keywords:	
Length:	
Genre:	
Classification:	
Studio:	
Release Year:	
Popularization (IMDb):	
Box office:	
Available on:	
Available on YouTube: ( ) yes ( ) no. Price: If yes, is it classified as children's content: ( ) yes ( ) no	
Language:	
Subtitles available: ( ) yes ( ) no If yes, are they Youtube-generated: ( ) yes ( ) no	
Country of origin:	
Film location:	
Directors:	
Writers:	
It is a series or a spin-off: ( ) yes ( ) no	
Percentage of Google users who liked this film:	
Adaptation: ( ) yes ( ) no	
Based on a 'recipe that works': ( ) yes ( ) no If yes, which:	
Summary:	
Additional observations:	

Source: authors (2023).

The aim of Table 1 was to classify the technical details of the analyzed productions in order to provide comparisons between the films and the organization of technical information, such as the names of the screenwriters and directors, country of origin, accessibility, availability, presence of classic narratives, box office, popularization, among others. It was based on a similar model by authors Reznik et al. (2019).

Table 2

Model of the analysis of the science conception realized in each animation

Criteria		Observations
film timeframe:	( ) Past ( ) Present ( ) Future	
Science to which it applies:	( ) Human Sciences ( ) Nature Sciences	
Use/application of the research:	( ) Personal Use ( ) Social Use	
Scientific knowledge construction: Tomazi et al. (2009)	( ) Presents historica aspects in the construction of knowledge ( ) References other studies ( ) Presents collectivity in the construction of scientific knowledge ( ) Reveals the idea of a process ( ) Characterizes the error as "a trial" ( ) Doesn't reduce the research procedures to the empirical	
In the film, science is used for:	( ) Good ( ) Evil ( ) Both	
Conceptual mistakes: Berk et al. (2018)	( ) Emulative ( ) Associative ( ) Extrapolative ( ) Appeal ( ) Speculative ( ) Metonymic ( ) Anomalous ( ) Unchanged	
Additional observations:		

Source: authors (2023).

Table 2 had the purpose of investigating how science was portrayed in the cinematography. In this way, the analysis model produced by Reznik et al. (2019) was used as inspiration to identify the field covered (natural or human sciences), whether the science was covered in the past, present or future and the intention behind its use. The analysis of how scientific knowledge is conveyed in animation was done using the criteria adopted by Tomazi et al. (2009). Taking into consideration that scientists are frequently represented with classical stereotypes (wizard, crazy, distracted, etc.), according to Castelfranchi et al. (2008), the use of science for good or evil was included. Furthermore, the analysis of the conceptual mistakes was done using the criteria adopted by Berk et al. (2018).

Table 3

Model of analysis of the representation of scientist characters in each animation

Criteria		Observations
Are there any scientist characters:	( ) Yes ( ) No	
Gender:	( ) Male ( ) Female	
Is a person:	( ) Yes ( ) No	
Age: Reznik et al. (2019)	( ) Child ( ) Adult ( ) Teenager ( ) Elderly	
Character:	( ) Protagonist ( ) Antagonist	

	( ) Supporting Character, ( ) Appears in a single scene
Clothing style: Reznik et al. (2019)	( ) Casual ( ) Formal ( ) Uniform/ Lab coat ( ) No outfit
Psychological Characteristics: Reznik et al. (2019)	( ) Crazy ( ) Egoist ( ) Dreamer ( ) Angry ( ) Pessimist ( ) Needy ( ) Melancholy ( ) Normal ( ) Perfectionist
Is portrayed as a scientist: Rosa, Maria et al (2003)	( ) Humanized ( ) Fantastic ( ) Dehumanized ( ) Nerd
Has a physical disability:	( ) Yes ( ) No
Any syndromes:	( ) Yes ( ) No
Ethnicity: IBGE classification (2024)	( ) White ( ) Black ( ) Brown ( ) Indigenous ( ) Yellow ( ) Impossible to tell
Social life: Reznik et al. (2019)	( ) Team worker ( ) Independent worker ( ) Social life ( ) Isolated life
Social status	( ) A ( ) B ( ) C ( ) D ( ) E ( ) Impossible to tell
Renowned or acknowledged by people or society	( ) Yes ( ) No
Workplace Reznik et al. (2019)	( ) Laboratory ( ) Field ( ) Library / Files ( ) Home ( ) School ( ) Other
The workplace is organized	( ) Yes ( ) No
The character does other things besides research, such as housework	( ) Yes ( ) No
Investigation area Areas of knowledge table by CNPq (2024)	( ) Agricultural Sciences ( ) Biological Sciences ( ) Exact and Earth Sciences ( ) Human Sciences ( ) Health Sciences ( ) Social and Applied Sciences ( ) Engineering
Work tools Reznik et al. (2019)	( ) Observation ( ) Glassware ( ) Chemicals ( ) Test subjects ( ) Data-collecting

	( ) Reading ( ) Alternative
Additional observations:	

Source: Authors (2023).

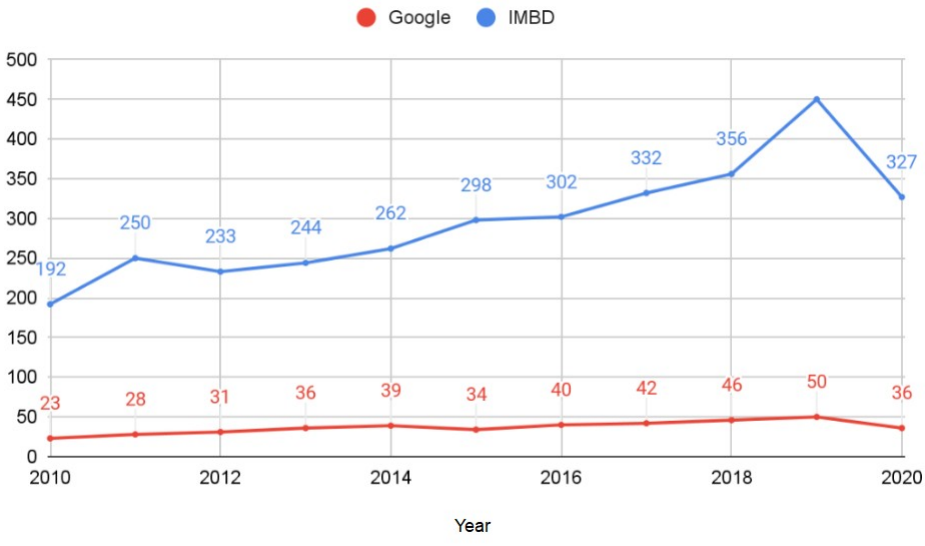
In order to produce Table 3, criteria adopted by Reznik et al. (2019) were also taken into consideration as well as age, clothing style, social life, workplace, psychological characteristics and work tools, seeking to identify and classify classic stereotypes. Besides that, the classification created by Instituto Brasileiro de Geografia e Estatísticas (IBGE) was used for ethnicity options and the areas of knowledge of Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) were used to establish the fields of work, in order to identify the racial and scientific diversity in the representations. The other classifications were added and/or modified to better understand the goals of this work, looking for stereotypes and female representation in the productions.

RESULTS AND DISCUSSION

Although Google is the biggest search engine used worldwide, the search for the number of animated films released between 2012 and 2022 turned up 405 results, while the IMDb platform indicated the release of 3246 films in the same period searched (Figure 1). Thus, we concluded that Google brings up superficial information as results, mostly American productions. That way, the amount of films in the Google search results corresponds to only 12,5% of the films in the IMDb catalog.

Figure 1

The difference in number of animated films between 2010 and 2020 on Google and IMDb

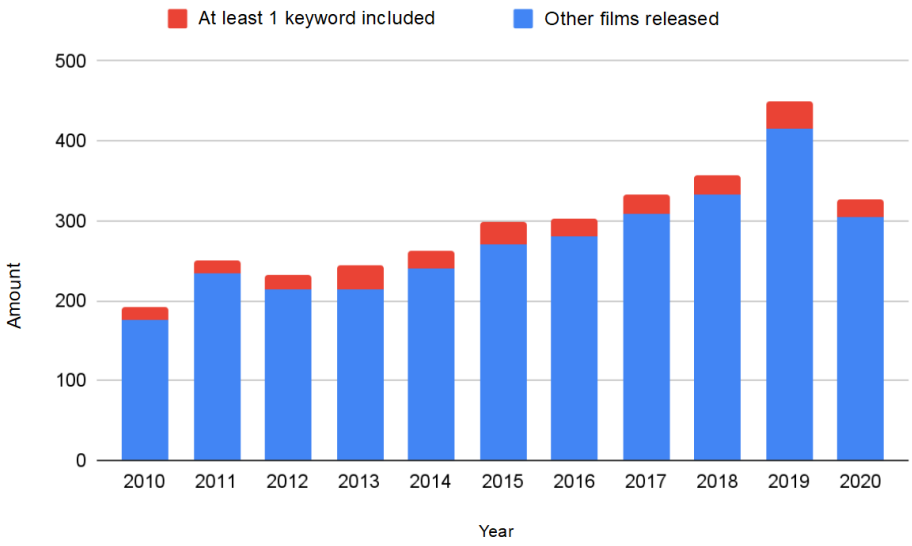


Source: authors (2023).

As observed in Figure 1, the amount of animated films tends to go up as time goes by, ignoring the atypical year of 2020 due to the COVID-19 pandemic, during which many producers decided to postpone their releases. However, analyzing the number of animations released year after year with the filtered keywords, we didn't find the same trend of growth or a strong relation, considering the big variation of this data. Thus, the theme related to science isn't rising or highly popular in animated films, as can be observed in Figure 2.

Figure 2

Amount of films that presented a keyword in relation to the total of animated films released yearly between 2010 and 2020



Source: authors (2023).

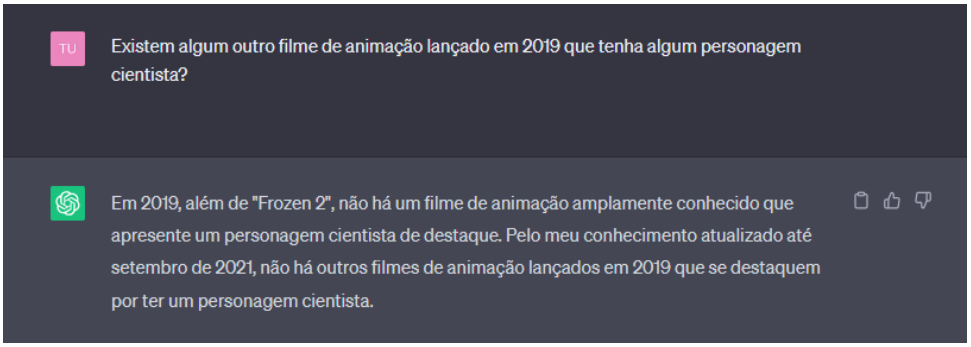
According to Figure 2, the number of animations released rises yearly, but there isn't a correlation with the number of animated films about science. In general, the animated films that bring at least one keyword related to science vary from 6,4 (2011) and 8,0% (2014), in relation to the total of films released every year. The years 2013 and 2015 were particularly remarkable, with 12% and 9,4% of films involving at least one of the keywords. Still, it is a consensus that films are valuable resources for scientific education, since they discuss science from a broad perspective, offering connections with everyday social life and possible imaginable futures (Piasi, 2015), the same way as cartoons can be used as a didactic alternative for children's scientific education (Tomazi et al., 2009). Moreover, it is important to analyze how science is seen by children because these are indicators of how the representation of science and technology is seen by the society that is common to adults and to the scientific culture as a whole (Castelfranchi, Yurij et al, 2008).

The search for films using artificial intelligence (AI) showed that not only Google considered famous films, because, using ChatGPT, when asked about released animated films, this returned between 2 and 10 films, regardless of the yearly searches. Even when asked if there were any other animated films released in a certain year in which there was a scientist character, the AI would answer that

"there aren't any widely known animated films with a relevant scientist character (Figure 3).

Figure 3

Dialogue with ChatGPT about the existence of other films released in a certain year with scientific characters



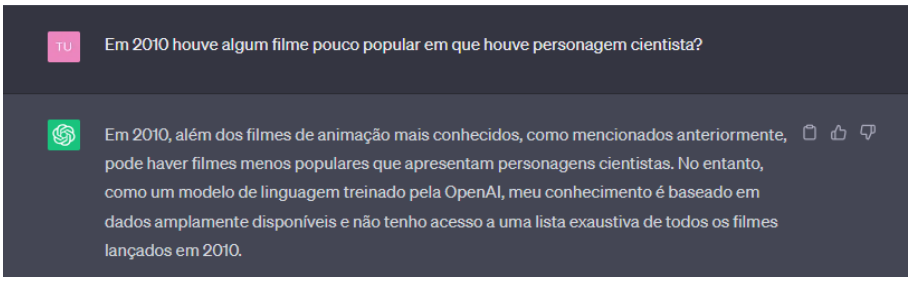
Source: ChatGPT. Access on May 25th (2023).

It is reasonable to infer that the spotlighted productions are not necessarily the "best" productions or have a fun and educational approach, but it is normally the productions belonging to large producers that receive publicity and marketing investments. Therefore, the population must be aware of the marketing games being played behind children's content, as in many cases, commercial advertisements and the sale of products related to animated films are used, with children as the target audience (Siqueira, 2006). In this context, Siqueira (2006) adds that the interest in purchasing these products can alienate the child from the social, economic and cultural 'reality' in which they are inserted.

In the case of ChatGPT, we imagine that only widely known animations enter its database, which prevents it from returning information about lesser-known animations, but which could address the topic of science and feature a scientist character. Just as the artificial intelligence itself recognizes, when asked if "In 2010 were there any unpopular films in which there was a scientist character?" (Figure 4), it brings up the precariousness of its access to some information. Furthermore, the AI still finds it difficult to identify scientist characters, as it constantly returned answers with characters who had no connection to science, and afterward corrected itself when asked about the role of the character in the animation with answers such as, "I apologize for the previous response. There was a mistake in my explanation. Terry from the film 'Soul' is not considered a scientist."

Figure 4

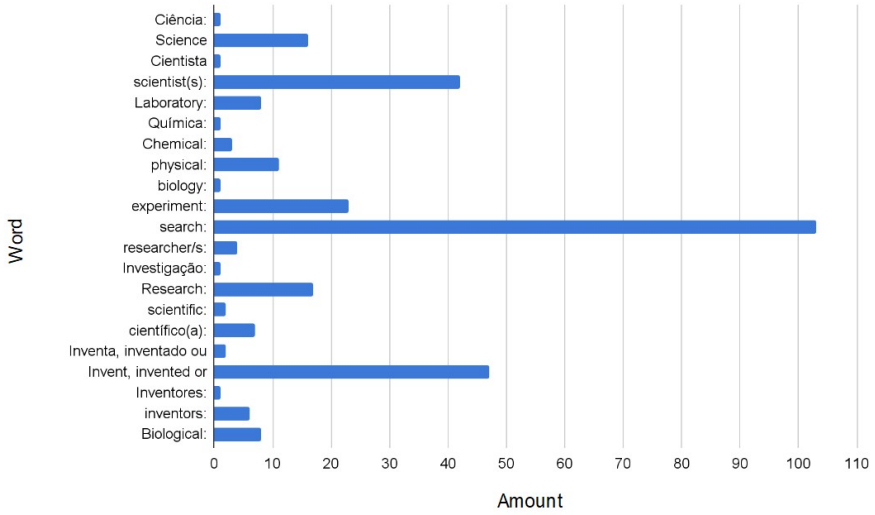
Dialog with ChatGPT about the existence of less popular films with scientist characters



Fonte: ChatGPT. Access on May 25th (2023).

Regarding the number of synopses or film plots that contained some of the keywords searched, of the animations cataloged on Google, only 13 had any of the terms. The IMDb website found 257 animations, of which the word “search” was the most recurrent, appearing in 103 films, followed by the word “invent” (47 films), “scientist” (42 films), “experiment” (23) and finally “science”, present in 16 films (Figure 5). Just like the research carried out by Tomazi and collaborators (2009), the terms “sociologist”, “anthropologist”, “psychologist” or “political scientist” were not found in either Portuguese or English. In the world of cartoons and animations, these do not seem to be recognized as science professionals, probably because they do not fit the stereotype of scientists promoted by the media, thus restricting the scientific process to a few areas of knowledge such as Chemistry, Physics, Biology and Technology. This is justified by the appearance of the words “química”, “chemical”, “physical” and “biology” in a total of 16 animations, which is equivalent to 0.5% of all animations cataloged by IMDb. Despite this, the words in Portuguese “physics”, “biology”, “biological”, “laboratory”, “experiment”, “research” and “researcher/s” also did not appear in any of the synopses and/or plots of the animations researched. **Figure 5**

Number of times each keywords shows up in animated films (2010-2020), considering at least one result



Source: authors (2023).

The appearance of any of these words (Figure 5) does not necessarily indicate the presence of science or a scientist character in the animation. Therefore, in order to choose the animated films that would be watched and analyzed, a search was carried out using at least two keywords, with the intention of filtering as much as possible the films that met the objectives of this work. Using this filter, 34 animated films were found (Table 4), with 1 film having been released in 2016, 3 films in 2017, 4 in 2018 and 6 in 2019, highlighting that, in this period, the increase in films with keywords coincides with the increase in films released year after year, as seen in (Figure 1). It is worth noting that among the more than 3 thousand animations released, only one had three of the keywords and was available to watch on a streaming platform, the film "Leo Da Vinci: Mona Lisa Mission", an Italian production.

Table 4

Animated films released between 2010 and 2020 with at least two keywords in the synopses or plot

Year	Words	Name
2010	Physical & Science	Brijes 3D
	Scientist & Science	Era
	Search & Biological	Winx Club 3D: Magical Adventure
2011	Scientist & Inventors	A Monster in Paris
	Scientist & Invent	Dace Decklan: Private Eye
2012	Search & Laboratory	Gusukô Budori no denki
2013	Scientist & Science	Sid the Science Kid: The film
	Scientist & Science	El extraordinario viaje de Lucius Dumb
	Physical & Experiment	1-9
	Search & Research	Aura: Koga Maryuin's Last War
	Scientific & Research	Game Over
	Scientist & Science & Research	The Mind Machine
2014	Scientist & Experiment	Sleep tight my baby, cradled in the sky
	Scientific & Research	Deadstar the film
	Search & Invent	The Somnambulists
2015	Scientist & Experiment	Ajin Part 1: Shôdô
	Scientist & Search & Invent	April and the Extraordinary World
	Scientific & Research	The Strange Eyes of Dr. Myes
2016	Scientist & Experiment	Ajin: Shôtotsu
2017	Scientific & Experiment	Big Pai, Big Filho
	Physical & Search	Travelers
	Scientist & Cientista & Inventa	Kikoriki – Legend of the Golden Dragon
2018	Inventa & Experiment	Boonie Bears: The Big Shrink

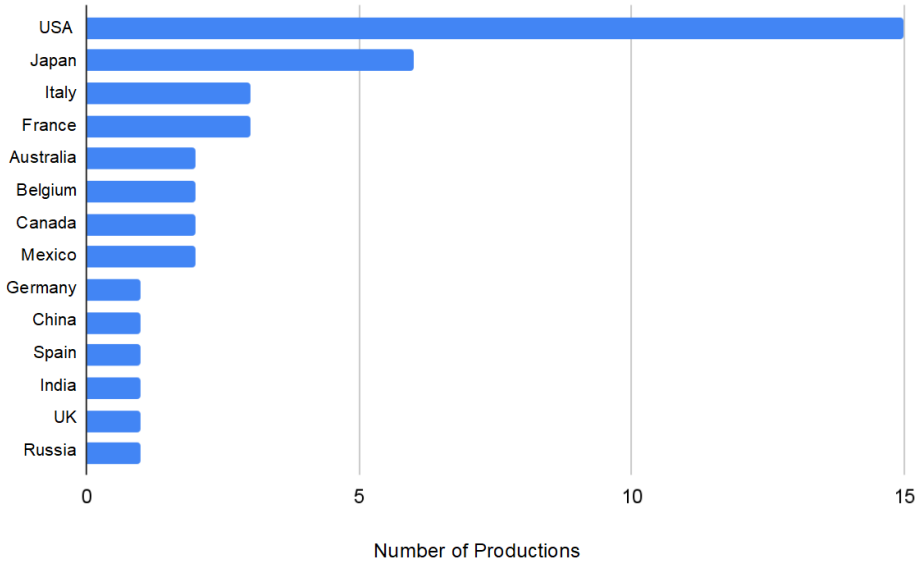
	Physical & Experiment	Hippopoetess
	Science & Search & Invent	Leo Da Vinci: Mona Lisa Mission
	Science & Scientist	Space Bear and the Love Bomb
2019	Invent & Chemical	Chemical Intervention in (film) History
	Search & Biological	The Big Wish
	Science & Científico	Investigation 13
	Scientist & invent	Spies in Disguise
	Search & Research	Paird
	Scientific & Experiment	Pokémon: Mewtwo Strikes Back - Evolution
2020	Scientist & Research	Conflicts of Green
	Scientist & Science & Research	The Adventures of Flare

Source: authors (2023).

According to the tabulation of the countries of origin of the films analyzed, none of these animations is a Brazilian production (Figure 6), which makes it difficult to use them as a teaching methodology, aiming to comply with law nº 13,006 of 2014, which says that Brazilian basic education schools must show two hours of national cinema per month, as a complementary curricular component, integrated into the school's pedagogical proposal. We understand that this law could also have the intention of using animations as a strategy to improve science teaching and learning, as animations can arouse students' interest in scientific content (Pereira, 2015). However, films do not guarantee learning by themselves, so it is up to the teacher to mediate the use of audiovisual content to promote students' scientific literacy (Bueno & Silva, 2018), but despite being a methodology that pleases students, many Teachers do not have enough preparation and time to elaborate discussions and mediate the dynamics (Berk et al., 2018), in addition to the lack of infrastructure in Brazilian public schools, which discourages the use of the tool as an educational method.

Figure 6

Number of animation productions with at least 2 keywords per country, including productions carried out in partnerships between countries



Source: authors (2023).

Thus, in relation to the number of films produced per country (Figure 6), it is observed that only 3 countries in America produced any animations with at least 2 keywords in the synopsis or plot, the pioneer being the United States of America (USA), with 15 films, followed by Mexico and Canada with 2 animations each. The absence of South American countries was observed, restricting the influence of a scientist and science representation to the North American point of view (Figure 6)

Regarding the availability of these animations, of the 34 that have at least 2 keywords in the synopsis or plot, 12 are available on some licensed platform, whether free or via subscription, with only 11 being dubbed or with subtitles in Portuguese (Table 5).

Table 5

Animated films released between 2010 and 2020 with at least two keywords available on a licensed platform

Year	Words	Name
2010	Physical & Science	Brijes 3D
	Search & Biological	Winx Club 3D: Magical Adventure
2011	Scientist & Inventors	A Monster in Paris
2012	Search & Laboratory	Gusukô Budori no denki
2013	Scientist & Science	Sid the Science Kid: The film
	Scientist & Science	El extraordinario viaje de Lucius Dumb
2014	Scientific & Research	Deadstar the film

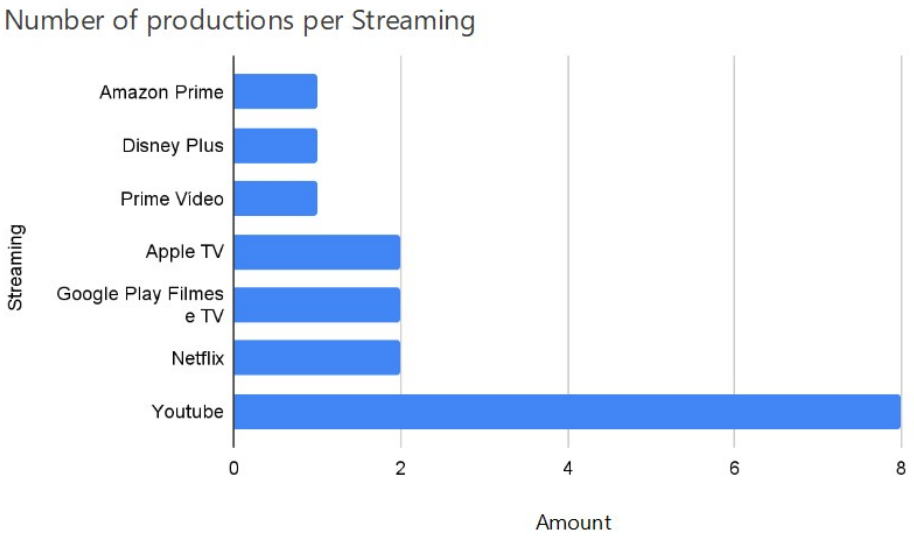
2015	-	-
2016	-	-
2017	-	-
2018	Science & Search & Invent	Leo Da Vinci: Mona Lisa Mission
	Inventa & Experiment	Boonie Bears: The Big Shrink
2019	Science & Científico	Investigation 13
	Scientist & invent	Spies in Disguise
	Scientific & Experiment	Pokémon: Mewtwo Strikes Back - Evolution

Source: authors (2023).

Of the 12 animated films presented in Table 5, 10 are available for free on YouTube and 2 are exclusively available via subscription-based streaming, such as Amazon Prime, Netflix, Disney Plus and Apple TV. In Figure 7 below, it is possible to observe these relationships. It is worth mentioning that, although the IMDb platform categorizes the film Investigation 13 as an animation, the footage does not fit into Denslow's (1997) classification as the action of generating the perception of movement (life) in what is static (inanimate) and, for this reason, it was not considered for the analysis of this work. Furthermore, the production Boonie Bears: Adventure in Miniature, although available for free on YouTube, is only in Chinese and without subtitles, which made it impossible to analyze.

Figure 7

Number of animated films available via streaming



Source: authors (2023).

Although most of the animations were found for free on YouTube, only 2 of the 8 available were in Portuguese, 5 were in English and 1 in Spanish, but they have automatic subtitles from the platform. However, one animation, “Boonie Bears: Miniature Adventure”, was only in Chinese and without subtitles, which made the production impossible to analyze. Another obstacle encountered was

that, to watch these films for free, the user is exposed to various commercial advertisements, such as banners and short videos that appear at the beginning or in the middle of the screenings.

It is worth mentioning that, in Brazil, there is still no regulation for the use of these advertising tools. Although there are clauses in the Consumer Protection Code (CDC) in article 37, section III, second paragraph, which states that, "advertising that takes advantage of the child's deficiency in judgment and experience is abusive" (BRAZIL, 1990) and in article 39, section IV, fourth paragraph, "preying on the weakness or ignorance of the consumer, taking into account their age, health, knowledge or social condition, to impose products or services on them" (BRAZIL, 1990), companies still take advantage of children's lack of persuasive perception to encourage early consumerism for their products.

On the other hand, there are animations such as "Pokémon: Mewtwo Strikes Back: Evolution" and "A Monster in Paris", which were available on the platform only as a paid option, so if the user wanted to watch them, they would have to pay at least R$6.90. According to data from streaming platforms collected on August 10th, 2023, in order to watch animations that were not free and/or dubbed in Portuguese, the user would have to pay amounts ranging from R$6.90 to R$55.90 (Tables 6 and 7).

Table 6

Cost by film for each streaming platform

Name	Price per film
Youtube	R$6.90 - R$9.90
Google Play filmes e TV	R$ 6.90

Source: data collected from streaming platforms on August 10th (2023).

Table 7

Monthly cost per streaming platform

Name	Price per month
Netflix	R$18.90 - R$55.90
Disney Plus	R$ 33.90
Amazon Prime	R$ 14.90
Apple TV	R$ 14.90
Prime Vídeo	R$ 14.90

Source: data collected from streaming platforms on August 10th (2023).

Due to the high cost (Tables 6 and 7) or the lack of financial resources to cover these expenses, many children end up consuming only content available on free platforms, the same ones that have low capital availability to innovate and for this reason stick to "recipes that work" to maintain their audience, thus creating an unintentional stereotype, and as this type of entertainment is the main source of information in the macrocosm for the growing individual, the public with little access to other sources of information will tend to give importance to what is being consumed, even if they are not aware of it (Siqueira,

2006). In this way, inequality in access to production can generate social inequality in the career choices of future generations.

According to IMDb data on the worldwide box office collection of each film, among the 13 mentioned, with the exception of “Sid the Science Kid: The film” and “Investigation 13”, for which no available data was found, the animation “An Animal Spy” - a production by Blue Sky Studios, Chernin Entertainment and Twentieth Century Fox Animation, in 2019, was the highest-grossing production, reaching 171,616,764 dollars and a profit of more than US$71 million. However, the amount invested, collected and profited from this animation does not compare with the highest box office of each year (Table 8), in which we can see that from 2010 to 2020, only one of the biggest box offices was an animation, "Toy Story 3", released in 2010, reaching over US$1 billion at the worldwide box office.

Furthermore, 90% of the highest-grossing productions each year are films that have a sequel or that already have an old version, such as "Beauty and the Beast" - a classic French fairy tale. The only exception is in 2020, the first year of the COVID-19 pandemic, in which several producers, especially the larger ones, chose to postpone the premiere of their productions until the following year, which impacted the ranking of highest worldwide box office that year (Table 8). The results indicate that the film plots that follow the “formulas that work”, such as superhero films, for instance, are often the highest-grossing films worldwide. Furthermore, it is important to pay attention to how science fiction is portrayed in films, as they often propagate the vision of an ideal science, hiding values, especially those of a social nature (Ferreira, Barbosa, 2018)

Table 8

Classification of highest-grossing films between 2010 and 2020

Yes	Highest-grossing films	Box office in US$	Animated film	Is it a sequel or a remake	Site
2010	Toy Story 3	$1.067.316.101,00	yes	yes	O Globo
2011	Harry Potter and the Deathly Hallows	$1.342.359.942,00	no	yes	Exame
2012	The Avengers	$1.520.538.536,00	no	yes	Veja São Paulo
2013	Iron Man 3	$1.215.577.205,00	no	yes	Exame
2014	Maleficent	$759.853.685,00	no	yes	Uol
2015	Star Wars: Episode VII – The Force Awakens	$1.671.537.444,00	no	yes	Portal Geek
2016	Captain America: Civil War	$1.155.046.416,00	no	yes	Revista Forbes
2017	Beauty and the Beast	$1.266.115.964,00	no	yes	Omelete
2018	Avengers: Infinity War	$2.052.415.039,00	no	yes	Omelete
2019	Avengers: End Game	$2.799.439.100,00	no	yes	Omelete
2020	The Eight Hundred	$461.421.559,00	no	no	Categoria Nerd

Source: Categoria Nerd, Exame, IMDb, O Globo, Omelete, Portal Geek, Revista Forbes, Uol e Veja São Paulo (2023).

Regarding the 10 highest global box office grosses annually, of the 110 productions, only 30 are animations, which means that approximately 27% of the largest productions are animations. Furthermore, none of them has two keywords related to science in the plot or synopsis, which reinforces the data seen in Figure 2that animated films do not have a strong relation to the theme of science.

With this, it can be inferred that films, including animation, are consumed by society. However, producers need to pay attention to the format, to avoid reinforcing a stereotype of scientists and how science is done.

ANALYSIS OF THE ANIMATIONS

Among the selected animations, ten were analyzed, namely “Winx Club 3D: Magical Adventure”, “Brijes 3D”, “A Monster in Paris”, “Gusukô Budori no denki”, “Sid the Science Kid: The film”, “The extraordinary journey of Luciu Dumb”, “Deadstar the film”, “Leo da Vinci: Mission Mona Lisa”, “Spies in Disguise” and “Pokémon: Mewtwo strikes back: Evolution”, highlighting “Winx Club 3D: Magical Adventure” and “Sid the Science Kid: The film”.

Even though all selected animations meet the requirements established by this research to be analyzed, only 2 productions proved to be relevant to the study. The first is "Winx Club 3D: Magical Adventure", an Italian production launched in 2010 by the companies Medusa film & Rainbow S.p.A and stands out for being the only animation with 100% female protagonists. However, it does not approach science in a didactic way nor does it have a scientist character. The second is the American animation "Sid the Science Kid: The film", released in 2013 and produced by producers BEL AIR-Pictures, The Academy of Motion Picture Arts and Sciences film Archive and Twentieth Century Fox Animation, stands out for being the only production with an educational purpose aimed at children's learning, mainly because it has protagonists ranging from 4 to 12 years of age.

Furthermore, the animation “Sid the Science Kid: The film” also features a cartoon version, which also has an educational focus, with this film being an adaptation of the cartoon. Currently, the content is only available for free on YouTube, with audio in English and automatic subtitles in Portuguese. Although it has an educational approach, the animation received a relatively low rating from users on the IMDb website, with only 4.3 out of 10 reviews indicating that they liked the content, which demonstrated that, despite having educational content, viewers still have a preference for animations that portray science in a fantastical and extravagant fashion, often using it simply as an entertainment tool.

The film tells the experience of four children who took part in a science competition and received an invitation to visit the museum developed by scientist Dr. Bonabodon, which was yet to be opened. Inside the museum, they learn concepts of physics, logic, probability, history and biology, from practical and interactive experiences. However, a problem with one of the robots, a tour guide, makes them collaborate to solve a dilemma and save the museum. With the film ending, it was possible to understand that it is possible to become a scientist at any age, and the importance of teamwork is highlighted as superior to individual

effort. The song "We're a Team of Scientists", played in the film, reinforces the message that children must join forces and work as a team to advance in the field of science. After all, the path is clear: together, all for one and one for all, as emphasized in the song.

A striking feature of this animation is the age range of its protagonists, which varies between 4 and 12 years old, encouraging them to continue developing and testing their hypotheses, indicating that there is no age limit for becoming a scientist. However, although the animation has significant educational potential, promotes gender equality in the representation of its protagonists and breaks the traditional expectations of scientists always wearing lab coats instead of casual clothing, it still presents stereotypes regarding the character Dr. Bonabodon, since he is represented as a white man with spiky hair isolated in his work, responsible for building the museum, the robots and conducting all the research alone, as he emphasizes in one of his lines. This, in turn, perpetuates the stereotypical idea of a scientist to children. However, this view of the scientist is not a new perspective, according to studies carried out more than 60 years ago by Margaret Mead and Rhoda Métraux (1957), in which for American students the figure of the scientist was characterized as an elderly white man in a lab coat and glasses who works alone in a laboratory and is mentally classified as crazy.

As this is an educational film, it stands out for avoiding conceptual errors in the scientific approach. Furthermore, it builds knowledge using historical elements, such as the dinosaur exhibition, incorporating references to other fields of study, thus promoting interdisciplinarity, with concepts from mathematics, physics, technology, biology and others. The film also conveys the idea that science is an ongoing process and accessible to everyone, encouraging children to become scientists. It is important to note that the film characterizes errors as "attempts" and not as failures, promoting the idea that it is okay to have incorrect hypotheses, as long as there is an effort to learn. Furthermore, the animation does not simplify the research procedures to mere empiricism, demonstrating detailed studies in the creation of the museum and its functionalities. Thus, science is portrayed as a tool for the good, involving practical experiments, based on observation.

Another interesting aspect of this animation is the representation of the school environment. Initially, the children carry out their research both at home and at school, however, the film does not distinguish these environments from everyday life. The school is depicted without laboratory equipment or glassware, consisting only of books and common tables. This approach serves to convey the message that there is no specific place for scientific practice, but rather that any environment can be suitable for developing, testing and concluding hypotheses.

Therefore, although there are films that address science in an educational way and promote gender equality, such productions are still scarce and difficult to access, since only one of the more than three thousand animations released in the period studied features elements of science in an educational way committed to transmitting accurate facts, demonstrating a gap in Brazilian and international cinematography.

CONCLUSION

Animated films represent one of the first digital entertainment experiences and access to diverse information for children. Therefore, this tool has the potential to play a crucial role in promoting science teaching and learning from childhood. However, several barriers make it difficult to use this resource, such as the lack of teacher training, the lack of infrastructure and the scarcity of films that address scientific themes or feature scientist characters, especially in the Portuguese language. When scientist characters are portrayed, it is common for them to be marked by stereotypes that perpetuate negative aspects, such as social isolation or individual work. Furthermore, female representation in this field is limited or practically non-existent, reflecting gender disparities in scientific and technological areas and highlighting the lack of encouragement for girls to pursue careers in these fields.

However, the lack of female representation is not the only challenge, the scarcity of productions from Brazil and other Latin American countries is also notable. This means that most productions are concentrated in the northern hemisphere, especially in the United States, creating a regional stereotype. Despite these obstacles, access to these animations is viable, especially through the free YouTube platform, despite the low quality of its automatic subtitles. Therefore, although animations have significant potential for teaching science, it is essential that producers of animated films understand the importance and impact that their productions can have on children's education and learning, in addition to making their productions accessible, both financially, so that teaching through cinematography is democratic, and for physically, such as the implementation of subtitles and dubbing in Portuguese. In this way, animated films could be used as tools that contribute to the teaching and learning process, inside or outside the classroom.

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NOTES

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