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Edutuber and Gender in STEM

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Abstract: The gender gap in the field of STEM (Science, Technology, Engineering and Mathematics) is nothing new. Recent research warns of this through programs and initiatives that use Information and Communication Technology (ICT) as a resource to reduce this gap. However, new questions and some areas of concern are arising out of the mass use of digital repositories. The possibility of consuming and producing video (prosumers) in these digital ecosystems brings to light the prejudices and stereotypes in these fields through their content. Considering the YouTube repository, this research analyses the edutubers on 81 STEM channels from a gender perspective in 190 immersions. Through a critical approach, oriented towards change for social transformation, an exploratory and descriptive paper has been written. It employs a mixed quantitative–qualitative method. The results are described in the form of four descriptive grids about edutuber environments where an evident gender gap in the STEM edutubers can be observed, and guidelines are subsequently outlined to attempt to eliminate it. It is concluded that the educational resources offered by YouTube are popular and have a significant impact on the young population, but these resources inherit past behaviours that also entail a new risk associated with the use of ICT.

Keywords: social responsibility; digital technology; equal opportunity; educational video; science for citizens; science learning

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1. Introduction

Although some progress has been made in the last forty years in gender equality in the sciences [1], the gender gap in Science, Technology, Engineering and Mathematics (STEM) education is nothing new [2], and neither is the interest in stereotypes in STEM education [1–6]. Research today in England [1,2,4], Hong Kong [5], Wales [3], USA [6], Finland, Norway and Russia [7] or Spain [8] focuses on the gender gap in STEM fields. These studies [1,4] highlight the fact that girls see STEM subjects as something for intelligent, brilliant, brainy, smart, non-nurturing and geeky people. Their vocational orientation does not fit in since they see STEM subjects as not very glamorous or feminine [1,4]. STEM subjects are incompatible with gender identity, and STEM-related professions are associated with loneliness [6]. Furthermore, social class, ethnicity and gender associate participation in STEM careers with further education [2]; therefore, including them in the educational syllabus from an earlier age is recommended [2,6,8].

Opportunities to relate them to young, feminine models are needed, where communities take part and communication and gender equality in STEM can be improved [3]. In the USA, gender inequalities arise at the ages of 6–7 years when identifying with STEM, and therefore, in addition to the central role of self-representation affected by such stereotypes, there is under-representation [6]. In Luo et al. [5], STEM stereotypes are seen to affect career interests through self-sufficiency and the expectations of results with dissimilarities between the "I" and the STEM career caused by these stereotypes.

There are currently programs and initiatives that take Information and Communication Technology (ICT) as a resource to narrow the gender gap. In Europe, 16 countries engaged in the SUPERCOMET2 project [9], and the BeTech! project is also following the same path [7], as is the GEM project [8]. Nevertheless, participation in the sciences in underrated sectors [2] must increase; government institutions warn about this [3], and there are calls for such action from international organizations [10–12]. Women approach STEM subjects very differently in regard to the use of ICT [7]. Today, gender biases and stereotypes are amplified and ongoing in girls, and there is algorithmic discrimination in job advertisements and recruitment and double marginalization in facial recognition technologies in regard to gender and colour of skin [12].

In Spain, female creators of audiovisual content do not even account for 15% of this ecosystem [13]. The prototype for disseminating science on YouTube is a young man with further education [14], and the gender gap between women and men in digital audiovisual creation is more than evident on YouTube in the Spanish speaking context [13,15–21]. The solution is to offer and provide other educational sources, outside of schools, that show just how exciting STEM subjects can be and to meet the people who are involved in them [5,7]. The creative possibilities regarding the production of educational content offered by YouTube guarantee attractive spaces, influential scenarios and popularity among preadolescents and adolescents [13,21–24].

Even so, the use of digital ecosystems, such as YouTube, has its pros and cons. The possibility of consuming and producing video (prosumers) is transferring gender biases, prejudices and stereotypes to this ecosystem through the social content of digital dissemination and education [13,23,25]. Furthermore, there is a void when analysing the channels through educational contexts in regard to gender. Analysis processes that go beyond the number of subscribers and views, such as ones that are centered on popularity and statistical rankings, are required. Along these lines, research on the presence of women in STEM subjects is required. In the Hispanic YouTube scenario, the gender gap between female and male creators of digital audiovisual content is obvious, whereas the European Parliament, in its resolution 2017/2210 (INI) on 17 April [11] (p. 14), urged its member states to design and implement programs to improve the capacities of women in STEM subjects.

It should be recognised that in an educational context, the evolution of the sex–gender device goes beyond the normative male–female binomial. For example, Jenzen [26] amplifies the term trans to include transgender and genderfluid, genderqueer, intergender and other variants. In this sense, Regueira et al. [27] pointed out that social networks can disseminate gender roles, perpetuate and reproduce power–knowledge relations and maintain gender stereotypes. This can lead to marked differences in identity expression, which can put gender equity at risk. Jenzen [26], amplifying the term trans, shows how transgender youth resist the prescribed user protocols of mainstream social networking sites and employs pragmatic strategies for navigating a binary gendered online world.

During adolescence, the consumption and production of digital content, as well as the underlying interactions, can influence the construction of identity [28]. It is important to note that this process can also perpetuate stereotypes and reinforce gender roles [29]. Regarding academic activities, it is worth noting, for instance, that out of a population of 1020 secondary school students in Galicia (Spain), cisgender youth are more interested in video content than gender-normative youth, and more cisgender female adolescents use this content than cisgender male adolescents [29].

The appropriateness of this work is evidenced mainly by the contributions of the OECD, the UN and UNESCO. In addition, it is worth recalling that Sustainable Development Goal 4 (SDG 4), together with SDG 5, addresses inclusive education and quality education regarding gender equality in the UN's 2030 Agenda. As stated in the last report, there is not enough progress being made today towards achieving the Sustainable Development Goals [30].

According to the Organization for Economic Co-operation and Development [31], women are under-represented in the Science, Technology, Engineering and Mathematics

(STEM) fields, with the gender gap widening over the last decade. Looking for solutions, the UN recommends integrating technology with teacher training [32], which involves focusing on what teenagers look for on YouTube, what they find, how they find it and what happens (content, aesthetics, gender representation, subject matters, interactivity and dynamics). This research focuses on all of these aspects that appeal to formative content and, by extension, educational content, which has a significant impact on young people. Sáinz [33], who was invited by the United Nations, highlights that didactic materials must be designed to help teachers make women's contributions to STEM more visible, and female teachers of STEM subjects should be made more visible as well. The UNESCO report [34] concludes that gender bias in technology needs urgent attention.

2. Materials and Methods

On the basis of the YouTube repository, this research paper analyses edutubers from a gender perspective in STEM education. An empirical, exploratory, and descriptive study is offered [35] (p. 412) and is aimed at change for social transformation. A triangulation of methods is employed [36–40]. Virtual ethnography is afforded [41–44], and a literature review [35] and an analysis of content with qualitative grills and word clouds is conducted [45–56]. One researcher (digital ethnologist) was used to collect information, which ensured that the methods that were to be triangulated were always used in the same way in all observations.

The procedure is shown in Figure 1. We proceeded on the basis of a non-probabilistic sample and convenience until data saturation. An iterative process of virtual ethnography was applied (Figure 1). The three instances of digital ethnography interspersed with a literature review and content analysis motivated the selection of the channels.

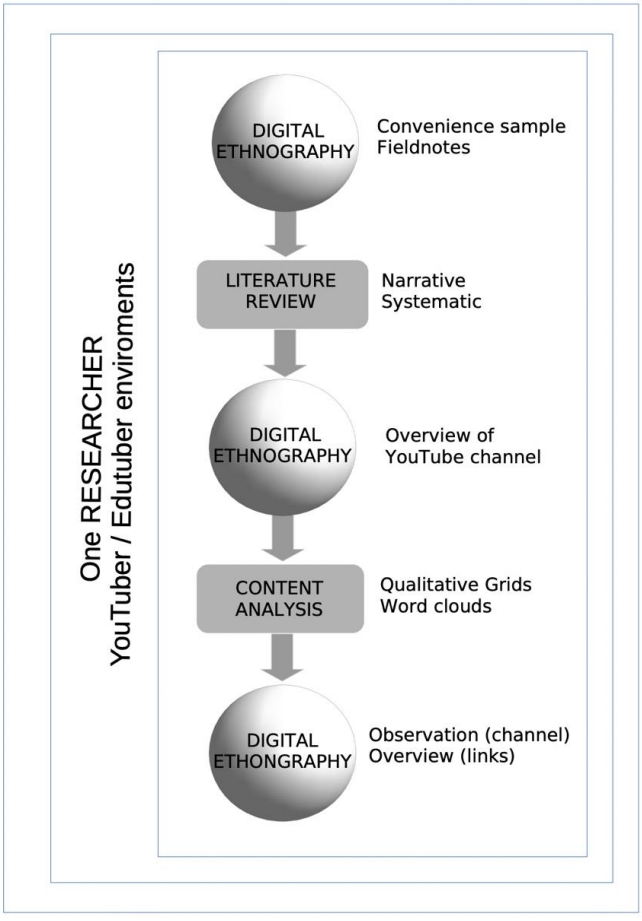

Figure 1. Methodology. Procedure for obtaining the sample of work channels and motivation for the choice.

Finally, the analysis took into account 117 channels that were sorted ethnographically. From that sample, 81 were not repeated and 36 were due to the fact that links to those channels from others were of interest. A total of 190 immersions were made, of which 151 were in specific videos, and 39 were related to the general content of the channels.

2.1. Objectives

With the objective of exploring the creations of female edutubers, their audiovisual creations were reviewed to observe the situation in the YouTube digital ecosystem. To achieve this, the general objectives were defined as (a) describing the spaces of edutubers and (b) describing the content of female edutubers in particular and in further detail.

2.2. Instruments

As this is a highly qualitative research study, digital field notes, memos and reports were used to create four qualitative matrices. In this study, they are presented in the form of tables arranged in rows and columns. These grids are functional and versatile for sorting information. In addition, they make the process more robust and make data collection and analysis more consistent while providing flexibility and increased dynamism to the research. Qualitative matrices are research-action tools that are useful in establishing types that allow for the description of social phenomena [46] (pp. 107–113) and are necessary in the planning of projects that analyse participation, engagement and social action alternatives in a qualitative way [57] (pp. 108–124) and [35].

2.3. Procedure

The first virtual ethnography analysis that was carried out involved immersions in channels. An immersion in a channel is defined as the video through which exercises are carried out to acquire basic knowledge of Physics and Mathematics in the first year of a Physics degree at a university. The grid under consideration was built showing binary male/female data (see Supplementary Materials). Table 1 summarises the immersions in channels in four categories, namely the note (digital field), the number of videos (total number of videos viewed), the name (title given to the saved document as a note) and the date (last time a URL was saved).

Table 1. Learning content. Subject "Physics and Mathematics for year one on Physics degree". Categories: note, videos, name and date.

Note	Videos **	Name	Date *
1	71	Introduction to the Mechanical Universe	23 November 2021
2	8	Algebraic Expressions/Coursera	16 September 2021
3	6	Learning numeracy	16 September 2021
4	44	Science Factor	29 May 2021
5	1	Learning trigonometry	12 April 2021
6	11	MRUA MRUV. Linear motion	7 April 2021
7	3	Dimensional analysis	5 April 2021
8	4	Physics Course: Motion	5 April 2021
9	1	Complete class of probability from scratch	9 March 2021
10	2	Route of particles in LHC	12 February 2021

* Last day the note was checked. ** Only the URLs linked to YouTube videos were counted.

Secondly, the virtual ethnography process entailed in-depth immersions, which become such via a standardization of the procedure with three dimensions. Ethnography followed the observation dimension when the channel was wandering, the annotation dimension after wandering the channel was lived and the linking dimension when other channels were visited via that channel followed. Fourteen steps were employed (observation dimension, seven steps; annotation dimension, five steps; linking dimension, two steps). Note that the visited channel may or may not be wandering and lived, but it

is always a channel linked from a previous one. The procedure in the second virtual ethnography followed the routine, as can be seen in Table 2.

Table 2. Virtual ethnography. In-depth immersion by type of immersion, routine and steps.

Channel	Routine	Steps
Wandering	OBSERVATION	1. Google: name of channel and mouse click 2. Youtuber presentation video 3. Entry interfaces to each video (photogram of each uploaded video) 4. Wandering around channel content, viewing three or four videos chosen according to most attractive title based on the subjective opinion of the researcher, taking three to four minutes each. 5. Sections that the channel contains 6. Video titles and duration 7. Viewing and content of links to other YouTube channels
To live	NOTATION	8. Grid with descriptors (URL, title, subjects, gender) 9. Viewing for 30 to 60 min 10. Number of views and subscribers, Social Blade consulted 11. Details provided, relevant notations from an educational point of view 12. Profiling of descriptions with new viewings
To visit	LINKING	13. Click with mouse from a "To Live" channel 14. Steps 2 to 4 (wandering channel/OBSERVATION dimension)

The ethnography process was carried out on 39 new channels with a total of 39 different immersions in STEM edutubers. To do so, the initial matrix introduced by [14] was taken, and the channels were analysed with seven categories (matrices including numbered table, title, type, number, content, source and gender). Finally, four matrices were built, and a package with five guidelines was obtained in order to attempt to eliminate the gender gap in regard to women STEM edutubers. In addition to the above data, further material can be found at the link shown at the end of the text.

3. Results

3.1. Grid 1 Analysis: Channels 1 to 41

Table 3 shows the immersions in STEM channels, the description of a video with the URL leading to the immersion, the time in minutes and the gender. The content of edutuber women is discussed as follows. To identify the gender, the male, female and mixed (channels with a man and a woman) genders were considered according to how representative each gender is on the channel. For example, on the *Matemóvil* channel "https://bit.ly/3u8tWxU (accessed on 25 July 2023)", the most representative figure is a man, and in the *Susiprofe* channel "https://bit.ly/3CTYDLh (accessed on 25 July 2023)" the most representative figure is a woman.

Table 3. Time of observation on STEM channels by gender (abstract).

Time *	STEM Channels	Gender **			
		M	W	M&W	W&M
958:06	41	30	5	4	2

* Time of observation expressed in minutes. ** M, man; W, woman; M&W, man and woman; W&M, woman and man.

Out of 41 channels (Figure 2), the exclusive creation by/presence of men is observed in 30 of them, i.e., 73.17%. Exclusive creation by/presence of women can be observed in five, i.e., 12.19% of channels. There are six channels (12.6%) with mixed creation/presence, i.e., with a man and a woman. Creation/presence is to be understood as the visible or audible image that is most visually relevant. This representation could be the person, the voice-over usually in a documentary, or the main person on the channel. The exceptions to these criteria were found on three channels because of the following reasons. One is that the producer and instructor in a virtual classroom environment is an important professor, so they embody the most significant image. When this happens, male representation is considered to exist (man as a gender in Tables 3 and 4). On this YouTube channel, the series of documentaries also uses a male voice-over to give mathematical explanations and physical reasoning and also to discuss the history of Physics. The purpose of the female voice-over at the start and end of each documentary, whose appearance lasts between three and twenty-five seconds, is only to introduce and round off the programme. There is only equal female and male representation in the classroom space (booth public), and they are only included in the opening and closing images with landscape views and close-ups of female and male students. Interest is focused on the documentaries in the series when one of the episodes is not available on the channel, so Wikipedia or other channels that appear on YouTube are used in order to find the link to the content. In these cases, the immersions in those channels were not recorded.

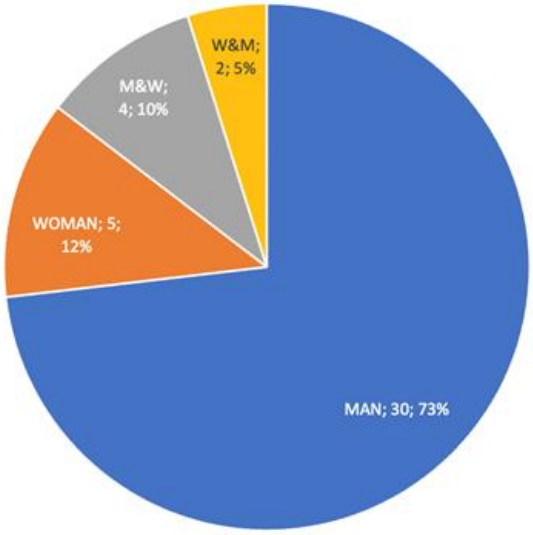

Figure 2. Number of channels by STEM subject and gender.

Table 4. Observation of 33 STEM channels from YouTube Spain (abstract).

	Abs. Freq			Rel. Freq		
	Man	**Woman**	**Mixed**	**Man**	**Woman**	**Mixed**
Exact Sciences	3	0	0	100%	0	0
Natural Sciences	18	11	1	60%	36%	4%
Total	21	11	1			

The second exception concerns a channel created and produced by a man, although a female professor appears in some of the videos. This is considered as a mixed intervention since much of the immersive time was spent viewing her videos.

The third exception is a channel created by a man, but the immersion takes place in a punctual documentary where the reporters and voices are women. Mixed representation is also considered on this channel since the living experience took place exclusively in regard to this video.

3.2. Grid 2 Observation with YouTube Spain in 32 STEM Edutubers by Channel and Gender

This grid was produced on the basis of 33 channels (Table 5 and Figure 3). Of the 33 channels, 3 are linked to Mathematics and 31 to Natural Sciences. Of these channels, three are repeated, one on Mathematics and two on Natural Sciences, which are identified in Table 4.

Table 5. Related to Grid 2 (32 STEM channels). Links by STEM teachers on YouTube Spain to other channels, by gender (abstract).

Total STEM Channels Linked	Links from Edutuber's Gender	Channels Linked	Link to a M *	Link to a W *	Link to Both *
36	By M = 5	31	23	7	1
	By W = 1	5	5	0	0
	Total 6	36	28	7	1

* M, man; W, woman. Both means a channel run by man and woman or woman and man.

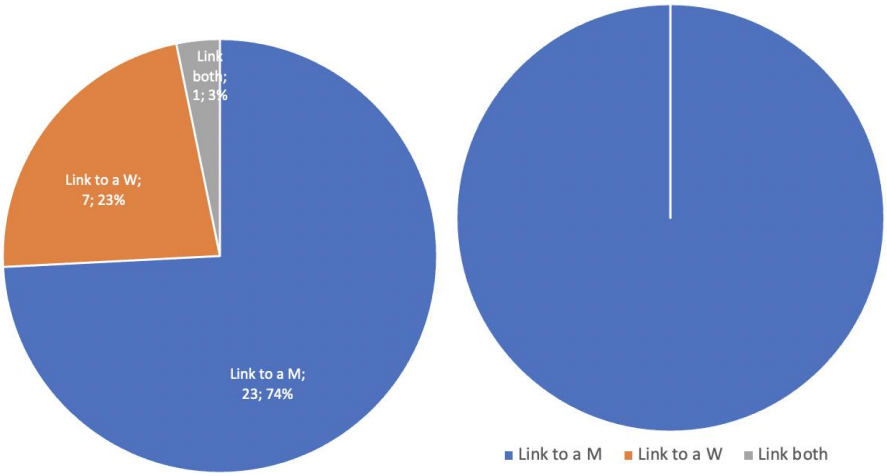

Figure 3. Links posted by STEM edutubers on YouTube Spain to other channels, by gender. On the right, links posted by edutuber men. On the left, links posted by edutuber women.

It has been observed that creating a channel that directly contains signature information is not common. Three indicators were used to determine the gender: the channel presentation, the observation of the video images and viewing short and randomly chosen excerpts on the channel. Table 4 shows this procedure applied to Grid 2.

The channels show STEM content (Figure 4). When observing the gender gap, it can be seen that of the 24 channels, there is a mixed channel with a varied representation of gender in which there are 10 female social edutubers and 21 male social edutubers. There are no channels with female representation that discuss the Exact Sciences.

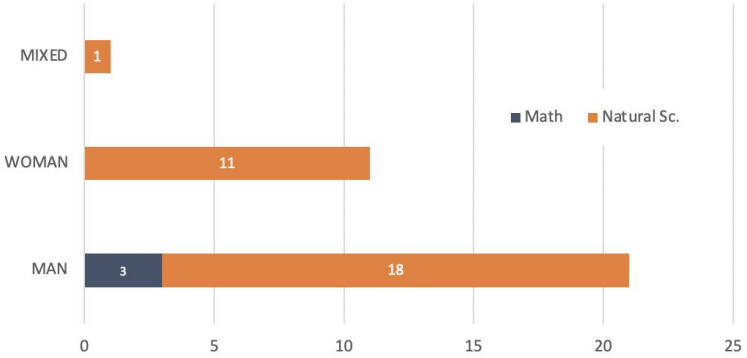

Figure 4. YouTube channels of Mathematics and Natural Sciences subjects by gender.

In regard to the Natural Sciences, the content published by female edutubers includes love and attraction on two channels. The former is about human beings, phenomena, awareness, tests and experiments. The latter shows reports, subjects of a critical nature and sexuality. Three more channels provide reviews on books or literature. The female edutuber publishes content on neurotransmitters, articles and advice on how to write a thesis. The audiovisual content covers nutrition, art, critics and interviews and deals with creativity associated with the brain and music, painting or dance, as well as literature. There are two more female channels that show experiments. The former deals with cosmetics, cooking and curiosities, whereas the latter discusses nature with a touch of humour. Moreover, another female channel provides audiovisual content on curiosities related to the human body, the organism, Microbiology, Metabolism, Genetics, the study of Biomedicine and featured channels. Finally, it is possible to find material on the Planetary Sciences presented by a predoctoral researcher (one channel) or discussions about robots, Nanoscience, atoms and materials (one channel).

Nevertheless, the Exact Sciences channels covering pure and applied mathematics exclusively feature male presenters. One channel provides in-depth analyses on the more interesting aspects of Artificial Intelligence, Machine Learning, algorithms and opinion articles about these subjects. One of them deals with mathematics today, combining statistics with humour, and his favourite channels on Biology. On other channels, Mathematics is related to the essence of numbers. Gauss is studied, and Pythagoras's theory, Euler and the creators' favourite videos on Physics and Biology are shared.

In regard to the Natural Sciences channels, audiovisual content on YouTube with male representation that was related to channels about Biology (two channels), Nutrition (two channels), Medicine (three channels), Chemistry (one channel), Physics (seven channels) was compiled. Moreover, there were other channels that covered Geology and geological Minecraft, and others discussed renewable energy, electricity and related concepts and current affairs.

Humour was observed on two channels about Biology, one about Medicine and another about Nutrition. One channel discusses Biology in a rather unusual way. It is possible to watch Biology topics with heroes and villains, such as Disney Biology with parasites, which provides a very animated space related to popular cartoon characters and encourages viewers to go to university. Medicine is discussed with guests, and a selection of their favourite music is also a topic of dicussion in this scenario. An educational channel run by José Kenji covers the subject of Nutrition with a touch of humour, a section on influential people in the fitness sector, anecdotes with nutritionists, debates and the stories of male and female guests.

Regarding Chemistry and Physics, three channels are attractive spaces that teach about science. Regarding subjects such as CERN (European Organisation for Nuclear Research), there are two channels, one of which is closed right now. The open one discusses Quantum Physics, the cosmos and experiments in Physics and also features other channels. There is very little female representation on this channel. Regarding Physics, another channel brings a new way of understanding education, covering Speculative Physics, Cosmology, Astronomy, Quantum Physics and Relativity. Other topics on three new channels focus on Physics and Chemistry, the periodic table and meteorites, the stars and the cosmos are discussed, biographies, scientific curios and the Theory of Everything are addressed, and there are links to his other channels. At the end, it is possible find tutorials, mega-tutorials and news about the cosmos and Physics in a new Physics YouTube space.

There are channels that deal with eating better and answer queries about Nutrition while posting TEDx talks and conferences. In the field of Medicine, there are channels that focuse on drugs and the body–mind relationship. On the subject of life and intimacy, Paul Mateo's channel on Medicine provides avant-garde content and content on the History of Medicine from his personal development and experiences as a doctor.

A mixed presentation with several people can be seen, which breaks the mould of normal edutubers (short videos, opening and closing with a sentence, camera position).

Among the differences with the others is the inclusion of a radio programme, consisting mostly of long videos (more than an hour) and recordings in exhibition spaces. Examples include video conferences with several people, round-table discussions and presentations at events. The channel broadcasts content on nutrition and the food industry.

On the third grid, special emphasis was placed on QuantumFracture (male) because it links to more science by redirecting consumers to TheQuantumFracture with a voice-over by a woman. This linked channel (in English) provides twelve other links, also in English. From observations, nine were male-represented channels, one had female representation and two had both male and female representation. However, this channel is just an exception.

Another YouTube Spain channel links to eight channels, one of which is run by a woman, six are run by men and one is run by a male and a female (mixed). Another links to twelve channels, three of which are run by women and nine of which are run by men. One more links to seven channels, of which only one has female representation, and another links to five channels, all of which are run by men. Finally, the last one links to three other channels, of which two are represented by men and one by a woman.

3.3. Links to Other by STEM Subject, Channel and Links, Description and Gender

In the content featured in the links posted by STEM edutubers (Table 6), the man provides new ways of understanding Physics, the title of his channel works in his favour in regard to time, he explains Mathematics and Physics but is also a singer, he resorts to Minecraft-type games and uses voice-over in cartoons.

Table 6. Related to Grid 3. Links to other edutuber by STEM subject, channel and links, description and gender (abstract).

	M	**W**	**Both**
Abs. Freq	11	4	2
Rel. Freq	64.7%	23.5%	11.8%

We have to highlight that in Grid 4 (Table 6 and Figure 5), the inter-cultural gap observed in the channels was the data of interest, and was only overcome by QuantumFracture (man), as we wrote before. This channel links to others, such as TheQuantumFracture (woman), which leads to a linguistic inclusion in English, and in turn, links to channels in Arabic and French. On the other hand, the woman STEM edutuber carries out science experiments while at the same time discussing love, and she discusses Planetary Science and talks about Einstein, the Earth and the universe. The mixed channels show long videos and short videos on subjects about the Earth, Ecology and Geology, which are very educational.

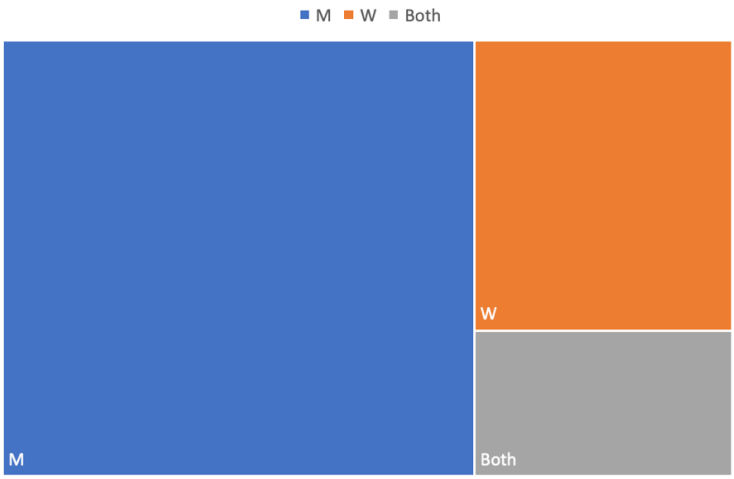

Figure 5. Links posted by STEM edutubers to other channels, by gender.

4. Discussion

In order to explain what the results offer in comparison with previous studies, this discussion section returns to the two aims of the paper. It can therefore be argued that the educational resources available on YouTube are popular and have a significant impact on young people. Edutuber teachers cater to students who want their needs for personal support [19,58,59] and information met and make collaborative space outside of the classroom a more enjoyable space [19]. Nevertheless, coinciding with [13,23], STEM edutubers' content inherits past behaviour, posing a new risk associated with ICT that needs to be discussed. The process of conducting digital ethnographies for STEM edutubers in three steps has resulted in the development of guidelines. The following paragraphs provide further information for discussion.

4.1. General Objective (a): Describing the Spaces of Edutubers

The digital contexts of edutubers are exposed to statistics and tracking. The figure of the edutuber is subject to public data and comments, which is information that can be accessed via the Internet, sometimes without any real effort. Work performed by edutubers always takes place in open-source media contexts. The digital ecosystem is a source of social and cultural wealth and is an example of public spirit through responsibility and social justice. Consequently, it can also be a tool for the communication of misogynist fear and degradation [12,13], a risk associated with ICT that needs to be worked on through a conviction of change. In light of the empowerment of the new media [60], the support of women is required. A literature review is required not only in regard to a conceptual analysis and the virtues of edutubers in regard to their characteristics but also in regard to their needs.

Both an interest in STEM and academic results are in harmony with one another, and therefore change through intervention is possible [6]. To eliminate the gender gap in STEM education, informal learning opportunities outside school that inform students about the fascinating world of STEM professions and acknowledge the people who have chosen these careers must be increased [7]. The identity construction of girls between 10 and 14 years of age does not fit in with STEM models, and tension and disconnection is created between those that are assumed to be competent and female students with respect to the sciences [1,4].

The first guideline is to deal with useful content for the formal teaching of STEM subjects. This guideline features four recommendations. The first recommendation is to be careful with the spelling of the titles of each video. Secondly, attention must be given to the "Information" tab to identify the content creator. Thirdly, when dealing with educational content, showing channels with attractive and common words and titles is recommended, and the names of the videos, such as "Explaining the Higgs boson to babies" taken from the Spanish Institute of Theoretical Physics (IFT) should also be displayed. Finally, in the case of curricular content, short titles are recommended with alphabetical graphemes that give meaning to the words and avoid mathematics symbols, unusual symbols, abbreviations, numbers or graphic points.

Finally, male and female STEM content creators should link their channels to the channels of other women. Finding links on STEM channels with male and female representation to other YouTube channels is not very common. Nevertheless, when the edutuber decided to link his/her channel to other channels, regardless of whether the channel was represented by a man or a women STEM edutuber, there were always more links to the channels of men than to those of women.

4.2. General Objective (b): Describing the Content of Female Edutubers in Particular, in Further Detail

Although social, ethnic and gender structural factors influence the career aspirations of the youngest, they are also influenced by family, attitudes towards science and identity [2]. In fact, there are cultural gender stereotypes in STEM that are being passed down by parents,

teachers, friends and the media [6]. In preadolescence and adolescence, critical media education is required to bring an end to sexist content [13]. Some researchers talk about imminent transmedia literacy, which entails a new culture, and Internet literacy, which is based on doing, consuming and creating (prosumers) through collaboration [60]. Critical media literacy vitally improves students' skills [61], thus driving their own audiovisual creations in equality.

The second guideline consists of offering content while changing the roles of stereotypes. There is audiovisual content linked to aesthetics and personal life, themes that are not generally covered by men. Attention is also brought to audiovisual content about music. Male representation is grouped in content on entertainment in general, and video games and sports in particular. The empathy of socio-cultural animators and the role of opinion generators among male edutubers is highlighted, but not among female edutubers.

STEM content represented by women deals with Biology, Physics, Robotics, love and attraction. A psychosocial meaning and a spiritual sense are observed in some of the content. Communication language focuses on dissemination, using reports and encouraging curiosity and experimentation. There is interest in reading, for example, through book reviews, and an interest in the orientation towards other people to access knowledge, experiments, interviews, critical opinions and humour also exists. Content created by men, on the one hand, does not cover love and attraction, and spirituality or criticism are not perceived in a relevant way. Nevertheless, audiovisual content about life and intimacy in conjunction with their professions is observed in men.

The third guideline, following from the preceding paragraph, consists of encouraging female edutubers to offer more daring and, at the same time, more diverse formats. Of the channels sorted ethnographically, attention is brought to the diversity of formats on YouTube that go beyond conventional video (audio or moving images, fun, sincerity, opening and closing). There is work with voice-over, podcasts and audiobooks, and YouTube shorts are introduced. More common are popular videos, the use of interviews and lists in the themes. Moreover, there is interest in flipped classrooms among male edutubers. In particular, dialogic processes are observed and mediated by narrative technologies (video conferences or round tables) or initiatives, such as the philosophical café and chats.

The fourth guideline consists of launching STEM channels with a female presence about the Exact Sciences, Chemistry, Geology, Medicine, Energy and the Environment in Spanish. This launch must be quantitative and qualitative. This analysis did not find any female STEM representation on channels for young people in the final years of secondary education or the first years of Mathematics in university. Male and female edutubers have similar interests in Natural Science subjects, such as Biology, Physics, Nutrition, and Robotics. Humour and concern about teaching other people and transferring knowledge is observed in female and male content creators alike. Nevertheless, female representation is not observed in content on Chemistry, Geology, Medicine, Energy or the Environment.

5. Conclusions

In conclusion, the UNESCO report [34] highlights an urgent need to address gender bias in technology. This research aims to contribute to this effort. Sáinz [33] pointed out that the type of person who is expected to succeed in a STEM career is a middle-class white male, and immigrant families, girls, women, and people with disabilities were excluded. High status, a high intellectual capacity, dressing casually, wearing a tie or glasses as well as preferences in music, readings, or sports are just part of these stereotypes as well. In this line, schools should promote different interventions that involve the whole educational community in order to avoid and reduce any sign of academic sexism. In addition, the exposure to female role models is highly recommended when attempting to debunk stereotypical portrayals in digital environments, which can have a strong impact. It is also crucial to include boys and attempt to change their mindset.

Jenzen [26] recognises that trans and queer youth subcultures are thriving on YouTube. Furthermore, because education must necessarily be of high quality and inclusive (SDG 4),

non-hegemonic gender identities are included in SDG 5, which combines gender equality with SDG 4. Looking at social networks, gender and video clips of adolescents, Vila-Couñago et al. [28] recognize the prevalence of research that approaches this issue from a binary perspective in a few studies that deviate from this approach. In fact, one of the limitations of this paper is that binary gender was used, and the collective LGTBIQ+ population, which is worth considering in research and in audiovisual creation, was not studied. Furthermore, the participation of preadolescents and adolescents in STEM channels has not been considered [62], nor have the functions of edututer guides as influencers. An in-depth study of the channels linked by STEM edututers also has not been carried out, which other researchers miss [15,43,63]. As suggested by [14], further investigation is needed to assess the gender gap in scientific content on Spanish YouTube channels.

Finally, didactic materials must be designed to help teachers on YouTube make women's contributions to STEM more visible. It is necessary to encourage and promote the creation of channels run by women who can serve as STEM role models. In this sense, female teachers of STEM subjects should be made more visible as well, especially for STEM students who are not in direct contact with female role models [33]. In line with the recommendations of the United Nations [32], sustainable long-term programs and initiatives should be promoted to increase girls' interest and participation in STEM. To ensure universal digital literacy in education, we must consider promoting new pedagogies.

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