The Dual Use of Didactic Videos in STEM Education and Dissemination: A Survey-Based Analysis

Ruben Lijo, *Member IEEE*, Eduardo Quevedo, *Member IEEE*, José Juan Castro

***Abstract*— The challenges associated with the education in Science, Technology, Engineering, and Mathematics (STEM) disciplines can be mitigated using didactic videos, but there are other challenges when considering such potential resources. Amautas is a new platform created to facilitate the search and pedagogical integration of good-quality didactic videos, by proposing a set of structured courses while reproducing a YouTube-alike communication style and, therefore, addressing both scopes: STEM education and dissemination. To evaluate Amautas' video-courses use and value for education and dissemination, a quantitative methodology has been followed through a 5-point Likert scale questionnaire (Cronbach's alpha = 0.906) with 489 participants. Overall findings show that the platform's proposal has achieved a dual use of their didactic videos for education and dissemination purposes (with respective 73% and 82.6% positive responses respectively), and users declare a high positive perception of key metrics and descriptors for adequate content, format, and communicative quality. In fact, 87.9% of participants agree that the contents help them understand topics of interest, and 88.5% agree that the presentation of contents is attractive and interesting. These results show a window of opportunity for further effort investment in the curricular alignment of STEM dissemination resources, fostering their incursion in real classroom scenarios.**

***Index Terms*—Educational Courses, Educational Technology, Electronic Learning, Social Media, STEM Education, Videos**

I. Introduction

DIDACTIC videos present multiple benefits when integrated as a pedagogical aid. As explained by the Cognitive Theory of Multimedia Learning (CTML), founded on the Cognitive Load Theory (CLT), videos have a positive impact on the processing capacity due to the dual channel of information reception (verbal and visual) [1], [2]. Only a limited amount of information can be processed at a given time, and the use of those channels allows to optimize the demands on working memory, which implies an enhancement in retention and knowledge acquisition [3], [4]. Therefore, the combination of both auditive and visual information allows students to achieve deeper learning than with either of those channels separately.

These aspects are positive for all students, but specifically for those coursing Science, Technology, Engineering, and Mathematics (STEM) disciplines, which are composed of a wide presence of abstract concepts that complicate conceptual learning [5], [6], [7], [8], [9]. But additionally, the integration of didactic videos can boost students' motivation, satisfaction, and performance when considered within a structured pedagogical approach [10], [11], [12], [13], [14], [15], [16], as well as acting as a helping resource in the reduction of academic stress and anxiety [17], [18]. These aspects increased during the Emergency Remote Learning (ERL) caused by the COVID-19 pandemic [19], [20], [21], [22], and have been described as some of the reasons for the high rate of students' decline in technological vocations and dropout [23], [24], [25].

Considering the nature of the link between videos and learning, all the abovementioned benefits of didactic videos apply whether the intention of knowledge acquisition is related to formal education or informal learning. In this regard, different collectives, professionals, associations, and other organizations are investing their efforts in the creation of STEM dissemination audiovisual materials, that are widely available on the internet and social media. YouTube is a great example, as the currently most used platform for the educational use of videos [26], [27], [28], where teachers and communicators have been uploading content for more than ten years with a high demand and consumption rate from the new generations of students [29], [30]. However, the use of YouTube is more focused on the transfer of information through video rather than acting as regular social media [31]. Therefore, collaborative learning and gamification strategies are somewhat limited unless an additional Learning Management System (LMS) is used in its educational integration.

However, there are also challenges and drawbacks associated

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with its use, such as the potential lack of videos' scientific rigor, students' negativity towards new processes involving social media, or the attention reduction when videos are not considered within an adequate pedagogical framework [32], [33], [34]. Additionally, adequate YouTube videos for education are not always easy to find due to the large number of videos published, as well as the popularity-driven search and recommendation algorithm, which is not contemplating an adequate evaluation of format or content quality [35], [36], [37]. In fact, recent reviews on YouTube use in pedagogical contexts describe that almost 81% of analyzed videos for potential educational use are of "poor quality" [38]. Moreover, as described by Khanagar et al., even considering the wide availability of videos online, students tend to feel that YouTube videos suggested by faculty are more valuable than those identified through regular searching [39]. These low-quality characteristics and the potential lack of rigor of many YouTube videos are also acknowledged in other research [15], [40].

A. Amautas: STEM dissemination courses with educational purpose

To overcome these challenges, Amautas platform[1] has been created aiming to develop a singular format that mixes the abovementioned characteristics of an engaging and well-produced YouTube educational video, with the structure, rigor, supervision, interaction with peers, and institutional agreements usually found in Massive Online Open Courses (MOOC) [41], [42], [43]. The intention relies on creating a learning environment that fosters personal autonomy and learning from peers in courses designed to host large numbers of participants, which can be accessed from any location and at any time without prior qualifications requirements. Additionally, similarly to MOOC courses, Amautas' courses count on qualified content creators and instructors from various STEM fields, which also facilitates interdisciplinary education [44], as well as the application of collaborative learning methods [42].

Amautas was founded by two Spanish scientists and renowned science disseminators, Javier Santaolalla and José Edelstein, together with Jorge Pérez as an expert in digital marketing. They were mainly motivated to create this new approach after analyzing the unprecedented learning conditions of ERL due to COVID-19, which evidenced the lack of suitable STEM education digital resources originally in Spanish. The intention was well-defined: reaching both society and formal education (mainly at secondary and tertiary levels) with an engaging dissemination voice and an adequate audiovisual format, content structure, and topic selection.

In order to make it real, a curated workflow is followed during the creation of each course (see Fig. 1). The initial step is to select a suitable topic that meets the needs of secondary or tertiary education, as well as topics of major concern from a STEM dissemination perspective. In this step, also horizontal coordination will be considered for new courses to reinforce concepts already worked in previous courses, helping in the creation of a higher layer of connected courses and linked contents that fosters the creation of wider and interdisciplinary training programs. Afterward, the content creation phase takes place, where an expert in the selected field of knowledge (with wide academic or professional background) prepares such content under the supervision of the Amautas' content management team. Once all the scripts have been created (normally ten chapters of approximately 10 minutes duration each), the audiovisual creation phase takes place, and all the recordings and visual animations are managed by the Amautas' content production team. The visual results are supervised by all stakeholders (both the content management team and the course author) to guarantee that all concepts are adequately illustrated. After this phase, an overall course validation takes place where all the working teams are involved under Amautas' global coordination. Once the course has been validated, questionnaires for students' self-appraisal are created, together with the course certificates that will afterward be personalized for each student who passes the training. Finally, the course is ready to be launched and promoted by the Amautas' content dissemination team.

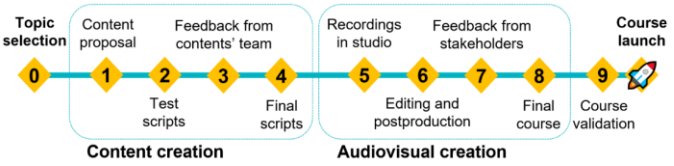

Fig. 1. Workflow of the Amautas' course creation process.

Contents are published on Amautas' platform, where the audience can access it via subscription modality. However, Amautas also provides content to third-party platforms, such as Movistar or Odilo, through institutional agreements focused on providing training materials to their students and workers. Some other content is also co-created with different organizations interested in the production of educational materials, such as the World Wildlife Foundation (WWF) or IMDEA Research Centers in Madrid. Finally, educational agreements are also reached with higher education institutions from all over the world, such as Tecnológico de Monterrey, Universidad Iberoamericana, or Universidad de Las Palmas de Gran Canaria, where their users' communities (students, professors, or associates) are granted access to all Amautas' contents. In a similar way as MOOC environments operate [41], these institutional agreements are at the core of Amautas' aim, to reach both professional and academic spheres, as well as society as a whole.

Currently, Amautas' exclusive contents are divided into several formats, including structured courses (with contents created and taught by relevant academics and STEM disseminators), master classes in the form of interviews about current scientific issues, counting with renowned academic personalities, or live retransmissions of 1-hour duration. Amautas' courses are, as of December 2023, composed of a total of 390 videos about topics such as mathematics, physical sciences, chemistry and materials sciences, technology and engineering, environmental and earth sciences, biology and life

[1] https://amautas.com/ (Accessed 09/09/2024).

sciences, history, philosophy, or arts. The most visited courses on the platform are "Quantum Mechanics" and "The Standard Model", each with more than 70,000 visits. Aiming to offer a sample of the platform's courses to the academic community, so that its value proposal can be appreciated, Amautas has made available a demo version[2] of the course "The Standard Model". It not only shows all the contents of the course but also offers the possibility of interacting with Amautas' Artificial Intelligence, which allows anyone to ask any question that will be answered using the contents of the platforms' courses as a reference.

Amautas' content creation team is composed of 62 authors, among which 69.4% are academics in different fields of STEM, and 30.6% are active professionals in their respective STEM sectors. Of all authors, up to 74.2% combine their main professional activity with regular and complementary STEM dissemination activities, either in traditional media (including television, radio, books, talks, or newspapers, among others) or new digital media (including social media, blogs, or podcasts, among others). Up to 16.1% of all authors are currently exclusively dedicated to professional scientific communication activities, journalism, or institutional dissemination of science and applied sciences.

Amautas platform was launched to the public on February 21st, 2021, and during its first two years of trajectory (until March 31st, 2023) it has achieved more than 240.000 single viewers, from which 54,000 are registered users belonging to Amautas' community. Of such users, 68% are men and 32% women, with the geographical distribution shown in Fig. 2. In terms of age, the most represented groups include the ages between 25 and 34 years old, covering 40% of the population; between 14 and 34, representing 30% of the population; and between 35 and 44, with a representation of 19%. The contents consumed in this period are equivalent to 5 years and 333 days, with an average retention rate of 80%, and even achieving an 87% in some of its courses.

Fig. 2. Geographical distribution of registered users.

B. *Objectives and Research Questions*

Due to its singular approach, combining educational and dissemination aims with MOOC-alike structured courses in a YouTube-alike format, Amautas platform has been selected as the case study for this pre-experimental research aiming to explore the combined use of videos for formal education and public dissemination purposes. There is currently extensive literature about the benefits of didactic videos in formal and informal education, as well as the specific potential of YouTube as a source of those videos. However, as previously exposed, it has also been documented how YouTube presents some limitations when it comes to selecting "good-quality" videos for formal education. Therefore, Amautas' value proposal presents a window of opportunity to facilitate the selection of dissemination videos optimized for their integration into formal education. Such distinctive and pioneering focus makes Amautas an interesting case study when it comes to further explore the potential synergies between multimedia dissemination resources and formal education.

This article intends to evaluate Amautas' proposed innovative format where videos address both education and dissemination purposes. Therefore, a survey-based evaluation has been performed to quantify the audience's perception of the characteristics of its contents, considering certain descriptors for the evaluation of educational videos as a reference. There is consensus in literature at those definitory metrics being grouped mainly in the following aspects: production quality and visualization of contents, video length optimization, technical accuracy, and completeness, use of examples and linking to prior knowledge, topic selection and relevance for the audience, explanation rhythm, and an engaging communication style [29], [43], [45], [46], [47], [48], [49], [50].

Moreover, previous works serving as a reference have been focused on the evaluation of an engineering channel on YouTube under these descriptors [51], in the framework of a project for the dual use of the channel for electrical engineering dissemination and education. These metrics were not only perceived to be achieved by the channel's content, but they were also key to its videos providing a positive impact as a complementary tool through their integration into engineering courses during ERL [52]. Therefore, it is also an objective of this study to verify whether the perceptions of Amautas' approach to deliver didactic videos in structured courses might be aligned with the perceptions of such YouTube channel with a dual purpose towards STEM education and dissemination.

Therefore, aiming to achieve these objectives, the following research questions are addressed in this research:

- RQ1: Are the didactic videos proposed by Amautas fulfilling a dual use for both STEM education and dissemination?
- RQ2: Does the Amautas audience consider its contents to be adequate for educational use, in consonance with literature descriptors in content, format and communicative style?

This section has presented a summarized introduction to video integration in educational environments, as well as further literature regarding its benefits and challenges. It also

[2] https://amautas.com/demo-curso-el-modelo-estandar (Accessed 09/09/2024)

briefly introduced Amautas. Moreover, the research objectives and the case study have been introduced. Section 2 addresses the methodology followed in this research, as well as the specific instrument used for data collection and the statistical approach for its analysis. Section 3 describes the most relevant results both from a descriptive and associative perspective, aiming to find deeper connections among the studied variables. Then, Section 4 aims to analyze the implications of such results related to the research questions, as well as describing this study's contribution to current literature. Finally, Section 5 aims to highlight the main conclusions of this article and the proposed future works.

II. Methodology

This article aims to evaluate Amautas' audience's perception of its contents, focused on both STEM dissemination and education. The assessment was done after the first two years of the platform's operation, and the data was collected from February 6th to March 27th, 2023.

This research implements a quantitative pre-experimental design divided into two phases: descriptive and associative. The data has been collected through a 5-point Likert scale questionnaire to measure Amautas' users' perception of the characteristics of its contents for educational contexts. Therefore, a survey-based descriptive study is presented, which is complemented by further statistical analysis that intends to search for deeper connections, explanations, and statistical associations among items. Informed consent was obtained from all the users involved in this study.

This pre-experimental research intends to evaluate the initial use of Amautas, both as a dissemination and educational resource, during these first two years of operation. It will allow to further understand the perception of current users about this proposed combination of a YouTube-alike format in structured courses, aiming to reach formal education. Further stages of this research will consider these insights in the proposal of optimized strategies for the curricular alignment of Amautas' contents, as well as for longitudinal experimental studies about its integration in real classroom environments.

A. Instrument and data collection

The total number of registered users in Amautas consists of 54,000 individuals, which has been considered as the population aimed to be represented in this study. In order to answer the proposed research questions, a questionnaire has been used adapted from previous works, especially analyzing the role of dissemination videos in engineering education [51].

Such instrument has been selected due to its alignment with the objectives of this study. Its design is focused on the evaluation of the potential dual use and adequacy of YouTube dissemination videos for entertainment and education, based on users' perspective. It examines the use preferences of the audience and the main metrics cited in the literature that define a "good-quality" educational video. These metrics are essentially related to the videos' content, format, and communicative style adequacy, as previously presented in the Introduction. The adaptation of this instrument consisted of the elimination of generic questions that were not considered relevant for the purposes of this study. Such questions addressed the immediacy factor in the consumption of YouTube's videos, as well as an evaluation of the generic perception of parameters unrelated to the platform being evaluated (e.g. classrooms equipment, professors' digital competences, videos' as potential substitute of assistance-based education).

Once the suitability of the questionnaire was confirmed, and it was adapted to the purposes of this study, it was shared with the active users through internal newsletters, social media postings and a popup in Amautas website. As the intention of this study is focused on the evaluation of the global perceptions of Amautas' users, not segregating by demographic groups, the objective is set in the obtention of a sample that could globally represent the platform's users. Therefore, there have been no rejection criteria for the sample, nor it has been stratified. Through these means, the final sample reached 489 users during the 50 days of data collection. Considering the Cochran equation with finite population correction (1) [53], the minimum sample size (n) needed to represent the population of 54,000 registered users with a margin of error (ε) of 5% and a confidence value of 95% (1.96 Z score) would be 381 individuals. Therefore, with the reached sample of 489 users, such minimum representative sample size is exceeded, and the resulting error margin is 4.4%.

$$n = \frac{\frac{Z^2 \cdot p(1-p)}{\varepsilon^2}}{1 + \frac{Z^2 \cdot p(1-p)}{\varepsilon^2 N}} \quad (1)$$

First, the questionnaire (Table I) was distributed to Amautas's audience to collect insight on their use of the platform's contents and their considerations about those contents' adequacy for educational use (considering contents, format, and communicative style). Such questionnaire consists of 11 questions evaluated through a 5-point Likert scale (being 1 strongly disagree and 5 strongly agree), aimed to evaluate key audience's perceptions to answer the proposed research questions.

TABLE I
5-POINT LIKERT SCALE QUESTIONNAIRE

ID	Questions
Q1	I use Amautas for educational purposes.
Q2	I use Amautas for entertainment (dissemination) purposes.
Q3	The selection of topics and content matches my interests.
Q4	The way the presenters expose content is attractive and interesting.
Q5	The rhythm of videos is adequate for concept comprehension.
Q6	The contents' level is adequate (I can follow the concepts and I also learn new things).
Q7	Amautas' contents are rigorous.
Q8	Amautas' contents help me better understand topics I'm interested in.
Q9	Amautas' contents are up to date.
Q10	The video's duration is adequate.
Q11	Audiovisual resources used (images/animations/music) help to understand the explained concepts.

Therefore, questions 1 and 2 are focused on evaluating the main purposes of Amautas' use (RQ1). Additionally, questions from 3 to 11 are specifically focused on evaluating Amautas

users' perception of its contents, format, and communicative style adequacy for educational use (RQ2) as per key descriptors extracted from literature [29], [43], [45], [46], [47], [48], [49]. In this case, the evaluation focuses on the following metrics: topic selection and relevance for learners (Q3), engaging communication style (Q4), explanation rhythm (Q5), technical accuracy and completeness (Q6, Q7), effective and up-to-date learning (Q8, Q9), video length optimization (Q10) and production quality and visualization of contents (Q11).

After collecting the responses from all participants of this study, the reliability of the instrument has been validated with the data obtained, acquiring a coefficient of 0.906 with the Cronbach's alpha method. This reliability coefficient measures the total variance attributed to the true score of the hypothetical variable that is being measured [54]. It ranges from 0 to 1, increasingly describing the reliability of the instrument, and is applicable to dichotomous variables and multi-point scales such as Likert's. According to authors such as Nunnally [55], or Huh et al. [56], values above 0.6 are considered sufficient to ensure the reliability of a questionnaire in exploratory research, even considering that values within 0.5 and 0.6 might be sufficient during the early stages of a research. Furthermore, 0.7 can be considered as a suitable threshold for more consolidated stages of research [55]. The 0.906 value obtained as result confirms the reliability of the instrument used in this article.

B. Data analysis

The statistical analysis performed in this article has been developed using Jamovi [57], [58], and considering a 95% confidence level in all cases. Shapiro-Wilk tests indicate that the distribution of the data collected is not normal, so non-parametric statistical tests are considered.

On the one hand, the descriptive phase is based mainly on exploratory statistics. Using descriptive statistics and box plots the main results obtained through the questionnaire are presented, quantifying the frequency responses over the 5-point Likert scale. The intention is to evaluate whether the audience is using Amautas' contents for an entertainment or an educational purpose (Q1 and Q2), as well as to know their perception on the metrics defining adequate videos for educational purposes (Q3 to Q11).

On the other hand, the associative phase uses χ^2 tests of association due to the discrete nature of variables. This phase intends to determine significant relations among items defining the audience's perception of key metrics for the educational use of the courses. Through this analysis, the interdependence of the different metrics will be evaluated. Moreover, in order to determine the strength of the associations, Cramer's V is also calculated as an effect size measurement.

According to Cohen [59], a conversion of Cramer's V parameter to Cohen's ω parameter considering the degrees of freedom in the association could allow us to reference the results of our χ^2 tests of association to Cohen's framework to evaluate whether the strength of described associations is small, medium, or large. As a general rule of interpretation, it can be considered that a Cohen's ω value equal to or lower than 0.1 is weak, even though there is a statistically significant association. For values between 0.1 and 0.5, associations are normally considered of moderate/medium strength. And finally, Cohen's ω values above 0.5 indicate that there is a strong association between items. Considering such a framework, Cohen's ω is calculated according to the equation (2), where ϕ' is Cramer's V, and (r-1) represents the degrees of freedom, considering r as the contingency table's smallest dimension.

$$\omega = \phi' \sqrt{r-1} \tag{2}$$

III. Results

In this section, results for both phases of the study are presented. Both descriptive and associative analyses are intended to provide insight into whether Amautas is currently being used for both STEM education and dissemination, as well as to answer whether the platform's didactic videos are considered adequate for educational use by its audience according to the descriptors previously explained.

A. Descriptive analysis

An initial exploratory analysis of the sample shows how participants are distributed mainly in Spanish-speaking countries because Amautas and its contents are exclusively available in such language. Spain is the most represented country with 159 participants (32.52% of the total), followed by Mexico with 97 participants (19.84%), Argentina with 67 (13.74%), Colombia with 42 (8.59%), Chile with 27 (5.52%) and Peru with 26 (5.32%). This distribution corresponds closely with the absolute values quantified in the population and described in the Introduction.

In terms of age distribution, 79 participants (16.2% of the total) are under 18 years old. Another 209 participants (42.7%) are between 18 and 30 years old, being the most represented age group. 69 participants (14.1%) fall under the age group between 31 and 40 years old. 60 participants (12.3%) are between 41 and 50 years old. And the 72 remaining participants (14.7%) are over 51 years old.

During its two initial years of operation, the platform has only been available through its website, with no specific app developed for mobile devices. Therefore, most of the users access it through a computer or laptop. Up to 296 participants (60.5% of the total) declared such use, while another big group of 137 participants (28%) declared using Amautas through their smartphones. Only 43 participants (8.7%) use it through their tablets, and 11 (2.2%) through television. Furthermore, delving into use preferences, 60.94% of participants declare watching Amautas' contents during the morning or at night. Up to 53.58% of participants declared that they used the platform during the evening, and only 12.27% and 9.41% used Amautas, respectively, at noon and early morning.

Finally, participants were also asked about their use of the different types of formats that the platform creates and publishes. From the Amautas' different types of content, courses were watched by 91.21% of participants, which is the most used format. They are followed by master classes in the form of interviews with relevant scientists, with 41.1% of participants declaring their use. Podcasts distributed by

Amautas are the third preferred format, chosen by 29.04% of participants. And finally, live retransmissions were chosen by 16.56% and 13.7% of participants, respectively for those who prefer to reproduce them in real time or on demand.

Once participants' main characteristics and use preferences had been generally evaluated, the questionnaire used as the instrument was distributed, and the collected data unveiled interesting information. Results are shown at Table II.

TABLE II
IDENTIFIERS (ID), LIKERT SCALE FREQUENCIES (%), MEAN SCORES, AND STANDARD DEVIATIONS (SD)

ID	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD
Q1	6.5	5.5	14.9	20.4	52.6	4.07	1.220
Q2	2.5	4.1	10.8	28.6	54.0	4.28	0.979
Q3	1.0	4.3	14.1	34.8	45.8	4.20	0.908
Q4	0.8	1.4	9.2	28.8	59.7	4.45	0.786
Q5	0.6	4.9	14.9	34.6	45.0	4.18	0.905
Q6	1.0	3.3	14.3	33.5	47.9	4.24	0.888
Q7	2.5	4.3	19.4	30.3	43.6	4.08	1.010
Q8	1.2	1.2	9.6	24.1	63.8	4.48	0.815
Q9	1.0	1.4	8.0	23.3	66.3	4.52	0.787
Q10	1.2	6.7	15.5	31.7	44.8	4.12	0.985
Q11	1.8	4.3	10.6	30.5	52.8	4.28	0.946

B. Dual use of videos (Q1 and Q2)

The first two questions of the instrument are related to the RQ1. They intend to evaluate the main purpose for participants to use the platform, understanding the dual intention of Amautas towards entertainment and education.

The main declared use is entertainment, with 82.6% positive answers (mean score of 4.28 out of 5), nearly followed by education, with 73% positive answers (4.07 out of 5).

Then, questions from Q3 to Q11 are intended to evaluate the adequacy of the platform's courses for educational use in terms of content, communicative style, and format adequacy. The following subsections will present the results from such descriptors.

C. Content adequacy of videos (Q3, Q6, Q7, Q8 and Q9)

Referring to content adequacy, several aspects could be highlighted such as the selection of topics, and the contents' technical level, rigor, usefulness, and their topicality.

Regarding the selection of topics and how they are presented, 80.6% of participants agree or strongly agree with the statement that the topics and contents selected match their interests (Q3).

Another 79.6% has a positive perception of the adequacy of the technical level, aligned with the idea that they can adequately follow explained concepts and learn new concepts (Q6).

Finally, the contents of Amautas' courses are considered to be rigorous (Q7), helpful to understand topics of interest (Q8), and updated (Q9), with respective 4.08, 4.48, and 4.52 mean scores out of 5.

D. Communicative style adequacy of videos (Q4 and Q5)

There is also a positive perception of the platform's users about its communicative style adequacy.

An 88.5% of participants valued positively the way that the different courses' presenters exposed their respective content (Q4). Therefore, they mostly agree and strongly agree with the appreciation that it is attractive and interesting.

The rhythm of the explanations (Q5) is also considered adequate for concept comprehension, with 79.6% of positive responses from participants. This implies that the explanations are not too slow so that they might be boring and also not too fast so that they would be difficult to follow.

E. Format adequacy of videos (Q10 and Q11)

On the other side, there is also a positive perception about the format adequacy of the videos composing Amautas' courses. This adequacy mainly refers to video length, which is crucial for both dissemination and educational videos [60], and concept visualization through animations and resource images.

A 76.5% of participants agree and strongly agree that the video length (Q10) is adequate in Amautas courses' videos. Moreover, the audiovisual resources included in Amautas' contents such as animations, images or music (Q11) are positively valued as aid material to help understanding the explained concepts. This metric obtained a mean score of 4.28 out of 5, implying that 83.3% of participants agree or strongly agree that these visual supports are adequate.

F. Amautas' educational use and users' satisfaction

Focusing on the pedagogical use of the platform, Fig. 3 shows that the higher values for Amautas' educational use are mainly related to the youngest age groups, where 4 and 5 educational use evaluations mainly point to the age group from 18 to 30 years old. On the opposite side, 1 and 2 evaluations for educational use are pointing to older audiences, with mean values close to the age groups of 41 to 50 years old in the first case, and 31 to 40 years old in the second case.

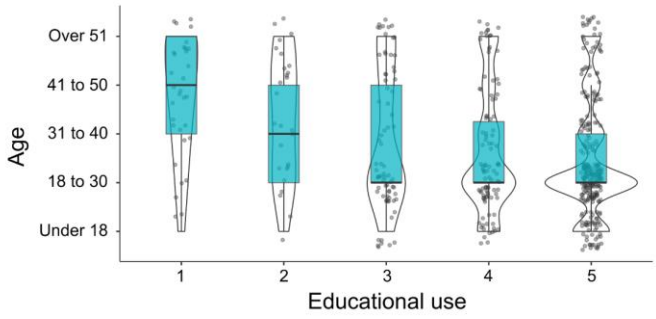

Fig. 3. Boxplots and violin plots of educational use split by age groups.

Lastly, after answering the questionnaire, participants were asked to evaluate, on a 10-point Likert scale, their general satisfaction with Amautas, as well as their satisfaction with the use of the website. In this regard, referring to the website, there was a high satisfaction level with a mean score of 8.65 (SD 1.42) out of 10. When asked how to improve their experience, the main suggestion is the creation of a dedicated application for smartphones, which was launched in June 2023 as a response to this demand. However, the participants' general satisfaction with Amautas is even higher than their experience with the website, as shown at Fig. 4, with a mean score of 9.18 (SD 1.12) out of 10.

G. *Associative analysis*

After the exploratory analysis has been performed, this section aims to deeply analyze the relevant associations between the studied parameters. With this aim, Table III presents χ^2 tests of association between the following items:

- Type of use of the platform's contents (Q1 and Q2).
- Content adequacy (Q3, Q6, Q7, Q8 and Q9).
- Communicative style adequacy (Q4 and Q5).
- Format adequacy (Q10 and Q11).

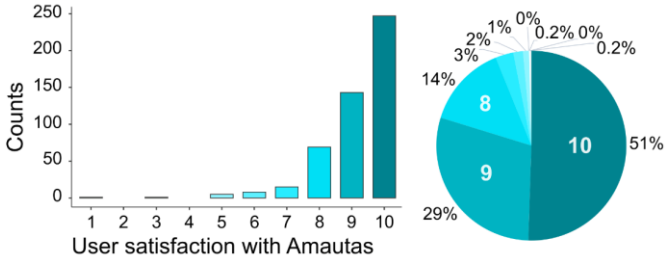

Fig. 4. Evaluation of user overall satisfaction over a 10-point Likert scale, represented in a bar plot and a pie chart.

TABLE III
χ^2 TESTS OF ASSOCIATION INCLUDING CRAMER'S V AND COHEN'S ω

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Q2	χ^2	98.30	—								
	V	0.224									
	ω	0.448									
Q3	χ^2	124.0	265.0	—							
	V	0.252	0.368								
	ω	0.504	0.736								
Q4	χ^2	135.0	280.0	**707.0**	—						
	V	0.263	0.378	**0.601**							
	ω	0.526	0.756	**1.202**							
Q5	χ^2	109.0	186.0	**506.0**	**707.0**	—					
	V	0.237	0.309	**0.509**	**0.601**						
	ω	0.474	0.618	**1.018**	**1.202**						
Q6	χ^2	109.0	152.0	443.0	**551.0**	**611.0**	—				
	V	0.236	0.279	0.476	**0.531**	**0.559**					
	ω	0.472	0.558	0.952	**1.062**	**1.118**					
Q7	χ^2	49.40	169.0	258.0	339.0	226.0	205.0	—			
	V	0.159	0.294	0.363	0.417	0.340	0.323				
	ω	0.318	0.588	0.726	0.834	0.680	0.646				
Q8	χ^2	160.0	243.0	483.0	**693.0**	469.0	410.0	370.0	—		
	V	0.286	0.353	0.497	**0.595**	0.489	0.458	0.435			
	ω	0.572	0.706	0.994	**1.190**	0.978	0.916	0.870			
Q9	χ^2	158.0	312.0	**580.0**	**839.0**	**547.0**	437.0	456.0	**897.0**	—	
	V	0.284	0.399	**0.545**	**0.655**	**0.529**	0.473	0.483	**0.677**		
	ω	0.568	0.798	**1.090**	**1.310**	**1.058**	0.946	0.966	**1.354**		
Q10	χ^2	77.50	157.0	254.0	322.0	254.0	269.0	188.0	262.0	327.0	—
	V	0.199	0.284	0.361	0.406	0.360	0.371	0.310	0.366	0.409	
	ω	0.398	0.568	0.722	0.812	0.720	0.742	0.620	0.732	0.818	
Q11	χ^2	158.0	165.0	365.0	**492.0**	357.0	276.0	241.0	361.0	409.0	221.0
	V	0.284	0.290	0.432	**0.502**	0.427	0.375	0.351	0.429	0.457	0.336
	ω	0.568	0.580	0.864	**1.004**	0.854	0.750	0.702	0.858	0.914	0.672

*All associations present a *p*-value of <0.001. Bold highlights Cohen's ω values above 1, which relates to Cramer's V values above 0.5 for the case of 4 degrees of freedom.

It should be highlighted that all the items present significant associations ($p<0.001$). Moreover, most of the items show strong associations (with Cohen's ω values above 0.5), so values highlighted in bold refer to those specific items showing even stronger associations with values of Cohen's ω above 1.

Most associations found in this analysis show high values of both Cramer's V and Cohen's ω, confirming a large association rate for most cases. First, comparing between educational (Q1) and dissemination use (Q2), we find that both variables are significantly associated with a medium association strength. Therefore, similar association values in both uses regarding the rest of the items are found. This holds true for most items except for the perception of an interesting selection of topics and contents (Q3), the perception of the presentation style (Q4), and the perception of rigor (Q7), which show Cohen's ω values higher than 0.2 resulting in stronger associations applying to those three items with the entertainment use than with the educational use.

Regarding the perception of an adequate selection of topics for each user's interest (Q3), the strongest association for this statement is found with the perception that the presentation style is attractive and interesting (Q4). Additionally, both beliefs are strongly associated with the perception that rhythm (Q5) and technical level are adequate (Q6), as well as with the perception that the platform's contents are helpful to understand topics of interest (Q8) and are also updated (Q9). Finally, the answers to the statement that the presentation style is attractive and interesting (Q4) also present remarkably strong associations with the idea that audiovisual resources integrated into Amautas' contents (Q11) are adequate.

The notion that the technical level of the platform's contents is adequate (Q6) is strongly associated to the idea that its contents are helpful to better understand topics of interest (Q8), considering that those contents can be properly followed and also provide new knowledge to its audience. Additionally, it also shows strong association with the perception that the platform's contents are updated (Q9).

IV. DISCUSSION

As explained in the Introduction, audiovisual resources present multiple benefits for learning STEM disciplines, both when focusing on formal education and informal learning. Dedicated platforms such as Amautas acknowledge this potential dual value of audiovisual material and provide structured multimedia aiming to satisfy both purposes. This section intends to answer the proposed research questions as per our previously explained findings.

A. *RQ1: Are the didactic videos proposed by Amautas fulfilling a dual use for both STEM education and dissemination?*

The findings presented in Results section support the initial hypothesis that Amautas' didactic videos are not only able to potentially cover both education and dissemination purposes, but they also support the notion that both uses are currently taking place.

When considering use preferences according to the

distributed questionnaire results, the main use of the platform is focused on entertainment (Q2) as a result of the STEM dissemination effort put forth by the formats developed. Such use is declared by 82.6% positive answers from participants, both agreeing and strongly agreeing with the statement (achieving a mean score of 4.28 over 5). However, educational use is also predominant in the platform (Q1), with 73% of positive answers (mean of 4.07 over 5).

The gap between both types of use in this case is not as high as that found in a previous study focused on YouTube use for STEM education and dissemination [51], where Sígueme la Corriente channel's main use preference was entertainment, with 87.2% of positive use, followed by 72.7% of positive answers for educational use. Educational use is also highlighted in a qualitative assessment performed in the same channel with a sample of 524 participants [61], where the use of videos was mainly related to understanding and knowledge acquisition purposes, highlighting their boosting effect for both interest and motivation, but also highlighting the dual use for education and entertainment. As evidenced, the percentual difference between the entertainment and educational use found in Amautas is smaller than that found for Sígueme la Corriente YouTube channel. Quantitatively, the reason for this is found in a significant difference ($p<0.01$) in the use for entertainment between Amautas and Sígueme la Corriente, while the educational use differences were not statistically significant ($p=0.079$). This difference in the entertainment use, which is higher in Sígueme la Corriente, might be related to the fact that this channel operates in YouTube: a platform designed for entertainment.

This fact is highlighted by Lee and Lehto [45], who also emphasize the challenge of also developing such a wide recognition of the educational value of YouTube. Subsequent studies on Sígueme la Corriente have demonstrated that, when implementing specific strategies towards an optimization of dissemination videos for education, there is a substantial increase in the audience's engagement with such type of content [60]. Moreover, the fact that Amautas is reproducing a YouTube-alike format, but in a separated environment specifically designed for both education and entertainment might also be a cause for the smaller difference between both uses when comparing YouTube and Amautas.

Regarding consumption behavior, courses are the most used format in Amautas, being declared so by 91.21% of the audience. Master classes in the form of interviews are the second most preferred format, with a declared use of 41.1%. This format is more focused on entertainment use with a curiosity-driven approach where renowned academic personalities are invited to discuss topics of the latest advances in STEM fields. Focusing on educational use, it is worth mentioning that it is mainly related to younger audiences, as shown in Fig. 3, where "agree" and "strongly agree" scores are mainly associated with age groups below 30 years old. Moreover, in terms of technology use distribution, younger audiences are also associated with computer and smartphone consumption, while television is mainly chosen by older participants. Additionally, the consumption pattern in terms of the time-of-day interaction was quantified, finding that the main use of Amautas is during the morning or at night (60.94%), closely followed by evening (53.58%). The use of the platform at noon and early morning is, by far, lower. However, as described by Laparra et al. [62], no correlation is found between the chosen time of the day for the use of these types of resources and academic performance.

Finally, when comparing the association between educational (Q1) and dissemination (Q2) use of Amautas, it has been found that both variables are significantly associated with a medium association strength. Results evidence the dual use of Amautas platform for both STEM education and dissemination purposes. Both objectives are interlinked, and though the finalities are different, they share common elements as will be explained in the following subsection.

B. RQ2: Does Amautas audience consider its contents to be adequate for educational use, in consonance with literature descriptors in content, format and communicative style?

An important aspect to determine the quality and adequacy of a video for educational use is to analyze the communicative abilities of the presenter, the technical level and content adequacy, and the artistic integration and visual resource richness to illustrate the usually complex and abstract concepts constituting STEM disciplines. Such correlations have also been previously confirmed for YouTube, linking content and format adequacy as relevant criteria for users' perception of educational value [51], [63]. Additionally, other authors have confirmed that audiovisual format aspects such as production quality and visualization of contents, video length optimization, technical accuracy and completeness, the use of examples and linking to prior knowledge, topic selection and relevance for the audience, explanation rhythm, and an engaging communication style are the main characteristics to define the quality of STEM didactic videos [29], [43], [45], [46], [47], [48], [49], [50].

In this sense, regarding content adequacy, there is an 80.6% positive answer frequency backing up the idea that topics and contents selected in Amautas' material match their interest (Q3), as well as a 79.6% confirming the adequacy of the technical level (Q6). Both ideas are also aligned with the feedback received in the previous YouTube study performed in the electrical engineering channel called Sígueme la Corriente [51], where respective positive answer frequencies were 82.4% and 91.6%. Additionally, there is a high rate of agreement in the idea that Amautas' presenters and teachers expose their content in an attractive and interesting way (Q7), with an 88.5% positive answer frequency. Perceptions that both communication style (Q4) and technical level (Q6) are adequate are strongly associated with the idea that the platform's contents are helpful in understanding topics of interest (Q8), as observed through χ^2 tests. These associations have also been described in Sígueme la Corriente YouTube channel [51].

The selection of topics and contents (Q3), perception of presentation style (Q4), and rigor (Q7) are valued features in Amautas' contents, though χ^2 tests have found that those items have stronger associations with entertainment use than with educational use. This extra concern on rigor for dissemination

videos has also been found previously on YouTube [51], confirming the tendency to consider rigor more characteristic from the entertainment perspective than from the utility perspective. Besides these facts, Amautas' contents are also considered to be helpful for the understanding of topics of interest (Q8), as well as updated (Q9), with respective 87.9% and 89.3% positive answer frequencies. Digging deeper, the notion that the platform's contents are helpful to understand topics of interest obtained a 4.48 mean score out of 5 in this study. Additionally, significant associations have been found through χ^2 tests between the educational use and this item. This is really aligned with the same evaluation performed on Sígueme la Corriente YouTube channel [51], where a mean score of 4.58 out of 5 was achieved with information from 912 participants, and associations were described for educational use. It is aligned as well with results obtained by D'Aquila et al. [64] for the same question applied to accounting video-aided lessons with a total of 246 participants (4.15 out of 5). Also related, with even higher evaluations, are results from Wells et al. [17], whose students found the use of video tutorials useful to learn their unit material, with positive answer frequencies of 91%. Finally, Aguilar López et al. [65] also found that both students and teachers often resort to videos as part of active learning strategies, highlighting their contribution to conceptual understanding and the reinforcement of memory retention. These gathered results serve as practical cases demonstrating the positive perception from users about video effects in facilitating the understanding of complex and abstract concepts for STEM education. These observations are directly aligned with the benefits of the audiovisual format described by the CLT and the CTML [1], [2], [3], [7].

Referring to format adequacy, participants have given positive answers to the perception that both rhythm (Q5) and video length (Q10) are adequate, with respective mean scores of 4.18 and 4.12 out of 5. Moreover, the audiovisual resources used in Amautas' contents (Q11) were considered helpful to understand explained concepts, with a mean score of 4.28 out of 5. χ^2 tests have revealed strong associations between such perception of audiovisual resources adequacy and the idea that the platform's contents are helpful to understand topics of interest (Q8). This same association has previously been verified in Sígueme la Corriente STEM YouTube channel [51], showing that such audiovisual resources are considered key in the educational value of didactic videos. Delving into this point, resources such as animations and drawings are commonly used in all videos composing the platform's contents, in order to help with the comprehension of abstract and complex ideas.

These kinds of audiovisual resources are described by Wu et al. [66] as useful tools for students to enhance their cognitive engagement and performance in active learning environments. Moreover, Beautemps and Bresges [46] found in their research that animations are perceived as the second most important element defining video quality, only after real footage. Finally, according to Jackman and Roberts [67], illustrations are one of the most important areas of recall when referring to long-term learning and retention, together with examples and explanations. Specifically related to this point, CTML explains how the two-dimensional communicative channel (verbal and pictorial) is the main reason for the educational benefits of didactic videos containing good quality animations and resources. It is considered, then, how individuals can only process a certain amount of information at a time and take advantage of both senses to optimize the working memory [1], [2]. These ideas might serve as a guide when designing the quantity of information to be shared in a video and how to distribute it among both the verbal and pictorial dimensions to successfully help conceptual learning of abstract and complex ideas in STEM disciplines [52].

In this regard, it is worth highlighting that the explanations offered by the platform's content creators are considered interesting and attractive (Q4), with positive responses from 88.5% of participants (resulting in a mean score of 4.45 out of 5). This item is also aligned with results obtained in the previous study evaluating Sígueme la Corriente YouTube channel, where the presenter's explanations attractiveness and interest was valued with a score of 4.61. These communicative skills usually found in YouTube content creators, and shared by Amautas' presenters, are the main characteristic for students to prefer edutubers as their academic reference, as pointed out by the works of Gil-Quintana et al. [30]. Additionally, previous studies carried out on Sígueme la Corriente show that one of the main impacts extracted from its pedagogical integration is an increase in motivation and interest in STEM subjects [52], [61], agreeing with Shoufan's findings when integrating videos as part of an active strategy for distance learning of embedded systems [10].

The audience's positive perception about content, format and communicative style aspects might be linked with the high retention rates obtained in the platform's videos, with a total mean reproduction value of an 80% of the total video length and reaching even 87% in some of its most successful courses. These values are higher than those normally obtained in YouTube, as described by Yang et al. [28], where in the best of cases the retention rate results in a 64.01% of video reproduction from computer users. Overall, user satisfaction with Amautas is particularly high, with a mean score of 9.18 (SD 1.12) out of 10.

In conclusion, Amautas's audience presents a highly positive perception about the descriptors for content and format adequacy, as well as for the communicative style of its contents' presenters and teachers. This is aligned with the consideration of the platform as suitable to fulfill not only its purposes towards curiosity satisfaction and entertainment (STEM dissemination purpose), but also to assume the role of interest boost in specific subjects, and conceptual learning aiding tool, when integrated into STEM education.

V. Conclusions

The wide availability of online STEM dissemination audiovisual resources that might be suitable for pedagogical aid brings a unique opportunity time for the teaching community. But it also brings the challenge of adequately selecting and integrating such resources in a real classroom environment. The presented case study based on Amautas platform shows a real

example of how informal didactic videos could fit for dual use in STEM education and dissemination activities, providing high quality and structured materials aiming at a pedagogical use.

Based on the participation of 489 current Amautas users, this study has shown that these types of courses are able to fulfill both educational and entertainment needs. There is a highly positive perception of key descriptors for audiovisual quality, as well as on content interest and technical level. Participants also have a highly positive perception of the way that teachers and presenters expose the platform's content, considering it both attractive and interesting.

In conclusion, the results of this study suggest that informal didactic videos used in STEM dissemination could also be suitable for STEM education when considering specific key aspects such as topic selection and relevance for learners, engaging communication style, explanation rhythm, technical accuracy, and completeness, effective and up-to-date learning, video length optimization, and production quality and visualization of contents. The creation of such types of didactic videos could also benefit from an approach based on the voice normally associated with STEM dissemination, maximizing their potential to engage with the audience and adequately illustrate complex and abstract ideas usually found in STEM education.

Therefore, this research further contributes to the understanding of didactic videos' role as a pedagogical aid. Moreover, the challenges presented for the adequate selection and integration of videos from other media, such as YouTube, might be made easier with a structured and cross-linked approach that fosters multidisciplinary learning and with a progressive increase in complexity. This way, proposals like Amautas' are helpful to override the additional barriers presented by the wide and unsupervised offer usually found in social media, as well as the biased characteristic of search algorithms.

VI. Limitations and Future Works

The main limitation of this study is related to the sampling bias. As it is a pre-experimental exploratory analysis focused on Amautas' audience as population, the considered sample consists of registered users of the platform, which should be considered when interpreting the results. Moreover, the fact that this study is focused on a specific innovative platform as a case study is a factor affecting the generalizability of the results. This analysis should be complemented in future works with the evaluation of similar resources aimed at a dual use towards education and dissemination.

As future works continuing this research line, the pre-experimental insights documented in this paper will be considered in the proposal of optimized strategies for the curricular alignment of Amautas' contents. Such curricular alignment will aim to match the courses offered by Amautas with the official curriculums for the different STEM subjects of formal secondary and tertiary education. Additionally, guidelines will be defined in the platform's workflow for the creation of new content already aligned with such curricular approach. Moreover, this alignment will further ease the resource's integration strategy from a pedagogical point of view and, therefore, contribute to spread the use of these kind of resources in educational environments.

The next step would be to specifically propose and develop a longitudinal experimental study about Amautas' integration in real classroom environments. This continuation of the research will allow to quantify and analyze its specific impact in students' learning and performance, together with a sensitivity assessment of different integration strategies in combination with active learning methodologies.

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