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YouTube and Education: A Scoping Review

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ABSTRACT YouTube has evolved to a global platform for formal and informal education. In contrast to traditional sources of learning multimedia, YouTube is a social platform with numerous characteristics that make its real value for education not obvious. We neither know how reliable the learning content on YouTube is, what best-practice strategies for using this platform in education are nor how watching YouTube affects students' performance and behavior. To shed light on these questions, we conducted a scoping review of the literature on YouTube and education. A total of 647 publications were included and analyzed thematically. Four research themes could be identified: (1) Content creation and assessment (2) User attitudes and acceptance (3) Usage strategies and behaviors (4) Impact on student learning. The findings of the respective studies were analyzed and compiled theme by theme. The main results of this review are: (1) There is an increasing concern about content quality on YouTube. (2) Despite versatile production and usage strategies, no relationships were established between such strategies and learning. (3) Most studies on the impact of YouTube on student learning reported positive results in the form of enhanced skills, competencies, interest, motivation, engagement levels, or test performance. We conclude that YouTube is a rich, free, easy-to-use, and enjoyable source of learning content. However, the challenges and risks associated with this platform suggest that it is best suitable for guided learning where teachers make or select the content and include it in a well-defined, pedagogy-driven learning context.

INDEX TERMS YouTube, Education, Technology in classrooms, Social media learning, Content quality

I. INTRODUCTION

Multimedia learning is the core service of YouTube when it comes to education. Learning through visual and verbal information has attracted enormous attention in the last two decades aiming to understand the effects of multimedia design on learning [1], [2]. Continuous efforts, e.g., in the context of massive open online courses, are made to understand and enhance the pedagogy of video-based learning [3], [4]. YouTube in education, however, is not just about multimedia learning, and this aspect has not been the focal point of research in this area. Rather, YouTube is a multifaceted platform that affects the process of teaching and learning uniquely in multiple ways. For example, the design of YouTube as a social medium allows every user to upload videos. This feature has led to a massive and continuous growth of freely accessible content with considerably different levels of quality. This situation is making the navigation through YouTube especially difficult [5], which is further complicated by the popularity-driven search and recommendation system of YouTube [6].

Especially this last characteristic creates an issue for informal or unguided learners who are increasingly exposed to unverified and partly misleading content [7], [8]. Another example is the entertaining nature of YouTube and the fact that it is not just a technology for education. Inviting students to watch YouTube is associated with different risks such as compulsive use that can result in reduced academic motivation [9], [10] as well as the exposure to content with sensitive images, violence, and other such activities [11]. So, teachers and instructors should be aware of these risks and learn how to overcome sub-optimal pedagogical practices for using YouTube [12].

On the other hand, YouTube is an opportunity for formal and informal education [13], [14]. Especially in the time of COVID-19, this platform gained increased attention to support teachers and students in distance learning [15], [16]. Educational institutions [17], [18] and professional organizations [19] are posting full lectures and rich materials on

YouTube, making learning content more accessible than ever. Furthermore, diverse professional creators of high-end edutainment content are adding value to this platform [20], [21]. This entertaining form of education is characterized by well-explained content and presentation of real-life examples, which are hardly available in educational settings [22], [23].

Furthermore, various technologies are currently available to facilitate the process of recording and uploading videos to YouTube. For example, many modern Android devices provide a user-friendly interface to upload recorded videos to YouTube without effort. Also, several software companies offer screen recording tools as a browser add-on that allows users to record their screens and upload the recording to YouTube conveniently. Such provisions have encouraged teachers and instructors to enhance their teaching and instructional design using various strategies [24], [25]. Also, students are increasingly using YouTube as a way for learning by teaching [26]. In addition to video playing, YouTube provides a commenting tool that can promote the interactions between viewers and creators as well as among viewers towards social learning [27], [28].

This snapshot of challenges and opportunities illustrates that education with YouTube is not just about multimedia learning. A few reviews were published to highlight some relevant aspects of YouTube in education. However, the literature lacks a comprehensive evaluation of the YouTube phenomenon in education. This evaluation is essential for understanding how YouTube has shaped the educational process in the first fifteen years after its creation and what we still need to investigate in the future.

This paper presents the results of a scoping review of the literature that has been published about YouTube and education between March 2005 and March 2020. The goal is to outline the research landscape in this area and to identify what has concerned scholars and the findings of their work by addressing the following research questions:

- **RQ1:** What are the main research themes that have evolved in the field of YouTube and education?
- **RQ2:** What are the main findings of the individual research themes?

This scoping review aims to inform researchers of the state-of-the-art in this area and help them classify and prioritize individual research activities. Also, practitioners such as content creators, teachers, and decision-makers in educational institutions can benefit from the findings of this review depending on their interests.

The rest of the paper is organized as follows. Section II describes the previous reviews on YouTube and education in brief. Section III describes the methodology we followed in this study. Section IV presents some general findings related to the research on YouTube and education and outlines the identified research themes (RQ1). The following four sections (Section V to VIII) describe the findings of the individual research themes (RQ2). In Section IX, we discuss these findings. Section **??** summarizes all the findings and presents a framework for future research. The same section describes the limitations of our study and concludes it.

II. PREVIOUS REVIEWS

Some reviews of the literature on YouTube and education can be found in the literature. Dughera et al. classified related research into two categories [29]: (1) Literature that describes how YouTube is used by young people. (2) Literature that explores possible connections between YouTube and learning both for formal and informal education. The findings of the first category confirm that young users are enthusiastic about YouTube. They turn to this platform to "show themselves, share their likes and dislikes, develop socialization experiences, find entertainment and at the same time, learn new things" [29]. Studies that connect YouTube to learning were divided into four groups by Dughera et al.: (1) General unfocused studies, (2) studies that investigate interest and informal learning, (3) studies that investigate formal education, and (4) studies that describe creators' practices. The authors explain the different groups by example without data aggregation.

Snelson (2011) reviewed 188 peer-reviewed journal and conference papers published between 2006 and 2009 with the keyword YouTube in the title [30]. The author identified 39 publications that address YouTube in education. Most of these papers were about describing best-practice for using YouTube in teaching. Also, the author identified five empirical studies addressing usage patterns, attitudes, and impact of instruction; six case studies about integrating YouTube into the classroom; two case studies about teacher education, and one case study about students' engagement or distraction through YouTube [30].

Snelson (2016) reviewed 35 studies published from 2008 through 2015. The author highlighted the differences between using available videos on YouTube and content production by teachers [31]. The same author elaborated on video production by students in her scoping review of the 61 studies published from 2006 through 2017, although this review was not specific to YouTube [32]. The author summarized that video production projects were used to meet information, performance, composition, literacy, or creativity goals.

Noetel et al. (2021) compiled the results from 105 papers that studied the impact of videos on student learning in higher education. They found out that videos are unlikely to be detrimental and usually improve student learning [33].

Several authors reviewed studies on the quality of medical and health-related content on YouTube [7], [34]. The number of reviewed papers varies between 11 and 37. In general, all these reviews conclude that YouTube contains both high-quality and low-quality content and that users should be cautious while seeking medical content on this platform.

III. METHODOLOGY

Fig. 1 outlines the approach we followed to perform this study. The presented methodology has some similarities with

PRISMA, but it is not it. In particular, PRISMA is more appropriate for systematic reviews that aim at answering very specific research questions. In contrast, the main objective of our study is to scope the research on YouTube and education. A scoping review aims to "identify knowledge gaps, scope a body of literature, clarify concepts or to investigate research conduct. While useful in their own right, scoping reviews may also be helpful precursors to systematic reviews and can be used to confirm the relevance of inclusion criteria and potential questions." [35]

The approach has eight stages with three rounds of review as described below.

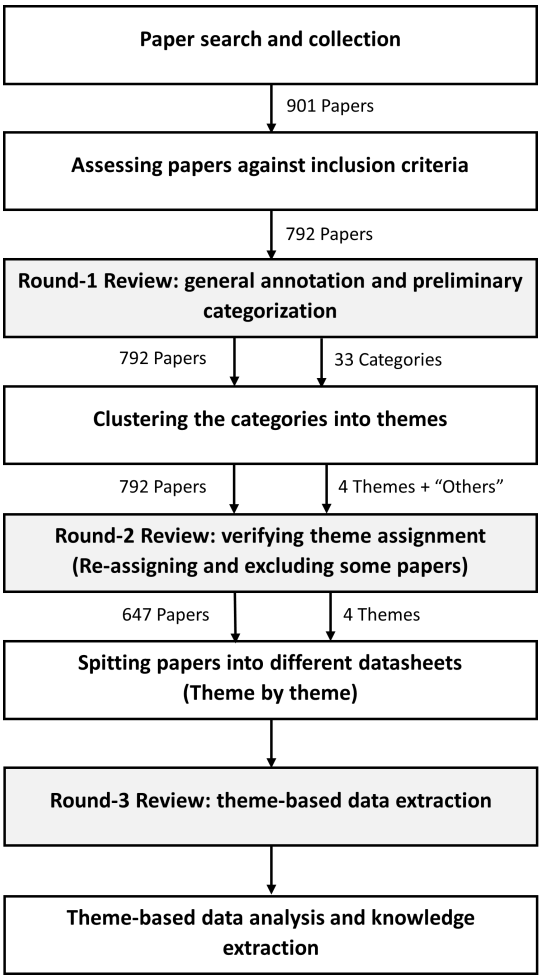

FIGURE 1: Research Methodology

a: Paper search and collection

We used Google Scholar to search for publications that contain the keyword YouTube in the title and at least one of the terms: education, learning, teaching, student, teacher, classroom, exam, schools, university, course, lecture, knowledge, information. Google Scholar is believed to be the world's largest academic search engine [36]. Khabsa and Giles estimated that this search engine covers 80 to 90% of all articles published in English already in 2014 [37]. The search returned 901 publications. We used a datasheet to record the following information about every publication: paper identification number, publication type, title, abstract, publication year, the number of citations, and the country of the first author.

b: Assessing papers against inclusion criteria

In this step, we went through the titles and abstracts of the collected papers and assessed them against the following inclusion criteria:

1) Scope The topic is directly related to formal (pre-school to college) or informal education.
2) Language The paper is written in English.
3) Type The publication is a journal or conference paper, a book chapter, or a thesis. Workshop papers, summaries, lectures, and panel documents were excluded.

First, we removed 46 duplicate papers from the datasheet. Then, we assessed the remaining 855 publications against the inclusion criteria. We found that 21 items were out of scope and 42 items were either not written in English or did not meet the publication type criterion. The remaining 792 papers underwent the Round-1 review.

c: Round-1 review: general annotation and preliminary categorization

In this step, we reviewed the abstracts of all publications and performed an initial annotation to record the following aspects:

1) The main research question of the paper
2) The methodology
3) The main results
4) Other information including the learner type (formal vs. informal), the field of study (medical, science, music, language, etc.), and the level of study (preschool, school, college, etc.)

Based on the main research question, we assigned the papers to preliminary categories that emerged during this annotation process. Examples of these categories are Effectiveness of YouTube, Technology incorporation in classrooms, Teachers' attitudes towards YouTube and their readiness to deploy it, and Surface video features. Appendix A provides a list of the 33 emerging categories.

d: Clustering the categories into themes

In this step, we inspected the emerging categories on similarities using coloring. Initially, we identified four themes: Production, Usage, and Impact. After multiple refinements, we ended up with four core themes and an "Others" cluster, which includes the categories that could not be assigned to any core theme. The outcome of this step was a matrix that maps the emerging categories to the established themes. This matrix was then used to assign the publications that fall under the categories into themes. Technically, we accomplished this by adding a new column to the datasheet called "Themes" to map papers to themes based on the developed matrix.

e: Round-2 review: verifying theme assignment

In this step, we reviewed relevant parts of the papers to verify the correctness of their assignment to the four core themes. Several publications were reassigned or excluded at this stage. The result was 647 papers in the four themes.

f: Spitting papers into different datasheets

Each theme has its characteristics and different types of data that need to be collected. To facilitate the data collection, we split the papers' records into four datasheets, one for every theme.

g: Round-3 review: theme-based data extraction

In this time-consuming step, we extracted relevant data from the papers depending on the theme. The types of collected data have emerged during this stage. For example, in the theme "Usage strategies and behaviors", we looked up data that describe different types of behavior, e.g., search and selection behavior, viewing behavior, and commenting behavior. This specification of behavior types was not known when we started but emerged through the review of the papers.

h: Theme-based data analysis and knowledge extraction

The data extracted in the last step were inspected for every theme to assure consistency and relevance. Various refinement and reclassification steps were necessary at this stage as well as an additional review of some papers. Where applicable, relevant results in different papers were compiled and presented as bar charts to highlight the frequency of related aspects.

IV. GENERAL FINDINGS AND RESEARCH THEMES

This section presents some general findings and outlines the identified four research themes. In the following four sections (Section V to Section VIII), we detail the findings of each research theme.

A. GENERAL FINDINGS

Fig. 2 shows the number of published papers on YouTube and Education from 2007 to 2020. The figure shows a rapid increase in the last three years. The number of publications has almost doubled from 2019 to 2020. Recall that this review concerns the papers published until March 2020 only. The number given in Fig. 2 for 2020 was determined using subsequent research to complete this information.

Asia was leading in terms of the number of publications, followed by North America and Europe, see Fig. 3. On the country level, the United States has published the largest number of papers (26.2%), followed by Indonesia (15.7%) and the United Kingdom (7%). 92.8% of the papers addressed YouTube exclusively, while the rest considered other social platforms besides YouTube. The most addressed educational fields include medicine and healthcare (36%), English language (19%), and science (12%). Almost 61%

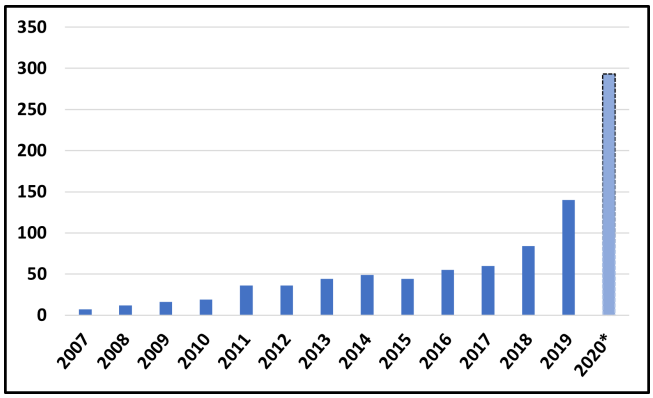

FIGURE 2: Number of papers on YouTube and education published between 2007 and 2020. *This review included the papers published until March 2020.

of the reviewed papers are dedicated to YouTube in formal education (pre-school to college), while the rest targets informal learning. The majority of the papers address college-level education (48%), see fig-general-target.

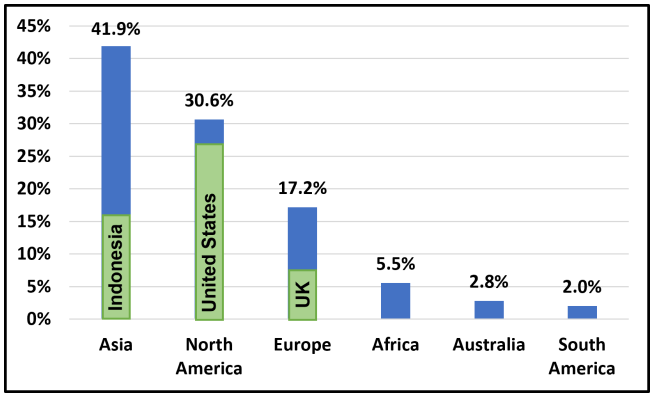

FIGURE 3: Contribution to the research on YouTube and education in terms of country and continent

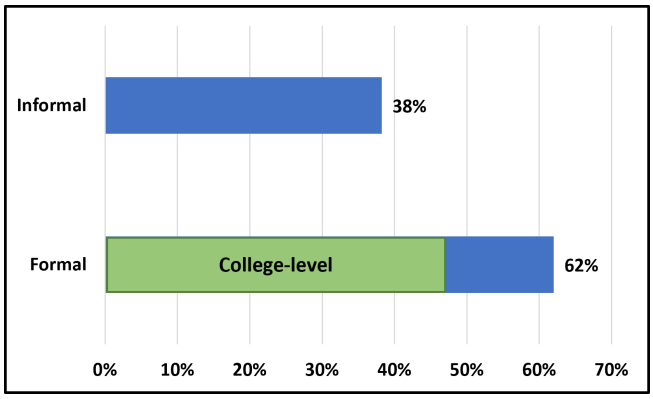

FIGURE 4: Portion of papers that address formal vs. informal education and college-level education

B. RESEARCH THEMES

Fig. 5 illustrates the four themes of research on YouTube and education that resulted from applying the thematic analysis part of the methodology we presented in the previous section. Interestingly, the identified themes reflect the general flow of YouTube's deployment in education to an extent: First, people create content and upload it to YouTube. Teachers, students, and other learners develop attitudes toward this technology and show some level of acceptance. When they decide to use it, they apply selected strategies and develop specific behaviors. Depending on the usage strategy and behavior, students can improve their learning.

The borderlines between the four themes are not rigid. For example, some authors, who investigate the impact of using YouTube on learning (Theme 4), frequently highlighted students' perceptions and attitudes (Theme 2). Also, some authors, who focused on strategies for using YouTube in the classroom (Theme 3), sometimes analyzed the impact on learning (Theme 4). Remember, however, that we decided to classify the publications based on the main research question in the respective paper to avoid multiple categorizations, which otherwise would make the study more complex. Table 1 outlines the number of papers assigned to themes.

TABLE 1: Number of reviewed papers per theme

Theme 1	Theme 2	Theme 3	Theme 4
223	66	112	246

V. CREATION AND QUALITY ASSESSMENT OF YOUTUBE VIDEOS (THEME 1)

The focus of this theme is two-fold: (1) Qualitative and quantitative studies that investigate how to create educational videos for YouTube and how the creation affects viewers' participation. (2) Content analysis studies that investigate the information quality of YouTube videos' content. Almost all the papers in this category relate to videos for medical education or health-related information.

A. CREATION OF EDUCATIONAL VIDEOS ON YOUTUBE

Offering content on YouTube has three steps: creation, upload, and dissemination. Google has optimized its platform, YouTube, to reduce the overhead of uploading content to a minimum and the hosting costs to zero. Also, YouTube offers some functions that help in content dissemination like subscription, sharing, and recommendation. The research on YouTube and education has essentially addressed the creation step. The related papers in this theme can be classified broadly into two categories:

1) Qualitative studies that analyze production features and strategies and identify best practices for the creation of educational videos for YouTube. This category makes around 55% of the reviewed papers (18 papers).
2) Quantitative studies that try to identify relationships between video features and viewers' responses. This category makes around 45% of the reviewed papers (15 papers).

1) Qualitative studies on video production

The goal of the considered qualitative studies is to provide guidelines for creating high-quality videos to attract learners and promote social interactions [38], [39]. For this purpose, the authors, of the reviewed papers, have analyzed different features related to:

a. The video (lifetime, duration, resolution, clarity, title, description, tags length, and production style)
b. The speaker (talking speed, gender, age, native, body language, etc.)
c. The viewers (location, gender, watching time, social interaction in terms of liking, disliking, sharing and commenting)
d. The content (relevance, motivation, and vividness).

The authors, then, made recommendations for the preparation, recording and editing, and uploading of videos as described below.

Preparation: During the preparation phase of an educational video, creators should define a clear learning objective, write a good script, and prepare high-resolution images and sounds for the video [40], [41]. Drew pointed out that the creators of educational videos should include real-life examples in their videos and ask open-ended questions to enhance active learning and to encourage students to apply, criticize, and analyze what they learn. [42].

The length of the script, and hence the video, is a frequently highlighted aspect in making educational videos. Most researchers recommend making shorter videos and avoiding lengthy overviews [43], [44] or summaries [41], although some authors assert that the duration of the video is insignificant for the educational quality of content [45], [46].

Recording and editing: After preparing the needed materials, creators should select high-quality hardware like a camera and a microphone [47] and proper software for recording and, possibly, mixing pre-recorded narration with the prepared images [41], [48]. While making the video, creators are advised to use suitable body language and a reasonable talking rate [40], [41]. Also, they should, as far as possible, include effective humor to encourage repetitive viewing and promote learning [40], [41]. Recorded videos often require editing. Creators are recommended to use professional editing tools for trimming, re-sequencing, and transitioning such as Moviemaker, adobe premiere, iMovie, and Camtasia Studio [41], [43] as well as for integrating images and animations [41], [43]. Adding subtitles and captions is also recommended by some authors [40], [49]. During editing, creators can insert annotations to support active learning and reduce passive viewing [47], [50].

Uploading: Finally, edited videos should be uploaded to YouTube. Creators need to add descriptive titles to their videos and choose attractive thumbnails to help users find the videos and select them [40], [41]. Researchers gave more

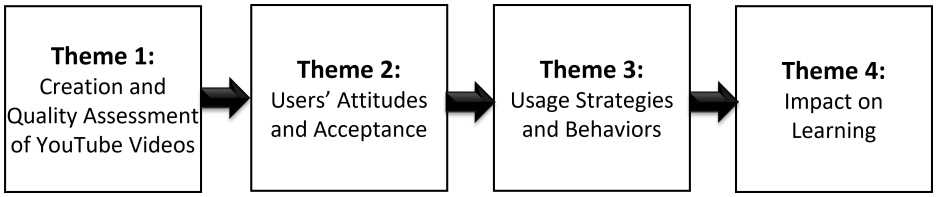

FIGURE 5: Four themes of research on YouTube and Education

hints for uploading videos such as adding related materials to descriptive playlists [47], [48] and enable comments to promote viewers' interaction [51], [52].

2) Quantitative studies related to video production

Several papers tried to find links between video popularity metrics such as the number of likes, dislikes, and views on one hand, and factors related to video-making, on the other. The analyzed factors either concern the speaker or the video production style as described below.

Speaker gender and language: Some authors analyzed the impact of speaker gender on viewers' perceptions of educational videos with some contradictory results. Meseguer-Martinez et al. found out that students tend to like videos produced by female instructors [44]. In contrast, Shoufan showed that the educational value of YouTube videos is not related to the gender of the speaker [45]. Some authors found that videos in specific fields were dominantly produced by male speakers [53], [54]. Educational videos were found to be more liked if the presenter is native and speaks at a higher talking rate [55]. Videos by creators, who engage viewers and call to action [56] or interact with users through comments [57] seem to be viewed more frequently.

Video production style: Some authors investigated the role of the production style on the viewers' perceptions. Shoufan and Mohamed found out that videos that use explanations on paper or whiteboard or multiple production styles attract more likes per view [55].Using a Talking-Head production style was criticized by Petty since it focuses on viewing the speaker and does not utilize the visualization and demonstration capabilities of multimedia [41]. Similarly, de Azevedo Fay and Matia observed that most videos that teach language grammar use oral explanation [49] without visual aids. On the other hand, Meseguer-Martinez found out that the videos that uses slides, graphic tablets or the videos in which the instructor appears on the screen are more likely to be liked by the viewers [44]. Velasco found that the number of views of educational videos on YouTube increases when the production quality is high and the video has a combination of elements like voiceovers, animation, and background music [56]. As mentioned previously, most authors who analyzed the relationship between video popularity and length found out that shorter videos are more likely to be viewed [57], [58], although the quality of content does not seem to relate to the video length according to [59].

B. QUALITY ASSESSMENT OF HEALTH-RELATED CONTENT

Health-related information is crucial and can - significantly - affect users' well-being and patients' decisions regarding medications and treatment procedures. Researchers showed early concerns about the quality of health-related content on YouTube and started inspecting this issue as early as 2007 [60]. Since then, the number of publications that assess the quality of health-related content has been ever increasing. In the following sections, we first highlight some methodological aspects and then compile the findings of reviewed papers.

1) Methodological aspects

The reviewed studies addressing content quality on YouTube have followed a semi-unified research approach and generally limited their scope to a single medical topic. Inclusion and exclusion criteria related to video characteristics, such as the number of views and comments, are specified to identify potential videos. The content quality of the considered videos is analyzed and evaluated by one or more experts using standard or self-devised scoring systems. Based on the given score, each video is classified into one of several quality categories specified by the researchers. The authors employ the relative frequencies of using these categories to provide a general evaluation of the quality of health-related information on YouTube. Based on the results of their studies, most authors formulate general recommendations for improving the information quality on this platform.

2) Quality assessment results

After reading the reviewed papers, we found that the authors used different numbers and labels for the quality classes. Such variations imposed a challenge for compiling the results. To overcome this challenge and allow a concise data aggregation, we mapped the authors' quality classes into one of the three new classes, Good, Average, and Poor, and we mapped the video assignments accordingly. Table 2 summarizes the average percentage of videos assigned to these new classes. Note that the sum of the third column exceeds 100% because not all papers have classified videos into three quality classes. Table 6 in appendix B shows a detailed example to illustrate this aspect.

Many authors have performed correlation analyses between the video quality and popularity matrices including the number of views and likes. Table 3 compiles the results of these analyses. For example, out of 43 papers that correlated the video quality with the number of views, only seven

TABLE 2: Compiled results of content quality analysis

Quality Class	Average percentage of videos assigned to this class[a]
Good quality	58%
Average quality	33%
Poor quality	81%

[a]Explaining why the sum is grater than 100% is provided in appendix B.

(16.3%) found a positive correlation [61], [62]. The other papers either reported negative (30.2%) or no correlation (53.5%), [63], [64].

3) Recommendations for content quality improvement

About 11% of the authors regard the quality issue on YouTube as very severe and recommend users to avoid this platform as a source for health-related information [65], [66]. In contrast, 2% of the studies raised no quality concerns [67], [68]. Most other authors provided constructive recommendations for improving the quality of health-related content on YouTube. Almost 44% of the reviewed papers encouraged credible sources such as medical organizations and professional institutions to upload high-quality content [69], [70]. Moreover, many authors urged that experts should play an active role in reviewing the content (6%) or recommending high-quality content to users (18%) [71], [72]. Furthermore, 14% of the authors recommend information seekers be cautious when viewing health-related videos on YouTube [73], [74]. Finally, 5% of the authors recommended that YouTube should improve its ranking, filtration, and recommendation systems to promote higher-quality content [75], [76].

TABLE 3: The correlation between video quality and popularity in the reviewed studies

Correlation	No. of papers correlating video quality and the number of views	No. of papers correlating video quality and the number of likes
Positive Correlation	7	7
No Correlation	23	14
Negative Correlation	13	6

VI. USER ATTITUDES AND TECHNOLOGY ACCEPTANCE MODELS (THEME 2)

Many authors investigated users' attitudes toward YouTube as educational technology, studied the opportunities and challenges of this technology, and analyzed the factors affecting its acceptance. The research in this area essentially relies on surveys and interviews of teachers, teacher candidates, instructors, students, and informal learners. 59%, 24%, and 16% of the studies addressed college-level students, school-level students, or informal learners, respectively. 36% of the papers relate to using YouTube for learning English or for medical studies. While most authors devised their instruments, the studies on YouTube acceptance relied on established models or theories such as the technology acceptance model and the unified theory of acceptance and use of technology. In the following, we first aggregate the findings of the studies on YouTube acceptance. Then, we summarize research results concerning user attitudes toward YouTube and highlight its opportunities and challenges for education.

A. ACCEPTANCE OF YOUTUBE FOR EDUCATION

Several authors were interested in understanding the factors that affect behavioral intention to use YouTube for educational purposes since this intention is assumed to lead to actual use. A widely used theory is the technology acceptance model (TAM) that attributes the behavioral intention to use technology to the positive attitudes toward it [77]. According to this model, positive attitudes are affected by the level of perceived usefulness, i.e., the "the degree to which a person believes that using a particular system would enhance their job performance" and the level of perceived ease-of-use, i.e., the "the degree to which a person believes that using a particular system would be free from effort" [77]. TAM or TAM-related models were used in four of the reviewed studies that investigated the acceptance of YouTube for formal or informal education [78]–[81]. Three further studies used the unified theory of acceptance and use of technology (UTAUT) [82]–[84]. This theory explains the behavioral intention to use technology by four constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions [85]. These constructs are moderated by gender, age, experience, and voluntariness. Some authors investigated the acceptance of YouTube based on older theories such as the theory of reasoned action [86], the theory of planned behavior [87], and the social cognitive theory [88].

Fig. 6 summarizes the results of the reviewed papers on the acceptance of YouTube as an educational platform. An unsigned number over an arrow gives the number of studies that showed evidence for the respective relationship. For example, six papers showed a significant relationship between positive attitudes toward YouTube and the behavioral intention to use it. In contrast, a negative number represents the number of studies that found no evidence for the respective relationship. For example, two papers showed that the perceived ease of use has a significant impact on the behavioral intention [79], [80]. However, two other articles found no evidence for such relationship [78], [81]. From the figure, we conclude the following:

1) The behavioral intention to use YouTube for education is essentially affected by the positive attitudes toward YouTube, the subjective norm, and the perceived usefulness of this platform.
2) The subjective norm (the belief that an important person or group of people will approve and support a particular behavior) affects both the behavioral intention to use as well as the actual use of YouTube for education.
3) The perceived usefulness of YouTube is mainly determined by the richness and vividness of its content, as well as by its support of educational tasks (task-technology fit).

4) The ease-of-use does not seem to be a significant factor for the behavioral intention to use YouTube.

B. YOUTUBE OPPORTUNITIES AND CHALLENGES

The opportunities of using YouTube for education can be divided into five categories as illustrated in Fig. 7. The percentages given in this figure represent the relative frequency of the papers that we assigned to the respective categories. So, the most frequently highlighted features in this context relate to pedagogical versatility. This describes YouTube's ability to support online teaching of big classes [89], learning through participation and knowledge exchange [90], as well as informal and life-long learning [13]. Many authors consider the perceptions that users develop about YouTube as an opportunity for using this platform for teaching and learning. For example, users find YouTube entertaining, enjoyable, and motivating [91], [92]. Some authors reported that teachers support YouTube because it can help students improve their confidence [93] and reduce their anxiety [94]. Many authors emphasize that content on YouTube is rich and vivid, which represents an attractive opportunity for education. So, YouTube offers various sources of content such as lectures, tutorials, and real-time examples [88], [95] and uses versatile ways for content explanation [92]. Finally, 15% of the advantages of using YouTube in education are linked to its free, easy, and convenient access according to [95], [96].

The challenges of using YouTube for education can be divided into four categories as illustrated in Fig. 8. The most frequently highlighted issues are related to the integration of YouTube into the classroom. Some of these challenges are the difficulty of classroom management [12], the lack of the systematic assessment of learner's progress [13], and the politicization of classroom when controversial topics were presented and discussed [97], hindrances through some school policies [98], and sometimes the lack of teacher's digital competence [99]. The next category of challenges relates to the content. On top of this category is the lack of measures to assess the content quality [12], which can make finding useful videos very time-consuming [90]. Also, issues related to copyright were mentioned [99]. Furthermore, some authors highlighted technical challenges for the adoption of YouTube, especially in developing countries. These include issues related to the connectivity to the internet, the availability of required devices, or the unstable supply of electricity [84]. Furthermore, some authors addressed some risks to students who use YouTube to learn. For example, young learners may be exposed to inappropriate content or privacy issues through comments or uploading private videos [93].

VII. USAGE STRATEGIES AND BEHAVIORS (THEME 3)

The impact of YouTube on learning depends on how teachers or instructors employ this technology and how students behave while using it. We identified 76 papers that address strategies and behaviors related to using YouTube in education. The majority of these papers address either strategies or behaviors exclusively. Four papers address both as summarized in Table 4. 57% and 16% of the papers study strategies for and behaviors of college-level or school-level students, respectively. 28% of the papers don't specify the learners' level. The reviewed papers span a wide range of fields as seen in Fig. 9. Accordingly, finding appropriate strategies and understanding students' behavior while using YouTube to learn English as a second or foreign language have attracted more research than any other field [100], [101].

TABLE 4: Number of papers addressing strategies and behaviors in the use of YouTube in Education

Strategies	**Behaviors**	**Strategies** and **Behaviors**	**Total**
43	29	4	76

A. METHODS USED IN THE RESEARCH ON YOUTUBE'S STRATEGIES AND BEHAVIORS IN EDUCATION

To study strategies and behaviors, the researchers used different qualitative and quantitative methods that can be grouped into six categories, as can be seen in Fig. 10. Discourse and sentiment analyses of user comments and case studies make half of the methods used in the reviewed papers. Viewers' comments are beneficial for understanding users' behaviors and responses to specific strategies especially when the users are not available to provide alternative data such as responses to questionnaires. Researchers applied different discourse and sentiment analysis tools to understand various aspects. These include investigating the use of YouTube as a self-directed or informal learning platform [28], [102], understanding students' responses to content presentation [103], or whether commenting in itself can enhance learning [104]. Case studies were used to investigate particular aspects in detail, e.g., how preservice teachers integrate YouTube into classroom teaching [105] or how students make meaning with information sources on YouTube to support their academic needs, e.g. seeking assistance for homework [106].

Several authors used qualitative approaches based on questionnaires and surveys. In [107], for example, the authors surveyed students about the preferred source of videos, YouTube, or the library's multimedia collection, and whether their choice depends on the tasks to be performed. Classroom observations and interviews were also considered sometimes using focus groups. For example, in [108] the authors interviewed 30 students to develop a scale for academic learning as a determinant of YouTube usage. Experiments were used in some quantitative studies, e.g., to assess students' perceptions and patterns of usage and the effectiveness of YouTube for problem-based learning [109].

B. FINDINGS OF THE RESEARCH ON YOUTUBE'S STRATEGIES AND BEHAVIORS IN EDUCATION

Fig. 11 shows seven categories of strategies that we could identify in the reviewed papers and the number of papers that fall into these categories. As can be seen, three categories relate to video creation, selection, and streaming. The other

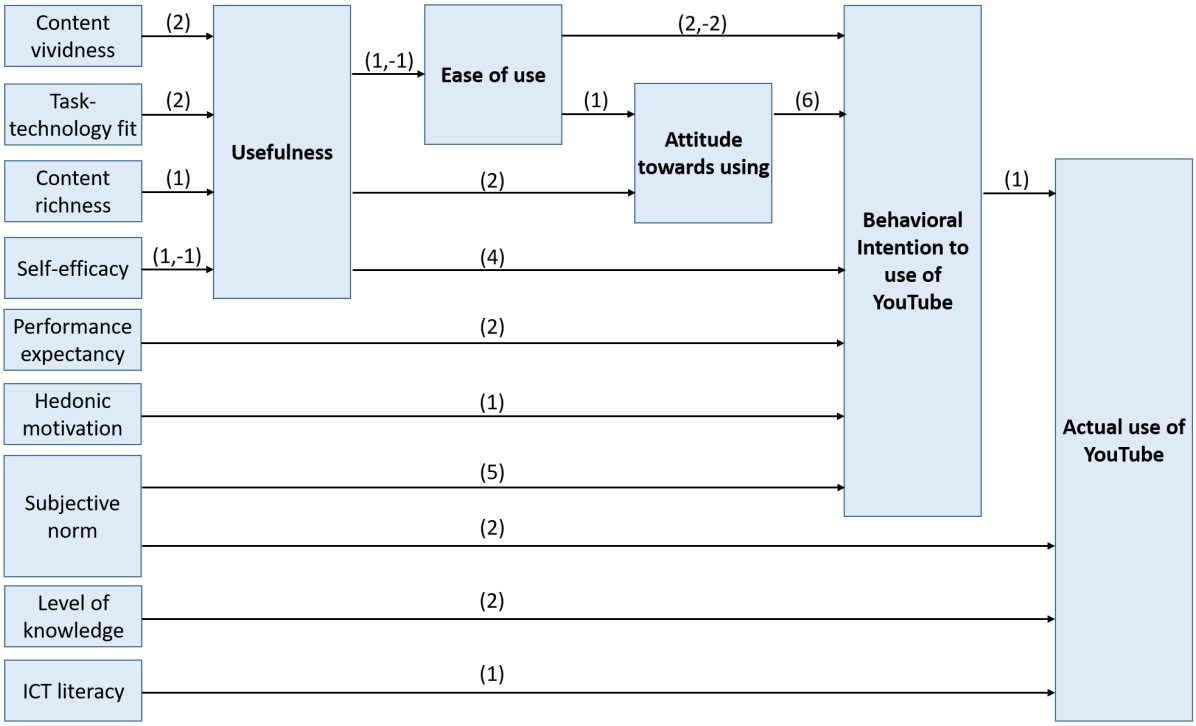

FIGURE 6: Factors affecting behavioral intention to use / the actual use of YouTube

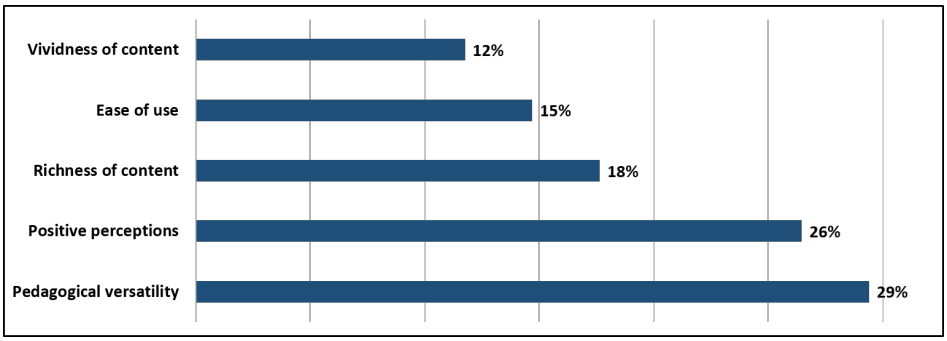

FIGURE 7: YouTube opportunities for education assigned to five categories

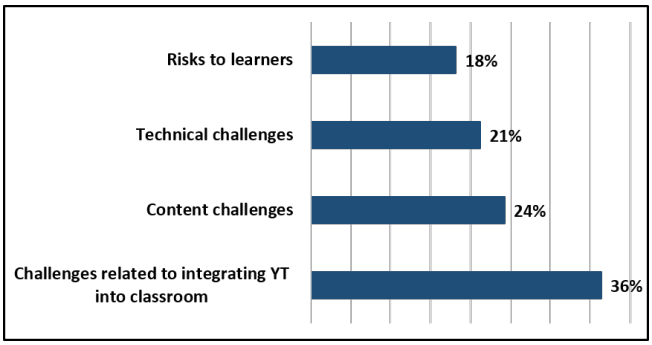

FIGURE 8: YouTube challenges for education assigned to four categories

four categories address pedagogy-driven usage strategies. Twelve papers investigated video creation or selection by students, e.g., for self-guided learning or peer instruction [100]. For instance, in [101], the students learned to teach their friends English using YouTube videos in different settings like embedding the videos into PowerPoint slides with or without written explanations.

In [110], the authors included YouTube creation assignments to enhance students' understanding of chemistry concepts through self- and peer-explanation strategies. As for strategies related to video creation and selection by the instructor, Faye, for instance, surveyed 213 first-year students about their perceptions of the use of instructor-made YouTube videos. The author found out that students prefer videos made by their teacher over those made by others. The study also suggests that the videos should be shorter than 15 minutes [24]. Some authors considered live streaming of educational videos on YouTube to allow the interaction with viewers [111].

From a pedagogical perspective, ten papers investigated

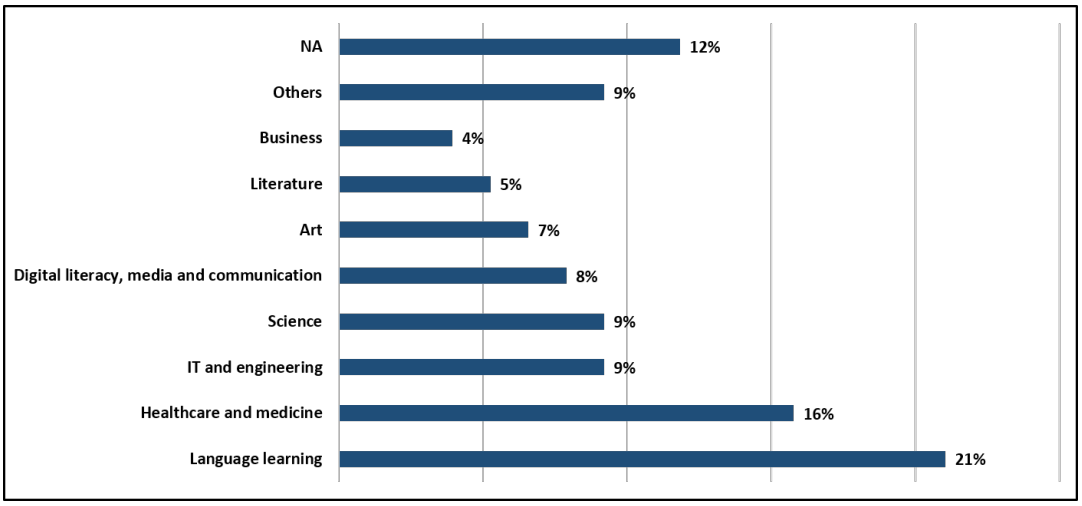

FIGURE 9: Fields addressed in the reviewed papers addressing strategies and behaviors

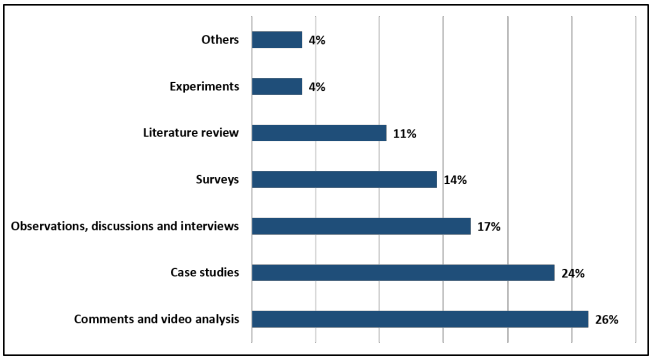

FIGURE 10: Methods used in the studies addressing strategies and behaviors

the potential of YouTube to support active learning strategies. These include among others problem-based learning (PBL) [109], [112], actions-in-ongoing-events in physical education [113], [114], homework and exercises [115], and embedding YouTube videos into Moodle activities [116]. Some authors believe that using YouTube within the classroom is more appropriate than asking students to watch videos outside the classroom [117]. Several authors discussed strategies for using YouTube in the classroom such as motivating the topic at the beginning and explaining complex concepts [112], [118]. In contrast, the possibility of using YouTube out-of-class has been investigated as an enabler of self-directed learning in the first place [111], [114]. Tisdell regards YouTube videos as an important source to enhance face-to-face lectures and tutorials [119]. Finally, collaborative learning is another strategy for using YouTube in education. Some authors inspected how YouTube can be used to stimulate students' and viewers' discussions and interactions and to create a learning community [120], [121] facilitating the construction of knowledge and understanding [112]. The reviewed papers address many aspects related to the learner's behavior. We categorized this behavior according to the viewing process starting from the motivation to watch, through the search, selection, and viewing, to the participatory commenting behavior, see Fig. 12. Essentially, the researchers found out that the viewing behavior is motivated by students' desire for self-directed learning [28], [122], social learning [123], or reviewing before exams [124]. When it comes to the search and selection of videos for learning, it is believed that there are two important factors: the relevance of the video and its popularity [118]. Pokharel found out that learners are used to checking the video metadata (likes, views, comments) before selecting a video relying on their experience for the final decision. Also, learners do not always seek videos made by experts but enjoy viewing amateur videos as well [125]. Furthermore, students seem to favor YouTube channels [126]. Native and non-native English speakers seem to have different search, selection, and viewing behaviors [127]. Two studies investigated the viewing behavior from a gender perspective [128], [129]. The findings, however, are contradictory concerning which gender uses YouTube for learning more frequently [128], [129]. The commenting behavior was essentially analyzed from a pedagogical perspective and how comments can be used to ask and answer questions as a form of peer instruction [104], [130]. Some authors addressed other aspects related to commenting behavior. For example, Myers found out that the frequency of commenting depends on the discipline. Math and science videos are less commented than those related to human sciences [123]. Bringula et al. applied cluster and sentiment analysis to the comments on programming-related videos and found out that most of these comments are about confirmation, gratitude, and recommendation [103]. Several authors highlighted negative behaviors while using YouTube in education. These include addiction [131], revealing personal information [132], and spurious or ad hominem comments on videos that contradict the learner's point of view [123], [130]. Finally, Leiner analyzed user comments and found several positive behavioral changes in children through watching selected YouTube videos [133].

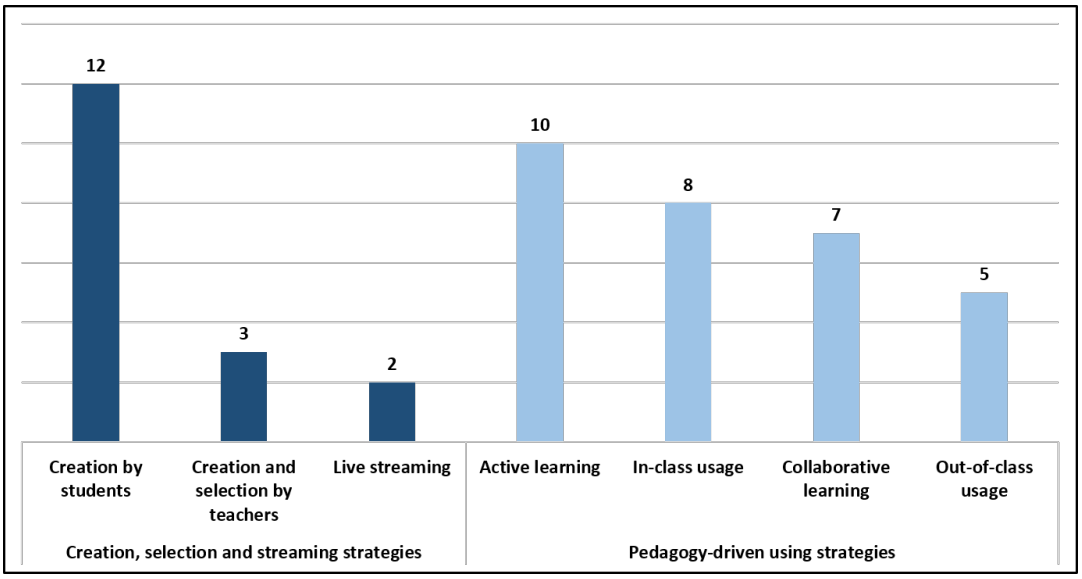

FIGURE 11: Categories of strategies addressed in the reviewed papers

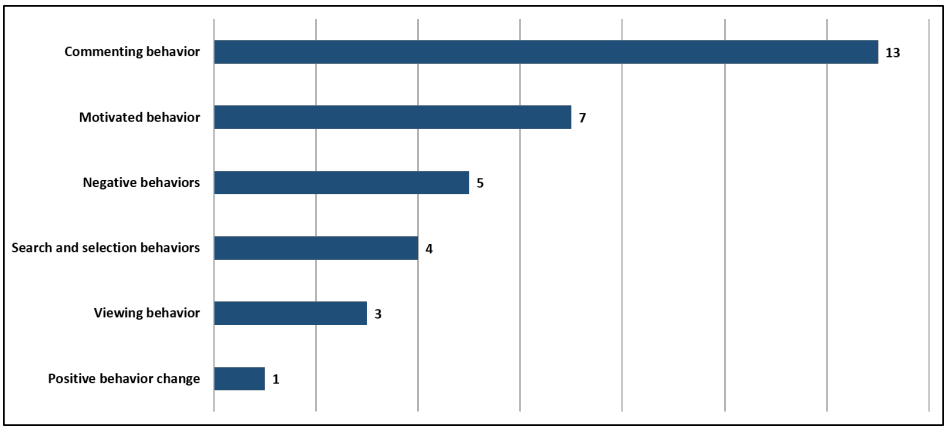

FIGURE 12: Categories of behaviors addressed in the reviewed papers

VIII. IMPACT ON STUDENTS' LEARNING (THEME 4)

The ultimate goal of any educational endeavor is to learn. In this review, we identified 246 papers that focused on the impact of YouTube on students' learning. In the following sections, we first summarize the research methods used in the reviewed studies. Then, we aggregate the findings of these studies. Finally, we summarize the recommendations, guidelines, and future directions as reported in the reviewed papers.

A. METHODOLOGICAL ASPECTS

To evaluate the impact of YouTube videos on students' learning, researchers collected different types of data using tests, surveys, interviews, class observations, and discussions, see Fig. 13.

Almost 39.8% of the reviewed papers used surveys and questionnaires to collect the students' feedback on how the incorporation of YouTube videos has affected their learning, understanding, and motivation [134], [135].

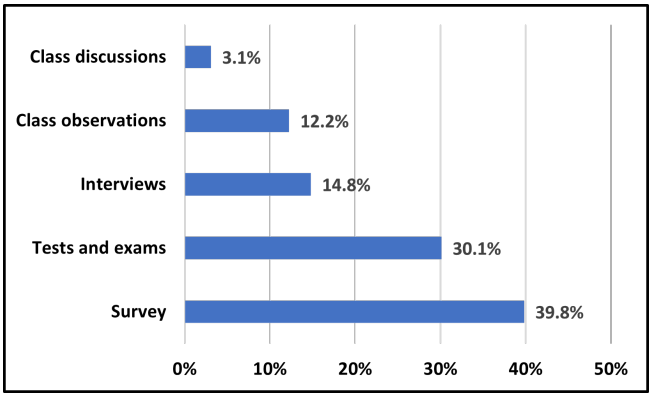

FIGURE 13: Methods used in the studies addressing the impact on students' learning vs. the percentage of the reviewed papers

Furthermore, 30.1% of the reviewed papers used tests or exams to assess the performance of the students after including YouTube videos in their classes [136], [137].

Around 44% of these papers that presented test-based assessment used pre-, and post-tests to measure the performance change [138], [139]. In particular, students were given a pre-test and post-test before and after watching the YouTube videos. In 22 papers, furthermore, the researchers divided the students into control and test groups where the latter learned through YouTube videos while the former used traditional learning methods [140], [141].

Interviews, class observations, and discussions were used in 30.1% of the reviewed papers. The goal of such qualitative studies is to understand students' opinions about and perceptions of YouTube [142], [143]. Different methods were used to analyze the collected data. These include the Constant Comparative Method, which is based on data comparison to identify similarities and differences [144], [145], the Interactive Model, which focuses on continuous interaction between the researchers and the students [146], [147], and the Thematic Analysis, which focuses on examining patterns of meaning within data [148].

Not all reviewed papers reported the number of students who were surveyed, interviewed, or observed. Table 5 summarizes some statistics related to the sample size, which varied between 10 and 439.

TABLE 5: Basic metrics for the number of students included in the reviewed studies

Mean	SD	Median	Max	Min
77.1	76.1	60	439	10

B. RESULTS SUMMARY

Through an in-depth review of the papers that investigated YouTube's impact on student learning, we could identify that the researchers assessed this impact mainly by reporting six possible outcomes. Fig 14 summarizes these outcomes and the percentage of papers that confirmed or disconfirmed the respective effect.

1) Promoting interest, motivation, and engagement

Our analysis showed that 26.8% of the reviewed studies have confirmed that YouTube videos promoted students' interest, motivation, and engagement [149], [150]. The researchers observed an improved level of attention [151], [152] and participation [153], [154] after incorporating videos into classrooms. Also, some authors reported enhanced engagement with the course content [135], [155]. Only a few studies have reported that some students have rated YouTube videos as less motivating in classrooms [156]. Some authors could not observe a considerable difference in classroom participation [157]. In another study, the authors reported that YouTube may negatively impact the social interaction in the classroom [158].

2) Improving test performance

Many authors analyzed the impact of YouTube on students' performance by administering written or oral exams or tests. The researchers tended to compare exam results before and after incorporating YouTube videos into classrooms. 18.7% of the reviewed papers found out that YouTube videos have a positive impact on the students' performance and grades [159], [160]. This means that the students who watched YouTube videos have scored higher than those who studied without viewing videos. On the other hand, five papers (1.9%) have found that students performed almost the same before and after incorporating YouTube videos into their classes confirming that YouTube videos have a little or no effect on the student's performance compared to the conventional methods [161]–[163].

3) Enhancing various skills

Almost 17.6% of the reviewed papers reported improvements in the students' skills after watching YouTube videos [164], [165]. The enhanced skills include language skills such as speaking [166], [167], listening [168], [169] and writing [170], [171]. Other skills unrelated to languages include software learning [172], hair-styling [138] and manual skills [173]. 1.5% of the papers took an opposite position by concluding that there is no significant correlation between watching YouTube videos and enhancing students' skills [174].

4) Promoting deep learning and understanding

In 16.9% of the papers, the researchers found that watching YouTube videos promoted students' learning, deep learning, and understanding [175], [176]. Surveyed students indicated that YouTube videos helped them to boost their learning and supported their understanding [177], [178]. On the other hand, some students believed that not all videos were helpful [143], [179].

5) Enhancing various competencies

YouTube was also believed to improve student's competencies in almost 13.1% of the papers, seee Fig. 15. Out of these papers, several studies highlighted the increase in confidence (32.1%) [180], [181], communication competencies (21.4%) [182], [183], creativity (14.3%) [184], [185], teamwork [186], [187], critical thinking [188], [189], problem solving [190], [191], and ethical thinking [192]. On the contrary, only few papers highlighted that YouTube videos do not affect students' competencies such as problem-solving abilities [193].

C. RECOMMENDATIONS AND GUIDELINES

We extracted, analyzed, and classified the recommendations made in the reviewed papers into the five items shown in Fig. 16. Accordingly, the authors of 48.1% of the reviewed papers made the general positive recommendation that teachers should consider using YouTube videos in classrooms [149], [171]. In contrast, 24.1% of the papers emphasized the teacher's role in selecting relevant, consistent, and high-quality content that addresses the learning objectives and suits students' backgrounds and cultures. Also, teachers

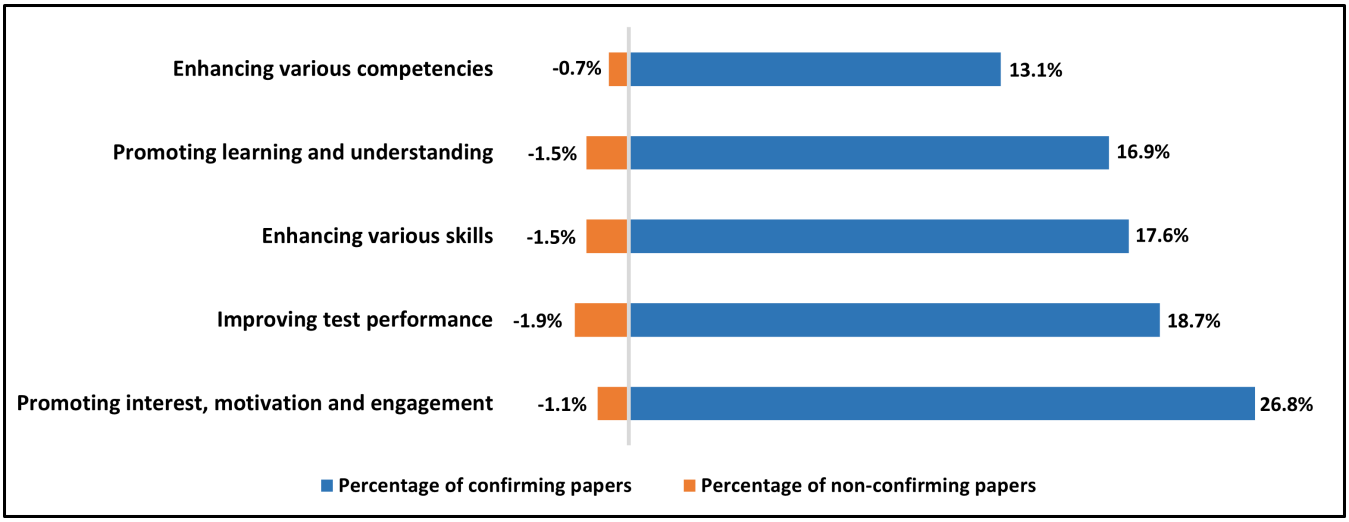

FIGURE 14: Possible outcomes of using YouTube in education as reported in the reviewed studies with the percentage of confirming (right) and non-confirming papers (left)

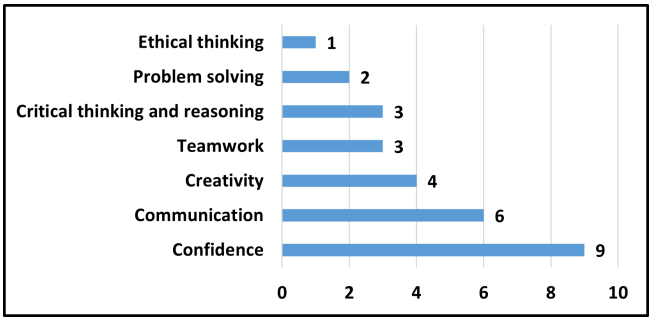

FIGURE 15: Enhanced competencies vs. the number of the papers addressing them

should use effective strategies for including YouTube videos in classrooms [147], [194]. Several papers reported that some teachers avoid using YouTube in classrooms due to difficulties in dealing with this technology and the lack of related training programs [195]. Therefore, 16.7% of the papers recommended that both teachers and students need to be trained on how to use YouTube and how to search for and select relevant videos [196], [197]. The authors, who were concerned about YouTube's quality, credibility, and privacy issues, advised students to use this technology with caution or to seek alternative platforms that provide access to specialized and high-quality material for credible sources [164], [181]. Finally, 1.9% of the reviewed papers suggested expanding the capabilities of the information and telecommunication technology to improve access to YouTube videos [179], [198].

IX. DISCUSSION

A. WHAT PRODUCTION FEATURES AFFECT THE USEFULNESS OF EDUCATIONAL VIDEOS ON YOUTUBE?

Content creation is a crucial task and we need to understand what makes a video useful for learning. Ideally, this can be investigated experimentally by exposing learners to videos with different features and observing learners' responses in terms of engagement, learning performance, or perceptions. Such evaluations are a common practice in the research on video-based learning. For instance, Pi (2022) analyzed the effect of the instructor's beat gestures and head nods in video lectures on visual learning [199]. The authors found out that the complexity of the content moderates this effect. While such rhythmic movements facilitate visual learning of simple material, they offer no benefits when the material is complex. Mohammadhassan, Mitrovic, and Neshatian (2022) investigated student engagement with educational videos and the impact of quality nudges (personalized interventions) on learning [3]. The authors found out that quality nudges enhance student engagement by writing more and better comments. Henderson and Schroeder (2021) conducted a systematic review to examine the impact of an on-screen instructor on learning and perception [4]. The analysis of the included twelve studies, however, provided no evidence neither for nor against the presence or absence of the instructor in the videos.

Unfortunately, such rigorous analyses of YouTube videos are scarce. Instead of observing students' responses, researchers tend to use popularity data to evaluate videos. However, there is no consistent understanding of such data and how they should be included in the analysis. While Velasco considers the number of views as an indicator of video popularity [56], others asserted that the number of likes per view offers a stronger prediction power [55]. In a previous publication, the authors highlighted that the quality of explanation is the most relevant factor for liking or dis-

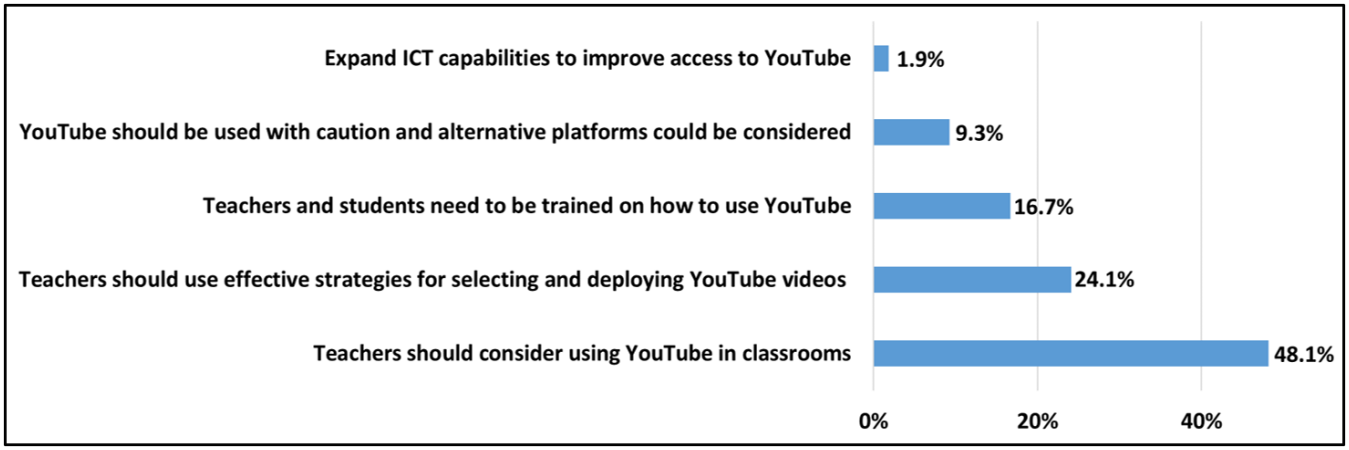

FIGURE 16: Impact on learning recommendations

liking a video by university students [59]. However, it is not clear what constitutes a good instructional explanation [200]. Maynard commented that videos produced by professional educators on YouTube help in improving the trustworthiness, richness, and quality of online videos [201]. However, the author observed that teachers are less active in this area due to limited time, resources, and institutional support, or simply because of the lack of interest or talent in creating and editing videos [201].

B. IS YOUTUBE A RELIABLE SOURCE OF EDUCATIONAL CONTENT?

This review showed that this research question was addressed almost solely for medical content both for formal and information learning. The compiled results of content analysis of medical and health-related videos in Table. 2 highlight a significant quality issue in this type of content on YouTube. For example, researchers who used the category "poor quality", found out that almost 81% of the analyzed videos fall into this category. This issue is worsened by the observed low or even negative correlation between content quality and video popularity metrics (e.g., views, likes) as shown in Table 3. This indicates that users are more likely to see lower-quality videos at the top of the returned list. Although not explicitly investigated in the literature, it would be expected that learners tend to select from the top of the list due to social popularity and time scarcity [202].

The issue of the appearance of lower-quality content at the top of the search list can persist due to the nature of popularity dynamics on YouTube. Figueiredo et al. described the popularity growth patterns of top videos and asserted that they "experience a sudden burst of popularity remaining attractive for a while" [203]. Probably based on this understanding among others, 11% of the authors, who performed content analysis studies on medical videos, expressed an entirely negative position and recommended that this platform should not be used for seeking medical and health-related information as shown in section V-B3. Indeed such as recommendation is impractical knowing that > 3.02 billion people are expected to use social media platforms such as YouTube to seek health information by 2021 [204]. Also, warning people of using YouTube to acquire medical knowledge ignores the fact that this platform hosts a large portion of high-quality and useful videos. Therefore, nearly 85% of the authors provided more practical recommendations to improve the situation as summarized in section V-B3. It is, however, not very clear how fruitful these recommendations are. For example, 44% of the authors recommended that professionals and health institutions should upload more videos on YouTube. However, this recommendation can only be helpful if these videos get a chance to appear at the top of the search list, which requires an improvement of YouTube's ranking and filtration system, as recommended by 5% of the authors. On the other hand, Desai and colleagues claimed that the public does not engage with videos uploaded by credible health organizations because such videos tend to show extensive educational content, making them overly appropriate for the public [205].

C. WHAT ARE THE MAIN ADVANTAGES AND DISADVANTAGES OF YOUTUBE AND HOW DO THESE AFFECT ITS ACCEPTANCE IN EDUCATION?

In Section VI-A, we saw that several authors applied different models to investigate the user acceptance of YouTube as an educational platform. The aggregation of data from these studies in Fig. 6 shows that the behavioral intention to use YouTube is essentially affected by its usefulness, users' attitude, and the subjective norm. The ease-of-use does not seem to be a determinant of YouTube acceptance according to this diagram. Two studies confirm its contribution to the behavioral intention to use, while two other studies do not. This contradiction could be explained by the arguments of some scholars who gave some criticism to technology acceptance models in general. For example, van der Heijden asserted that users assess their perceptions of a particular technology from different orientations, which can lead to conflicting results [206]. Furthermore, that people tend to change their attitude towards a technology depending on the current context [207]

or the purpose of use [208]. As we saw in this review, users seek YouTube with different orientations and in various contexts: quick reviews before exams, solving homework assignments, entertainment, acquiring how-to skills, etc. For example, users who seek help in solving a specific homework assignment, enjoy edutainment content, or want to know how to change their car battery, may face considerably different levels of difficulty in finding what they look for on YouTube and develop different attitudes towards the usefulness of this technology. This indicates that technology acceptance models for YouTube as an educational platform should not be general. Instead, researchers should target groups of users or students who have similar orientations and learning purposes and design the questionnaire for specific learning contexts. Such a focused study was presented by Lee and who extended TAM for procedural learning [78].

Apart from TAM-based studies, several authors highlighted the ease of use as one of YouTube's advantages as summarized in Fig. 7. Again, this evaluation is general and does not relate to a specific function. Indeed, creating and editing a video is not as easy as the search for specific information on YouTube nor is watching a recommended video on this platform as easy as integrating content into the classroom and assessing students' learning after viewing this content.

D. HOW IS YOUTUBE USED IN EDUCATION AND HOW DOES IT AFFECT STUDENTS' BEHAVIORS?

The reviewed literature covers a wide range of usage strategies as depicted in Fig. 11. Indeed, the ways YouTube has been used in education are versatile and support different pedagogies such as learning by teaching, active learning, and collaborative learning. Less is known about self-regulated learning strategies while using YouTube. Such strategies were addressed in the context of asynchronous online courses [209].

Integrating YouTube videos into Learning Management System (LMS)-based activities seems to be an especially promising strategy because it allows teachers to assess how helpful the selected videos are by analyzing students' responses to embedded questions [25], [116]. Also, using LMS allows instructors to add short questionnaires to collect student perceptions of the selected videos. By analyzing the performance and perception data, instructors can optimize their selections of the videos in the long term. Embedding links to YouTube videos in LMS activities has another considerable advantage for students' behavior. It helps them watch the video within the LMS page, i.e., without visiting the YouTube website which reduces the risk of distraction and excessive use [10].

Searching and selection strategies on YouTube are underresearched as well. Finding appropriate content on social media is a general challenge [210]–[212]. This task is complicated by the huge offer of content, the popularity-biased ranking by search and recommendation systems [6], [213], and the difficulty to assess content coverage or quality without watching the video. Some professional YouTubers provide descriptions for their videos but it is not clear whether learners make use of these descriptions before they decide to watch. Indeed, people seek YouTube to watch rather than to read. More research is needed to understand students searching and selecting strategies and behaviors. It is tempting to assume that students and teachers pick from the top of the list suggested by the YouTube search engine. More research is needed to confirm such behavior and its impact on learning, knowing that YouTube ranks videos according to popularity rather than quality. Similarly, the commenting behavior on YouTube needs more investigation to understand how far it can support learning. Indeed, the possibility to reply to comments can be used to ask questions and read answers as suggested by some authors. Unguided scrolling through comments, however, can be time-consuming and distracting.

Analyzing behavioral viewing patterns is also important to understand video-based learning [214], [215]. Eye-tracking technologies have gained increasing attention for understanding students' engagement with educational videos [216], [217]. The research on YouTube and education can benefit from this technology to analyze viewing patterns.

E. WHAT IS THE IMPACT OF YOUTUBE ON STUDENT LEARNING?

The majority of the authors who assessed the impact of YouTube on student learning reported positive results in the form of enhanced skills, competencies, interest, motivation, engagement levels, or test performance. Though encouraging, these results are hard to explain in the context of video-based learning. Specifically, a considerable body of research confirms no significant advantage of video- over text-based learning [2], [218]. Unfortunately, an in-depth analysis of success factors is generally missing in the reviewed papers on the impact of YouTube on learning. So, we don't precisely know why YouTube has contributed to student learning and what role the content selection or the integration strategy has played. Only a few authors touched on these aspects [148], [219]. Some researchers highlighted that the video selection should be aligned with the curriculum [164], [220], consider students' background and learning level [221], and seek high-quality, accurate, and non-biased content [158], [222]. Maryani and Aguskin found that teachers need to consider the students' language-proficiency level while selecting a YouTube video [148]. Berk emphasized that teachers need to be careful when selecting videos to avoid non-relevant or potentially offensive videos. Also, they need to consider the type and the structure of the video based on the learning situation [223]. Kostka and Brinks Lockwood recommended that teachers should use a combination of teacher-made and readily available videos to reinforce the instructor-student relationship and allow students to receive different explanations [224]. Berk highlighted seven steps for using a video clip in teaching: (1) Select an appropriate video (2) Ask a motivating question to prepare the students for what they will watch (3) Introduce the video and its purpose (4) Play

the video (5) Stop the video, whenever needed, to highlight a concept and then replay it (6) Assign a learning activity to the students (7) Start a group discussion to reinforce the learned concepts [223].

While such guidelines for video selection and integration are relevant, they are still general and lack evidence-oriented investigation. Multimedia learning theories and specifically the cognitive theory of multimedia learning [225] provide evidence-based principles for the construction of learning content. However, we don't know how such principles can be applied to the selection of YouTube videos for students. On the other hand, it is not clear which strategy for integrating YouTube videos into the teaching and learning process works better. More in-depth research and more replication and comparative studies are needed to understand the impact of YouTube on learning as pointed out by some authors [137], [223].

Considered together, the types of outcomes that were assessed to evaluate the impact of YouTube on learning in the reviewed studies provide a coherent picture, see Fig. 14. We know that interest and motivation drive engagement, engagement promotes deep learning and understanding, and understanding improves test performance. However, none of the reviewed papers has assessed such a chain of outcomes. For example, we don't know whether the students, who reported higher interest, motivation, and engagement, or were observed to show the same, had performed higher in their exams. Mayer, Fiorella, and Stull confirm that a video that's interesting does not necessarily contribute to students' learning [226]. Furthermore, assessing the deep learning and understanding was essentially based on students' self-reports [227], [228], which is hard to confirm without quantitative assessment.

F. RESEARCH DIRECTIONS

Based on the findings of this review we propose a framework for future research on YouTube and education as outlined in Fig. 17 and explained in the following points.

1) Video creation has three tasks: preparation, recording and editing, and uploading. Are there any relationships between these tasks? For example, is there a preferred production style for specific topics or areas?
2) In medical and health-related videos, most studies confirmed a low or negative correlation between popularity-based metrics (e.g. number of views and likes) and content quality. Is there any evidence for or against such popularity-quality relationships in other fields in education?
3) The quality of content is the most relevant aspect of video creation. Can the YouTube system be developed to allow for expert endorsement of content and to rank the videos according to these endorsements in the first place?
4) Users seek YouTube for the vividness of its content and good explanation quality. However, we still don't know what makes a good explanation on YouTube? Are there any general principles for making content vivid and easy to understand?
5) The research shows that users have preferences for some production styles and technology-supported production quality. How significant are such factors for learning?
6) Uploaded videos can be made accessible and visible to everyone. This can open the door for public ratings, comments, and discussions. What role should the teacher play in such discussions and how can this affect students' perceptions and participation?
7) Papers that investigated user acceptance of YouTube in education are not related to a specific field, area, or mode of learning. Specific acceptance models would be desired to provide a better understanding of users' perceptions and their intentions towards using this technology.
8) With all evidence about the low reliability of medical and health-related videos on YouTube, it is highly desired to understand how people deal with these videos, apart from viewing and rating.
9) The question regarding creation vs. selection is not straightforward. Selecting a video may be attractive to save production time and costs. However, finding the right video that aligns with the learning objective at hand and features the expected level of quality can be very time-consuming or even impossible. Also, there is no guarantee that videos made by others will stay online in the future. More research is needed to understand these aspects.
10) Making videos by students is a way of learning by teaching. However, posting such videos on YouTube may create privacy issues. It is desired to understand parent concerns or attitudes towards posting videos by their children.
11) The ever-growing content on YouTube and the obscurity of the popularity-oriented YouTube algorithm make the task of searching and selecting videos not straightforward. The content analysis of medical videos has shown that the best videos do not necessarily appear at the top of the list. How do users behave when they search for and select videos for learning on YouTube? How does such behavior affect learning? This aspect is highly relevant because selecting a video often requires users to view it partially. So, checking multiple videos can be very time-consuming.
12) Having the video created or selected, what is the best way to integrate it into the teaching and learning plan? Should videos replace or complement other learning components? Videos can be watched before, after, or within the class hour. They can be watched only or embedded into an activity. All these are relevant questions that are not yet addressed in-depth in the literature.
13) YouTube is associated with various risks to student behavior such as destruction, addiction, revealing personal information, and writing inappropriate comments. It is urgent to investigate methods and strategies to mitigate

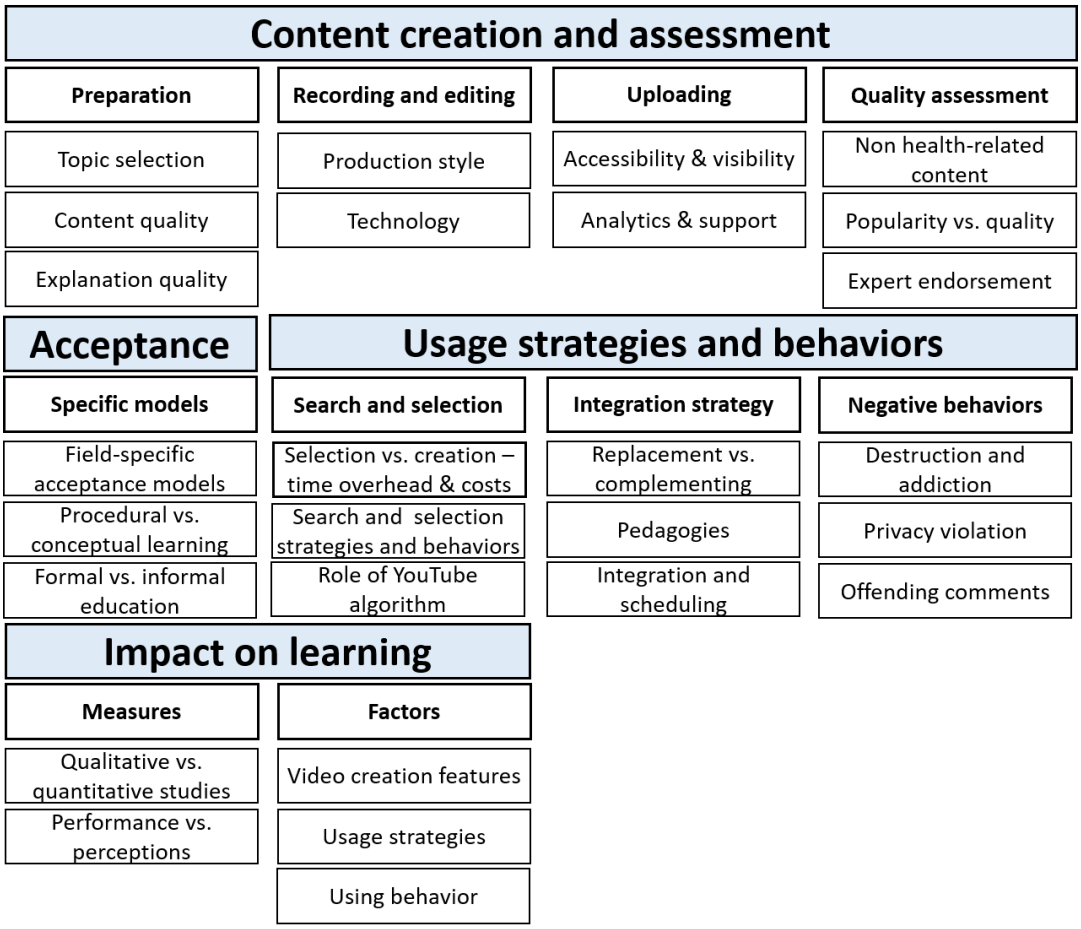

FIGURE 17: Framework for future research

these risks.

14) The ultimate goal of watching educational videos is to learn. While researchers have investigated individual aspects from interest to test performance, we still don't know the relationship between the interestingness level of a video and its contribution to actual learning nor have we sufficient studies that confirm YouTube's ability to enhance students' skills and competencies.
15) While some studies investigated the relationship between video creation features and user rating and commenting, an in-depth investigation of the impact of such features, usage strategy, and behavior on learning is still missing.

G. LIMITATIONS OF THIS STUDY

This study has several potential limitations. The main drawback is that the thematic classification was based on the main research question in the reviewed papers. Some authors addressed two or more aspects that belong to multiple themes. For example, some studies that investigated video production by students could be assigned to two themes: video creation and usage strategy. Still, we chose to classify these studies to the usage strategy theme because the main concern here is how to learn from making videos, not how to make them. The theme-centric analysis of the classified studies is another limitation of our work. Indeed, the single-theme classification and the theme-by-theme treatment have affected the general statistics and prevented a cross-theme analysis. Nonetheless, we hope that the discussions we presented in the previous sections have created some links between the different themes. Another limitation of our work is restricting the search to papers that contain the keyword YouTube in the title. Indeed, this has led to the negligence of some relevant studies. Also, using a single search engine and considering English papers only have limited the number of considered studies. Finally, the studies were classified and analyzed by the authors only. However, regular discussions and agreements were made to assure consistency and completeness.

X. CONCLUSIONS

This review showed that the literature on YouTube and education has focused on four themes: content creation and assessment, user attitudes and acceptance, usage strategies and behaviors, and the impact on student learning. This thematic classification tells a coherent story: We first need to create the content. When the content is available, users can

check it out and develop attitudes toward it. Positive attitudes lead to accepting the technology, developing strategies for using it and showing different usage behaviors. Depending on the usage strategies, behaviors, and content itself, the users can learn new things or improve their learning level.

The study confirms that YouTube is a rich, free, easy-to-use, and enjoyable source of learning content. If used properly, this platform can also have a positive impact on students' interest, motivation, engagement, learning performance, skills, and competencies. Proper usage includes applying effective strategies and positive behaviors. The challenges and risks associated with this platform suggest that it is best suitable for guided learning where teachers make or select the content and include it in a well-defined, pedagogy-driven learning context.

A. DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author on request.

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APPENDIX A EMERGING CATEGORIES FROM ROUND-1 REVIEW

1) Effectiveness of YouTube
2) Technology incorporation in classrooms
3) Teachers attitudes towards YouTube and their readiness to deploy it
4) Surface video features
5) Usage patterns
6) Influence and information propagation
7) Video production and designing techniques
8) Information quality
9) Viewers behaviors analysis
10) Potential uses and strategies
11) Technology acceptance
12) Traditional methods vs. YouTube
13) Students perceptions, preferences and strategies
14) Selection of videos
15) Motivation to learn through YouTube
16) Technology Implications
17) Impact of video production on students
18) YouTube as an informal learning platform
19) Training the students to use YouTube to learn/develop their skills
20) Promoting educational videos on YouTube by institutions
21) Predictors of the use of YouTube
22) Factors impacting viewers' experience and satisfaction
23) Role of YouTube to keep learning information
24) Designing and developing instructional materials from YouTube
25) Students' attitudes towards using YouTube as a platform for continuous education
26) List educational videos/channels (not ranked)
27) The use of videos for the promotion of libraries
28) Content annotation for learning purposes
29) Proposing an app/instrument that uses YouTube for learning purposes
30) How to improve YouTube for educational purposes
31) Legal implications of obtaining and processing copyrighted content
32) Social media development and issues
33) YouTube impact on the society

APPENDIX B AVERAGING THE PERCENTAGES OF VIDEOS ASSIGNED TO QUALITY CLASSES

TABLE 6: An example for averaging the percentages of videos assigned to quality classes

Quality label in the reviewed papers	Quality classes used in this review	Percentage of videos (Paper 1)	Percentage of videos (Paper 2)	Percentage of videos (Paper 3)	Percentage of videos (Paper 4)	Avg. of percentages
Reliable	Good	40%	-	-	-	36.25%
Accurate		-	20%	-	55%	
Useful		-	-	30%	-	
Fair	Average	-	40%	-	-	37.5%
Slightly useful		-	-	35%	-	
Misleading	Poor	-	40%	-	-	45%
Not reliable		60%	-	-	-	
Inaccurate		-	-	-	45%	
Not useful		-	-	35%	-	