Computer-Animated Videos in Education: A Comprehensive Review and Teacher Experiences from Animation Creation

Alexandros Kleftodimos

Department of Communication and Digital Media, University of Western Macedonia, 52100 Kastoria, Greece; akleftodimos@uowm.gr

Abstract: Animated videos have been used in education for many years, and their efficacy in enhancing student motivation, engagement, and performance has been evaluated and reported in many studies. The aim of this study is twofold. First, after examining seventy-seven research articles, this study will attempt to provide an updated comprehensive literature review on the topic for the last decade. The articles were obtained from Google Scholar and Scopus following a certain methodology (search keywords, inclusion and exclusion criteria). The articles were examined for aspects such as the educational fields in which animated videos have been utilized over the last ten years, the researchers’ countries, the types of animated videos, the software tools used to create the educational animations, the research methods employed, and the aims and findings of the studies. The second part of this paper will present animated videos produced by teachers together with their experiences from the development process and classroom use. This study concentrates on the software tools the educators chose to use and their perceptions about developing their own animations. Findings indicate that when animated videos are produced by teachers, their creativity is boosted, and their communication skills are enhanced.

Keywords: animation; animated videos; learning; education

1. Introduction

Animated videos have been used in communication and education for a long time. Understanding and evaluating the messages conveyed by animations and having the technical skills to create animations are part of media and information literacy.

UNESCO has recognized information literacy as a fundamental human right essential for national development, educational progress, and economic and civic welfare. Information literacy emphasizes the importance of accessing, evaluating, and using information of all kinds. In contrast, media literacy focuses on the ability to understand, evaluate, and use media. Consequently, UNESCO has combined media literacy and information literacy into media and information literacy (MIL) to expand the scope of these two literacies [1,2].

Media and information literacy broadens the traditional concept of literacy to encompass the knowledge, perceptions, skills, and experiences necessary for creatively, lawfully, and ethically accessing, analyzing, evaluating, using, producing, and communicating information, science and media messages in general [2–4]. It also emphasizes that MIL is among the essential human rights. Individuals with MIL skills can effectively use various media, resources, and information channels in their personal, professional, and public lives. They are able to understand what information they need, when they need it, and know why, where, and how to access it. They recognize who produces information and why and understand the role, responsibility, and performance of media and information providers. They can analyze and assess information, messages, beliefs, and values presented by the media and other information sources.
According to UNESCO, MIL, as a capability, enables citizens to interact effectively with media and other information providers. It fosters critical thinking and lifelong learning skills, essential for social life and active citizenship. UNESCO believes that MIL plays a crucial role in fostering a democratic culture and an active civil society. MIL skills are not innate and must be systematically taught in schools, Universities, and research settings to ensure they are developed to their fullest potential.

Media and information literacy is a vital skill in today’s digital age, where information is abundant and comes from various sources, including traditional media like newspapers, television, and radio, and digital platforms such as websites, social media, video-sharing sites, podcasts, and mobile applications. More specifically, media literacy is a wide concept that incorporates the skills to: (a) access media, which is the ability to track and acquire information from different types of media sources effectively; (b) analyze media, which is the skill to critically examine the content conveyed by media sources in order to understand their purpose, recognize misinformation and disinformation, identify biases, recognize propaganda, and distinguish between fact and opinion; (c) evaluate media, which is the ability to assess the credibility, accuracy, and reliability of media content and understand the economic, political, social, and cultural factors that influence media production and distribution; and (d) create media, which is the knowledge and skills to produce media messages in various media formats and be able to communicate these messages effectively across various platforms. These media formats include text, visuals (e.g., bitmap images, illustrations), narration, videos, 2D and 3D animation, and virtual and augmented reality technologies.

Media literacy helps individuals become more informed and responsible consumers and creators of media. It fosters critical thinking skills, enabling people to better understand the complex media landscape and engage more thoughtfully with media content.

As mentioned, animation is amongst the media formats addressed by media literacy. Today, many media sources offer a plethora of animated videos. These videos are used for various purposes, including entertainment and education. In the case of animation, the media literacy competencies would be adjusted as follows:

Analyzing animated videos: Media literacy involves analyzing how animations are created and what messages they convey. It also involves understanding the basic elements of animation and the production process phases. This includes storyboarding, animation production tools, character and object design, and visual effects.

Evaluating animated videos: Media literacy is also concerned with evaluating animated content. It includes the critical evaluation of animations, just like any other media form. Animations can also contain misinformation, disinformation, biases, and propaganda.

Creating Animation: Being media literate involves consuming and creating media. According to Gillmor, “being literate in today’s world means more than just smarter consumption, however actively you do that. Being literate is also about creating, contributing, and collaborating” [5]. Achieving literacy in new media and audiovisual productions is a challenging process that demands time, practice, and experience. Just as reading a novel is easier than writing one, watching a video is simpler than creating one.

Animation creation is a powerful form of media production that requires knowledge of scriptwriting, storyboarding, visual storytelling, narrative structure, and technical skills. Media literacy includes using various software tools and hardware technologies to create audiovisual content. For animation creation, this means being acquainted with software and hardware used in animation production, such as Adobe Animate, Blender, Toon Boom, Animaker, and motion capture cameras.

There is a large body of literature regarding the use of animations in education. However, while animations have a long history of educational use, and there are many research efforts regarding instructional animations, attempts to measure their impact on educational outcomes in the past have been in many studies inconclusive and often contradictory [6]. One of the early studies conducted by Mayer and Moreno in 2002 [7] found that, similarly to other multimedia (text, images, and video), animation can promote
learner understanding when used in ways that are consistent with the principles of the cognitive theory of multimedia learning. Therefore, according to the authors, the question is not whether animation is effective in learning or not but under which conditions animation can be effective.

Despite a number of contradictory studies regarding the effectiveness of animated videos, a large body of literature supports their adoption in the educational process. As we will see later in this paper, most studies on the topic in the last decade suggest that animated videos are suitable for learning and more effective than other media (digital or printed). Furthermore, animated videos are widely used for educational purposes, and this is evident from the popularity of platforms that host educational videos, such as Kurzgesagt in a Nutshell (https://kurzgesagt.org/, accessed on 17 April 2024), a popular platform that hosts explanatory animated videos. Kurzgesagt maintains a YouTube channel that hosts animated videos that mainly explain science topics. The Kurzgesagt channel hosts, at the moment, 220 animated videos which have 22.2 million subscribers (17 April 2024). Their videos gather millions of views each. Their most popular video, which is about the Coronavirus, has gathered 88 million views.

In addition to Kurzgesagt, there are also other similar initiatives in many countries. For example, in Greece, there is an initiative called Daily Physics (https://www.kathimerinifysiki.gr/, accessed on 17 April 2024). This initiative is run by a physics teacher who produces all the animated videos. The Daily Physics channel on YouTube contains videos in the Greek language, covering mainly topics in Physics. At the moment, the channel contains 69 videos and has 278 thousand subscribers (17 April 2024). The Daily Physics videos gather thousands of views each. The most popular video has received more than a million views.

Today, there are also a number of online software tools for rapidly creating animations, such as Animaker (https://www.animaker.com/ accessed on 19 April 2024), Muvizu (https://www.muvizu.com/ accessed on 19 April 2024), Powtoon (https://www.powtoon.com/ accessed on 19 April 2024), and Canva (https://www.canva.com/ accessed on 19 April 2024). These tools are suitable for educators without expertise who wish to create their own educational videos and use them to make their lessons more engaging and effective. Furthermore, the recent advancements in AI tools and the appearance of generative AI platforms are currently transforming the content creation landscape, and animation production could not be left out. Currently, creators can use AI tools to obtain quicker 2D and 3D graphics (e.g., Midjourney, DALL-E 2) and also create animations to a certain extent with such tools.

The aim of this paper is twofold. This paper will first try to provide a comprehensive review of the literature based on research studies that have been published in the last ten years (2013 to 2023), examining issues such as the educational fields in which animated videos have been utilized over the last ten years, the researchers’ countries, the types of animated videos used in these studies, the software tools used to create the educational animations, the research methods used, and the educational level for which the videos were produced. Finally, an attempt will be made to report on the findings of the studies.

The second part will present animated videos produced by teachers who attend a postgraduate program together with their experiences from the development process, their opinions about the software tools they chose to use, and their experiences from the development process and from classroom use in cases where the animated videos were adopted in the educational process. Particular focus will be given to the software solutions that were adopted by these teachers for creating 2D and 3D animations. Their experiences were reported in their thesis and through a questionnaire and short interviews.

It is evident from the above that this study will attempt to provide answers to research questions such as the following:

- In which educational fields are animated videos utilized?
- What are the most common types of animated videos?
- What are the most popular software tools for creating animations?
- For what educational level are the research articles focusing on (and animations produced for)?
- Do teachers create their own animations?
- What software tools do teachers prefer for producing their own animations?
- What are the benefits for teachers who produce their own animations?

This study’s contribution to the existing body of literature that focuses on the field is that it provides a comprehensive literature review by examining seventy-seven studies from 2013 to 2023 and reporting on the experiences of teachers who have actually produced their own animated videos, giving particular focus on the development process and the tools they used to produce the animations. From the studies that were examined and used in the literature review, it became evident that there is a lack of studies that focus on the experiences of ordinary teachers who create their own animations.

2. Related Work

As mentioned in the Introduction, Mayer and Moreno, in their study [7], argued that animation, similarly to other multimedia forms, should follow the principles of the cognitive theory of multimedia learning in order to be effective. These principles include the multimedia principle (animation with narration is better than narration alone), the spatial contiguity principle (screen text should be near the corresponding animation images rather than far from them), the temporal contiguity principle (corresponding animation and narration should be presented simultaneously rather than successively), the coherence principle (extraneous words, sounds, and video should be excluded from the animation), the modality principle (the animation should be accompanied with narration rather than on-screen text), the redundancy principle (an animated video accompanied with narration is more efficient than an animated video, which includes narration, and on-screen text), and the personalization principle (words should be conveyed in conversational rather than formal style).

In many studies, animations were often compared to other forms of media, digital or printed. A number of studies compared animations to static images in terms of their efficiency in learning. Hoffler and Leutner’s meta-analysis [8] revealed an overall advantage of instructional animations over static pictures, whereas Tversky, Morrison, and Betancourt, in their 2002 study [9], argued that in many cases, animations are not more effective than static graphics. According to the authors, animations are often too complex or too fast to be accurately perceived. Animations may be more effective than static graphics in cases where the information they convey does not concern complex systems, as for example for real-time reorientations in time and space.

Years later in 2018 Hartman and Johnson [10] compared four different presentation formats in learning a topic of pharmacology: text only; text and static images; animation and text; or animation with narration. The comparison of these presentation modes found no significant difference in performance knowledge gains. Overall, while instructional animations are widely used in education, many studies report that they are not always effective for learning. According to Ayres and Paas [11], this is because the information presented is transient, meaning that information appears and then disappears, and one is often required to keep the disappeared information in mind in order to comprehend the next piece of information. This is a highly demanding task for working memory, which is limited in capacity (e.g., [12–14]). Other studies propose that animations may overwhelm working memory with information, as learners must process many items simultaneously [9,15].

And there are also studies that have found that there has been little or no improvement in learning when students watch animations that explain science concepts (e.g., [16]).

However, although there have been studies where the effectiveness of animations when compared to other media is either not proven or inconclusive, most studies dealing with educational animated videos report the effectiveness of the medium and its superiority over other media formats. For example, in a number of studies that compare animations
to static visualizations, animated educational videos have proved to be more effective (e.g., [17–21]).

For example, the Castro-Alonso et al. study [21] compares animation with static visualizations for learning LEGO manipulative tasks, and the results show an advantage of the animated videos over the static visualizations. In the study conducted by Bilginer and Uzun [20], the authors compare animation to visual materials in learning the circulatory system, and the results again show the superiority of animations. In Gero et al. [18], the authors conducted experimental research comparing animations to static diagrams in learning electronic devices. Again, the results favor educational animations.

In a recent study conducted by Mahler and Mayer in 2023 [22], Anime Japanese cartoons were compared to slideshows for learning a biology topic. The study’s findings showed that anime cartoons can be an effective learning medium. More specifically, the anime groups scored significantly higher than the slideshow group on retention and transfer tests. The anime groups also had significantly higher ratings of motivation and enjoyment, whereas the slideshow group had significantly higher distraction ratings.

Furthermore, in a metanalysis conducted in 2016 Berney and Bétrancourt [23] investigated whether animation is beneficial overall for learning compared to static graphics and found an overall positive effect of animation over static graphics.

As we will see later in this paper, although the literature regarding the effectiveness of animated videos is often contradictory, when examining studies published in the last decade, the number of studies that report positive effects of animations on learning is substantially higher than the studies reporting little or no positive effects. This reinforces the idea expressed in early studies (e.g., [7,8]) that the question should not be whether animations positively affect learning but when and how this occurs.

Another issue highlighted in the literature is the various types of animated videos used in research studies. In the study of Plass, Homer, and Hayward [24], the authors mention that there are many types and categories of animations, such as 2D and 3D animations, whiteboard animations, and Japanese anime.

In the literature, there are also research studies that compare different types of animations and their effectiveness in the learning process. For example, in the study of Hoyek et al. [25], 3D animations were compared to 2D animations in teaching human anatomy. Results showed that the 2D group surprisingly outperformed the 3D group in some cases, while the 3D group outperformed the 2D group in questions requiring spatial ability. Similarly, in the study conducted by Alkofahi et al. [26], the authors examined the effectiveness of 2D and 3D animation in improving mathematics education among first-grade students. In this study, 3D animation proved to be more effective than 2D animation.

In the study of Surjono and Muhtadi [27], the authors compared four different types of media: (a) narrated animation, (b) on-screen text animation, (c) animation only, and (d) printed materials. The findings showed that narrated animation achieved a bigger effect than its counterparts.

3. Mapping the Research Field

In order to map the research field of animated videos, we explored the Google Scholar search engine and Scopus database by using the keyword search terms (“Animation” OR “animated videos”) AND (“Education” OR “Learning”). The search was also narrowed to the last ten years (from 2013 to 2023).

The search yielded 55 research articles from the Google Scholar search engine that contained the keywords in either the title, the abstract, or in the keywords section of the article. This study focused on research articles in which animations were produced, used, and evaluated in the learning process. Therefore, review and meta-analysis articles were excluded. Articles dealing with courses on animation that did not use animation as a learning medium were also excluded. Furthermore, studies in which the animation was part of a virtual or augmented reality application were also excluded since this is a different
type of experience than plain 2D and 3D animations. Reports, posters, papers in a language other than English, undergraduate and postgraduate theses, and studies in which the research aim, and results were not clear were also excluded. After the screening, 23 articles were excluded, and the final result was 32 articles that were published in scientific journals, international conference proceedings, or book chapters.

Seventy-seven (77) articles were found using the same methodology in the Scopus database, and thirty-two were excluded for the abovementioned reasons. Duplicate articles were also excluded. Therefore, the process yielded 45 articles from the Scopus database.

Overall, the subsequent analysis is based on 77 articles (45 from Scopus and 32 from Google Scholar).

The articles can be found in the Reference section [10,17–22,25–94].

The aspects recorded for each paper are the following: title, type of article (journal, book chapter, conference), year of publication, authors’ country or countries (in cases of collaborations between researchers from different countries), type of animation used, educational level (university, secondary or primary education), field of study and subject that the animation was created for, software tools used in the creation of the animation, sample size, institution were the experimental research took place, purpose of the study, and results.

3.1. Type of Article

As Figure 1 shows, the majority of articles about educational animations were mainly published in scientific Journals rather than in Conference proceedings or Book chapters.

![Type of article](image)

Figure 1. Type of article.

3.2. Year of Publication

Figure 2 shows that apart from 2013, a year in which 13 articles were published, the number of published articles for the rest of the years ranged from 5 to 8. Therefore, there is a similar distribution of published articles in the years from 2014 to 2023.
ware tools for rapid animation creation, such as Animaker, seem to be popular in Indonesia (e.g., [21,32,33,38,41]). However, 2D animation is a broad category that also contains (e.g., [48–51,74]).

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3.3. Country of Research Article
In Figure 3, one can see the countries of the researchers. A number of studies had collaborating researchers from more than one country, and these countries were counted separately. It is evident that many studies come from Indonesia (e.g., [34,39,41,94]). Software tools for rapid animation creation, such as Animaker, seem to be popular in Indonesia since many studies investigate the effectiveness of animated videos created by this tool (e.g., [48–51,74]).

3.4. Type of Animations
Regarding animation types, most studies utilize 2D animations created by various tools such as Animaker, Adobe After Effects, Adobe Flash, and Microsoft PowerPoint (e.g., [21,32,33,38,41]). However, 2D animation is a broad category that also contains animations such as Japanese anime (e.g., [22]), simulations (e.g., [55,59,64]), animations consisting solely of mathematical formulas or geometrical shapes (e.g., [57,72]), and slow-motion animation [20]. It must be said, however, that 2D animation production can be less demanding than the production of other forms of animation, such as 3D animations.
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Regarding animation types, most studies utilize 2D animations created by various tools such as Animaker, Adobe After Effects, and Microsoft PowerPoint (e.g., [26,38,39,50,57,87,88]). The animation production was intended for K-12 education (both primary and secondary). In another study, the production of animated videos targeted children in special education. It is obvious, however, from the graph that most studies concern higher education (university and teacher training), and there is certainly more space for research in K-12 education (primary and secondary education). After all, animations are very attractive to children, and results have shown in many studies that they raise satisfaction levels and achieve better learning gains than other methods.

3.6. Field of Study

Animations have so far been used in a broad range of fields in education. Figure 6 depicts the fields of study for which the animated videos were produced. The studies were grouped into the 30 categories mentioned in the graph below. Twelve studies concern animations produced for topics that can fall into the broader category of medical studies. These topics include human anatomy [25,56], colorectal cancer [43], pharmacology [10], nursing [55,61], health education [60,67], the circulatory system [20], biochemistry [65], embryology [69], and medicine education [70]. Topics related to mathematics and geometry were grouped into the category “Mathematics”, which is the second most popular field for which animated videos in the examined studies were produced and used in the educational process (12 articles, e.g., [26,38,39,50,57,87,88]). The other fields that gathered a considerable number of studies are Physics (8 articles, e.g., [34,46,52,91]), Language learning (6 articles, e.g., [29,35,37]), and Engineering (6 articles, e.g., [64,83,85]). The category of language learning concerns different languages (e.g., English and Chinese), and the category of
engineering concerns various topics related to all the engineering fields (e.g., electrical and mechanical).

![Educational Level](image)

**Figure 5.** Educational level.

![Educational fields](image)

**Figure 6.** Field of study.

### 3.7. Software Solutions

Various software solutions were utilized to create educational animations. One way to create the animations is from scratch, using professional tools to create all the assets that will be used in the animated video. These include software tools for bitmap image editing (e.g., Adobe Photoshop), vector illustration creation or editing (e.g., Adobe Illustrator), sound editing (Audacity), tools for creating animations and special effects (e.g., Adobe After
Effects) and video editing tools where all the assets are brought together for the final video production (e.g., Adobe Premiere). This method requires expertise, and some tools (e.g., Adobe After Effects) have a steep learning curve. The production is also time-consuming, but the benefit is that the creator is able to produce whatever he/she imagines.

The other way to create animated videos is through online platforms that contain libraries with a broad range of assets (e.g., images and illustrations, motion graphics, animation effects, and sound effects). Examples of such platforms are Animaker, Muvizu, Powtoon, and Go Animate. These tools are much easier for people without experience to learn and operate. These platforms often contain a free version with a limited number of assets and capabilities and paid-plan versions with more assets and capabilities. However, these tools also come with limitations. In all cases, the creators are limited to the specific software capabilities.

Table 1 presents the software tools used in the examined articles and the number of studies in which they were used. It shows that Adobe Flash was the most popular tool used in seven studies. Flash was initially a product of Macromedia, which was eventually obtained by Adobe. Therefore, in some studies, it is mentioned as Macromedia Flash. Today, the successor of Flash is the software tool Adobe Animate. Animaker is also a popular online platform for producing 2D animated cartoon-like videos. This online platform was used in six (6) studies. These studies were all conducted in Indonesia.

Table 1. Software tools used in the studies for creating animated videos.

<table>
<thead>
<tr>
<th>Software</th>
<th>Number of Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autodesk MAYA</td>
<td>2</td>
</tr>
<tr>
<td>Adobe Premiere</td>
<td>1</td>
</tr>
<tr>
<td>3D Studio Max</td>
<td>2</td>
</tr>
<tr>
<td>Blender</td>
<td>1</td>
</tr>
<tr>
<td>Microsoft PowerPoint</td>
<td>3</td>
</tr>
<tr>
<td>Adobe Flash</td>
<td>7</td>
</tr>
<tr>
<td>Adobe Dreamweaver</td>
<td>1</td>
</tr>
<tr>
<td>iMovie</td>
<td>3</td>
</tr>
<tr>
<td>iMovieMotion</td>
<td>1</td>
</tr>
<tr>
<td>iMovie</td>
<td>3</td>
</tr>
<tr>
<td>WinHIPE</td>
<td>1</td>
</tr>
<tr>
<td>Animaker</td>
<td>6</td>
</tr>
<tr>
<td>Powtoon</td>
<td>3</td>
</tr>
<tr>
<td>Muvizu</td>
<td>2</td>
</tr>
<tr>
<td>VYOND</td>
<td>1</td>
</tr>
<tr>
<td>Moviemaker</td>
<td>1</td>
</tr>
<tr>
<td>Adobe Photoshop</td>
<td>1</td>
</tr>
<tr>
<td>Adobe After Effects</td>
<td>4</td>
</tr>
<tr>
<td>Anime Studio Pro</td>
<td>1</td>
</tr>
<tr>
<td>Microsoft PowerPoint</td>
<td>2</td>
</tr>
<tr>
<td>Custom software</td>
<td>1</td>
</tr>
<tr>
<td>Vrtools Dev software</td>
<td>1</td>
</tr>
<tr>
<td>Adobe After Effects</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 1. Cont.

<table>
<thead>
<tr>
<th>Software</th>
<th>Number of Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adobe Premiere</td>
<td>1</td>
</tr>
<tr>
<td>Gimp</td>
<td>1</td>
</tr>
<tr>
<td>Audacity</td>
<td>2</td>
</tr>
<tr>
<td>Go Animate</td>
<td>1</td>
</tr>
<tr>
<td>Easy Java Simulations</td>
<td>1</td>
</tr>
<tr>
<td>Clip Studio Paint</td>
<td>1</td>
</tr>
<tr>
<td>Adobe Illustrator</td>
<td>1</td>
</tr>
<tr>
<td>Java-based software tool</td>
<td>1</td>
</tr>
<tr>
<td>Autodesk Maya</td>
<td>2</td>
</tr>
<tr>
<td>Jeliot 3</td>
<td>1</td>
</tr>
<tr>
<td>Autodesk Inventor</td>
<td>1</td>
</tr>
<tr>
<td>Not mentioned</td>
<td>29</td>
</tr>
</tbody>
</table>

Table 1 also shows that a large number of studies did not mention the software tools that were used for producing the animations used in educational settings. Furthermore, some recent tools, such as Canva, are absent from the list. Generative AI tools for multimedia production (images, animations) were also absent but this is understandable since these AI tools are a recent development.

Another important aspect that needs to be raised is who created the animated videos in these studies. In most cases, animations were created by university researchers and/or computer experts, and there are also cases where research was conducted using third-party animations found on video-sharing sites like YouTube. There are also many studies that do not mention anything about the animation development process or studies where it is not clear who the creator is and what his/her educational role is. In the examined studies animations were rarely reported to have been created by ordinary teachers. This does not, however, mean that teachers do not create their own animations. There are probably many cases where teachers are animation creators since software platforms such as Animaker and Canva make this task feasible today for teachers without advanced technical skills. These initiatives, however, are rarely reported in the literature.

3.8. Type of Research

Most studies were experimental or quasi-experimental, and qualitative and quantitative methods were utilized to assess the efficiency of educational animations. Experimental and control groups were used in many studies to compare various types of animations (e.g., animation with narration vs. animation with text [10]), animation with captions and keyword annotations vs. plain animations [29], animations showing hands vs. animations without hands [42] and animations vs. other mediums (e.g., slideshows [22] and static images [5,10,16,21,28,31,32,42]). Questionnaires were mostly used to assess student perceptions, satisfaction, and positive feelings, and pre-test and post-tests (e.g., [36,38,39]) were used to assess the knowledge gained. Interviews and field observations were also used (e.g., [18,19,41,51,58,63]). There were also studies that focused only on the creation of the animations without testing the efficiency of these animations in an experiment [50–54,66].

3.9. Aims and Findings

Analyzing the articles revealed that many studies focus simply on the adoption of animations in educational settings and report on the benefits gained from their use in student performance, satisfaction, motivation, and engagement (e.g., [39,41,43,44,52]) while other studies focus completely on the development process (e.g., [50,52–54]). However,
there are also studies that go beyond the simple usage of animations. These are comparative experimental studies involving animations and other mediums of instruction. The main categories that resulted from the analysis are listed below:

(a) Animation vs. static images

Comparing animations to static images, as mentioned in the Section 2, has often been the focus of many studies since the early years of the 2000s. Tversky, Morrison, and Betancourt, in their review in 2002 [9] found that animations often had no advantages over still pictures, and in cases where they proved to be superior, this was due to a lack of equivalence in content or procedures between animated and static graphics (e.g., the animated graphics contained more information). The authors also argued that animations were often too complex or too fast to be accurately perceived. Five years later, the meta-analysis conducted by Höfler and Leutner [8] revealed a medium-sized overall advantage of instructional animations over static pictures. The meta-analysis also revealed the circumstances under which animations proved to be more effective (e.g., when animations are representational rather than decorative, highly realistic, and when procedural-motor knowledge was to be acquired). The results were in line with theories of cognitive load and multimedia learning (e.g., Mayer’s theory of multimedia learning [7,95]).

In the examined corpus of research studies, a number of studies dealt with the same issue. These were the following: Daly et al. [28], Castro-Alonso et al. [21], Marcus et al. [42], Hartman and Johnson [10], Taylor et al. [17], and Gero et al. [18]. Some of the studies showed no benefits at all, as for example, the Hartman and Johnson study [10], which employed animations to convey complex information about pharmacological mechanisms. These mechanisms are dynamic processes and, therefore, suitable for representation by animation. However, the study did not show any benefits for students with prior biochemistry knowledge compared to static images. Similarly, Daly et al. [28] investigated the use of animated images versus still images by creating two versions of a short multimedia presentation on vascular neuroeffector transmission. While the animated video was shown to increase student satisfaction, the authors did not find strong evidence in favor of animated images over still images.

On the contrary, a number of studies showed benefits when animations were used. In the study of Castro-Alonso et al. [21], animations proved effective and superior to static visualizations for object-manipulative tasks such as constructing a three-dimensional shape using Lego bricks. Two different types of animations (showing hands and not showing hands) proved superior to static images for learning a hand-motor task, such as tying two different knots. The with-hands animation had even higher instructional efficiency when compared to the animation that did not show the hands tying the knots. Taylor et al. [17] compared animated material to static material for learning cyber security issues. The animations were perceived as slightly more informative by the students when compared to the static materials. In the study conducted by Gero et al. [18], the students who studied the subject of electronic devices (i.e., transistor) through animation achieved better than their peers who learned through static diagrams and expressed more positive attitudes.

(b) 3D vs. 2D animations

Some studies compared the efficiency of 2D animation to that of 3D. For example, Hoyek et al. [25] compared the effectiveness of 2D and 3D animations in human anatomy. Results were mixed. The 2D group performed better than the 3D group on the trunk assessment. On the upper limb assessment, no difference in the scores on the overall anatomy examination was found. However, the 3D group outperformed the 2D group in questions requiring spatial ability. Overall, it was revealed that 3D digital animations were effective instructional multimedia mediums in teaching human anatomy especially in recalling anatomical knowledge requiring spatial ability. 3D animations also proved to be efficient in the Al-Balushi study [44] in visualizing the spatial interactions between
submicroscopic entities in a chemistry course. This study, however, did not compare 3D animation to 2D.

Alkofahi et al. [26] compared 2D and 3D animation as a method of teaching mathematics to first-grade students. The study found that using 3D animation in the classroom was better for performance, recall, and learning in tests than 2D animation.

In the study of Wu and Chiang [72] 3D animations proved to be more effective than 2D in a graphical course. The study showed that applying 3D animations yields better performance in understanding the appearances and features of objects constructed by oblique and double-curved surfaces. It makes sense that 3D images would have an advantage in understanding and interpreting orthographic projections.

(c) Comparing animations with different features

In Aldera and Mohsen’s study [29], the authors compared three different types of animation on vocabulary learning and listening skills: (a) plain animations (A), (b) animations with captions (AC), and (c) animations with captions and annotations (ACA). The results showed that the ACA group achieved better than the AC group, and the AC group surpassed the A group in vocabulary recognition and vocabulary production tests. However, the A group performed significantly better than the other two groups in listening comprehension and recall. Surjono and Muhtadi experimental study [27] compared the following media: (a) narrated animation, (b) on-screen text animation, (c) animation only, and (d) printed materials in an e-learning course. Narrated animation proved to be superior to the other media types.

Liu et al. study [59] explored the interaction effects between animation and computer simulation multimedia types, along with the presentation modes of written and spoken learning guidance. This study’s results showed that participants achieved better learning results from animation when it was accompanied by spoken text and from a simulation when it was accompanied by written text.

(d) Animations vs. other multimedia forms

Mahler and Mayer investigated the potential of Japanese animation (anime) for improving science learning [22]. The study compared Anime to slideshows. The anime groups scored significantly higher on retention and transfer tests than the slideshow group. Additionally, the anime groups scored higher on motivation and enjoyment, while the slideshow group had higher ratings for distraction.

(e) Comparing animations following different instructional methods

Moreno et al. study [71] aimed to compare conflictive animations’ effectiveness with normal learning animations. The study results showed that students using conflicting animations enhanced their metacognitive skills, and compared to a control group (normal animations), their conceptual knowledge improved at a better rate.

Lowe and Bouchex [32] investigated whether contiguous animation, designed using the composition approach, enabled learners to construct more effective mental models of a complex subject compared to non-contiguous or conventionally designed animations. In this study the compositional animation proved more effective for developing higher mental models for piano mechanisms than the two other methods (non-contiguous and comprehensive conditions).

Angranaeni et al. [58] aimed to use animation and humor to improve learning outcomes. Their study results indicated that using humor and animation improved outcomes.

(f) Animation vs. conventional and other forms of instruction and learning

Gambari et al. [38]’s study findings indicated that the students who learned by watching animated videos performed better in post-test and the retention test when compared with students who were taught geometry using the conventional method. Akpınar’s study [45] showed that interactive animations used as presentation tools were more effective than conventional instruction in improving students’ understanding of static electricity.
concepts. Zheng et al. [70] compared computer animation to traditional instruction in healthcare students’ learning of emergency medical care response procedures. The results showed that there was no statistically significant difference between the two methods. Barak and Hussein-Farraj [65] aimed to compare the effectiveness of three different methods in learning Biochemistry (understanding of proteins structure and function): (a) hands-on exploration of animations, (b) teacher’s demonstrations of animations, and (c) traditional textbook-based instruction. The results showed that combining model-based learning with 3D animations improved students’ understanding of the structure and function of proteins. Xu et al. [37] investigated the comparative effectiveness of reading, animation, and writing in developing foreign language learners’ orthographic knowledge of Chinese. The study proved that each mode of instruction had its benefits for particular tasks. Writing and animation both led to better form recognition, while reading produced superior meaning and sound recalls. In addition, the effect of animation on meaning recall was also better than writing. Writing proved to be superior in developing the skill of reproducing characters from memory.

(g) Animations used in combination with other material forms

Chiou et al. [36] compared teaching materials combining animation and multidimensional concept maps to multidimensional concept maps in learning concepts related to Financial Accounting. The study showed that animation combined with multidimensional concept maps yielded better results in learning achievement, retention, and satisfaction. Veres et al.’s study [68] employed animation and interactive games to explain the consequences of the Earth’s rotation and revolutionary motions and compared this material to plain animation. The results showed that combining animation with interactive games is more effective.

Similarly, the Inangil et al. [61]’s study revealed that using animation and gamification in online distance learning enhanced both the knowledge and motivation of Generation Z students in online distance education for a diabetes nursing course.

(h) Adopting animations and reporting the results

A significant number of studies are concentrating on adopting various forms of animation (2D, 3D, whiteboard, stop-motion) in the educational process and reporting on their efficiency. The majority of these studies report positive results in learning gains and/or increased motivation, engagement, satisfaction, and/or enjoyment [41,46,52,63]. A number of these studies focus also on the creation process.

It has to be highlighted, however, once again that there is a lack of studies that report on initiatives where teachers create their own animations, experiences gained from the production process, and the use of animation in their instruction. In the examined studies, there is often no reference to who created the animations, or animations were created by university researchers and/or computer experts, and research was often conducted with third-party animations found on video-sharing sites (e.g., [68]).

Therefore, this study contributes to the existing body of literature by presenting teacher initiatives to develop their own animations and any possible benefits that such a process may have.

4. Creating Educational Animated Videos: Presenting Educators’ Productions and Experiences

Many tools have been used to create educational animations, and some of these are mentioned in Table 1. The authors of Kainz et al. [66] mention in their study in 2013 that some of the tools they found by exploring the literature to be used for educational animation production were the following: Adobe Flash, Aladdin4D, Autodesk 3ds MAX, AutoCAD, Autodesk Inventor, Autodesk Maya, Blender, Cinema 4D, Electric Image Animation System, LightWave 3D, Microsoft PowerPoint, Modo, Muvizu, Poser, Silverligh, Trimble SketchUp, SWiSH Max, Synfig Studio, Adobe Flash Professional.
A typical process for creating educational animated videos is the following: First, the topic is explored by studying the relevant literature, and experts in the field may also be asked to contribute to the knowledge that will be presented via the animated videos. Then, a scenario is written, and animators may again collaborate with knowledge experts in this task unless the animator is also an educator who knows the topic very well. Regarding the technical aspect, a software tool for creating vector graphics or 3D models is used at the beginning of the production process. Popular tools for creating vector graphics are Adobe Illustrator, Inkscape (open-source), and CorelDraw, and popular tools for creating 3D graphics are Blender and 3DStudioMax.

Vector graphics and 3D models can also be obtained from online repositories and used in their original form or edited to obtain new synthesized creations. There are many online repositories where an audiovisual creator can obtain vector graphics for free. Some examples are Pixabay (https://pixabay.com/el/ accessed on 19 April 2024), FreeVector (https://www.freepvector.com/ accessed on 19 April 2024), Vecteezy (https://www.vecteezy.com/ accessed on 19 April 2024), and FreePik (https://www.freepik.com/ accessed on 19 April 2024). Some of these repositories also contain video clips, music, and sound effects, which can also be used in audiovisual productions for free. Equivalently, 3D models can be obtained from similar repositories that host artists’ 3D creations. Some examples are SketchFab (https://sketchfab.com/ accessed on 10 April 2024), Free3d.com (https://free3d.com accessed on 10 April 2024), CGTrader (https://www.cgtrader.com/ accessed on 10 April 2024), TurboSquid (Turbosquid.com accessed on 19 April 2024) and Archive3D (https://archive3d.net/ accessed on 19 April 2024).

After obtaining the necessary graphics (2D or 3D) for the animation scenario, animation software is used to introduce movement to the graphics. Adobe After Effects is a well-known software used by professionals to perform this task. Other tools for creating animations are Adobe Animate (the successor to Adobe Flash) and the open-source animation software Synfig.

After the graphics are obtained, an audio processing software (e.g., Audacity) is used to record narrations or edit other audio assets such as music and sound effects. Finally, all the elements are brought to a video editing software in order to produce the final animated video, which contains a combination of the mentioned elements (i.e., animated graphics, narration, background music, and sound effects). Popular video editing programs are Adobe Premiere, open-source alternatives such as Open-shot, Shotcut, Kdenlive, and other tools that can be used for free, such as CapCut and Davinci. Motion can also be introduced using typical video editing programs. However, the animation capabilities of these software tools are limited.

This procedure is followed by the professionals working for Kurzgesagt and the physics teacher who created the videos for Daily Physics mentioned in the introduction. These procedures are explained in videos that exist on their YouTube channels, such as “How to make a Kurzgesagt video in 1200 h” https://www.youtube.com/watch?v=uFk0mgltjns (accessed on 19 April 2024) and “Q&A with Stefanos (in Greek)” https://www.youtube.com/watch?v=16ZjN5wietQ (accessed on 19 April 2024).

Some of the software tools mentioned above are intended for professional use and have a steep learning curve (e.g., Adobe After Effects). Today, however, as already mentioned there is a broad range of online platforms for creating animated videos, such as Ani-maker (https://www.animaker.com/ accessed on 19 April 2024), Powtoon (https://www.powtoon.com/ accessed on 19 April 2024), and Canva (https://www.canva.com/el_gr/ accessed on 19 April 2024). Canva is a popular platform for creating graphics, posters, animations, and videos. All these tools are much more friendly for beginners who want to produce professional-looking audiovisual productions without going through the steep learning curve of other professional tools such as Adobe After Effects. The drawback, however, is that the creator would have to rely on the set of graphics and animations provided by these tools for rapid content creation, and these assets may not always be suitable for implementing the scenario that the creator has in mind.
In a postgraduate course organized by the Department of Communication and Digital Media, University of Western Macedonia, Greece, several students undertook a thesis related to educational animations. These students were education professionals, and most of them worked in primary education. During their studies, they attended a lesson named “Digital Media and Production of Digital Content”, where they were taught the basics of vector image creation and vector image processing (e.g., synthesizing new vector images from images found in online repositories such as Pixabay) as well as the basics of video and sound editing.

Their aim for undertaking the particular thesis subject was to learn software tools they could use in the future to produce audiovisual material that would make their lesson more engaging and effective. The teachers also became acquainted with learning theories relevant to educational multimedia, such as the principles of multimedia learning [95,96].

The students were free to investigate the available software options and use their preferred tools. The design and development process were reported in their work together with the experiences gained from this process. Their productions followed the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate) [97]. Furthermore, results and observations were obtained from using the animations in classroom settings in some cases. Finally, the creators of these animated videos answered an open-ended questionnaire, and some were also interviewed to record their perceptions about the software tools used to create the animations and the usefulness of the knowledge they gained during this process.

4.1. Creating Animations for Education

As mentioned in the previous sections, the students were free to choose the topics they liked and the tools to create the animations. Having learned the basics of creating vector images (either by starting from scratch or by using vector graphics from repositories in order to synthesize new images from existing ones) and video and sound editing, the students were encouraged to investigate and evaluate software tools and online platforms in order to choose those that they considered more appropriate for the task. Their choices and their animated videos are described in the following sections.

4.1.1. Creating an Animated Video for the Topic of “Energy”

One of the students, who is a primary education teacher, chose the topic of “Energy” and created a 10 min educational animated video on this topic. The topic of energy is taught in the syllabus of the 5th grade in Greek primary schools. After being taught this subject, the pupils are expected to (a) understand the various ways that energy is produced, (b) to be able to differentiate amongst these types of energy (e.g., kinetic, dynamic, nuclear, thermal, electricity, chemical, and renewable), and to (c) categorize processes and mechanisms producing these types of energy.

Based on research carried out in the past [62,98–100], the use of animations in the learning of Natural Sciences can have positive outcomes in the following aspects:

- To understand better terminologies and scientific concepts,
- To explain and interpret concepts and phenomena correctly,
- To motivate and engage students, and
- To achieve better scores on tests.

In Figures 7 and 8, we can see some screenshots of the created video.

The student used storytelling and dialogue to make his explanatory animated video more engaging.

The video covered topics such as the types of energy and how they are produced. It contained voice-over narration and some text. The text shown in the screenshots is translated into English for the purposes of this paper.

The tools used in this production were the following:

- Animaker (for animation creation),
- Canva (for creating graphics and animations),
- Illustrator (for creating vector graphics), and
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**Figure 7.** Screenshot from the introduction of the animated video on the topic of “Energy”.

**Figure 8.** Screenshots from the animated video on “Energy”.

Animaker has a free version with basic features and subscription versions that provide more assets (e.g., illustrations and animations). The student used a subscription version of Animaker (Figures 9 and 10). The student also used Inkscape and the online platform Canva to create vector graphics since the freely accessible version of Animaker could not cover all his needs with the platform’s available illustrations. Inkscape is an open-source software for creating and editing vector graphics. Canva started as an online graphic design platform, but today, it also incorporates video editing and animation creation capabilities. Furthermore, today it incorporates generative AI capabilities, giving users the ability to interact with a chatbot to create multimedia content just by giving instructions.

The student also used Wevideo (https://www.wevideo.com/ accessed on 20 April 2024), a video editing tool in order to edit and create the final animated video. Wevideo is an online video editing platform that is user-friendly and suitable for beginners. It has a free version and subscription versions with more options (Figure 11).

The student utilized his audiovisual creation in one of his classes. More specifically, he used it in the Physics lesson taught in the 5th grade of primary school. According to his report, the results were very positive. The animated video was used as a support material, and it seemed to pay off. The animated video provided more representative clarifications on the subject of Energy. The students showed a better understanding of the concepts and were better able to classify the forms of energy.

More specifically, the educator adopted the animation in his class (consisting of 25 students) in the following way: First, he investigated the students’ prior knowledge using brainstorming. It was observed that the students knew little about the topic. Then,
he introduced new knowledge about the topic of “energy” using examples from the 5th grade schoolbook. Then, all students participated in an activity where they were asked to take turns to categorize various energy forms. The teaching method in this phase was the traditional one, through the book and with the supervisory material contained in it. In the end, a discussion took place.

Figure 9. Screenshot from the development environment of Animaker.

Figure 10. Screenshot from the animation development process in Animaker.

Figure 11. The Wevideo video editing environment.
The students seemed to respond positively to the educator’s questions, but their answers varied widely, and there was a little ‘confusion’ in classifying the forms of energy. Finally, the students’ knowledge was evaluated using a worksheet. The average mark obtained was 6.4 (with a scale from 1 to 10). In the second phase, the animated video was introduced. The students were given tablets and watched the animated video in teams. In this way, the students could also work within the context of the group. As the educator mentioned, “The students were quite observant, very focused, and quiet while watching the animated video, which certainly foreshadowed positive results”. Furthermore, he mentioned, “It seemed to me that even if I were absent from the class, it would not have made a difference, as the students were excited and completely focused on the information conveyed by the animated video”.

In the end, the students were again given an evaluation worksheet similar in format and difficulty level to the worksheet used in the previous phase, consisting however of different questions. The average score obtained this time was 8.6. Based on the performances obtained after viewing the animated video, it was obvious that the student’s knowledge of the topic had increased to a significant level, and what is equally more impressive is that there were no performances below the base of 5. It seemed that with the use of computer animation, the concept of energy and its forms were better understood.

Finally, at the last phase of this intervention, the students were asked to create their own short, animated videos about energy-related topics using the Canva online platform. The students showed a high level of engagement and excitement about this activity.

The interventions that took place in these classes were very constructive for both the teacher and the students. Some of the teacher’s observations and perceptions are the following:

- Students were particularly excited, observant, and attentive when it came to using new technologies.
- The students’ performance increased after the use of the animated video, which shows that understanding the concepts through viewing the animated video was quite successful.
- Using new technologies can bring positive results, not as a substitute for traditional methods but as support material during teaching.
- The interest of students is maintained undiminished when viewing an animated video, compared to the traditional teaching method (where students feel bored, talk to the student next to them, and do not pay attention), and this creates a very orderly situation in the classroom.
- In addition, by including animated videos, the students prompt their peers to pay attention, which helps the teacher focus more on teaching rather than putting effort into maintaining class order.
- Explanatory animated videos can help students visualize processes and notions and recall this knowledge easily when needed.

The educator answered yes to a question about whether he used the knowledge he acquired on animation creation after completing his thesis. As he mentioned in his answer to the questionnaire, he utilized his knowledge to create an informational animated video for a school event. He also most certainly believes that he will be using this knowledge in the future to create animated videos for his classes since he has experienced positive acceptance from his students.

4.1.2. Creating Explanatory Animated Videos for Environmental Issues

The aim of this work was to strengthen environmental awareness through the creation of four explanatory videos. These videos covered the topics of plastic pollution, acid rain, ozone depletion, and global warming. The videos were approximately 3 min each, and they were produced by a postgraduate student with an education degree. Similar software tools, such as the ones mentioned in the previous section, were also utilized in this case. More specifically, the tools used were the following:
Animaker (for animation creation),
Canva (for graphics and animation),
Adobe Illustrator (for producing or editing vector graphics),
Adobe Photoshop (for bitmap image editing),
Audacity (for audio editing), and
Filmora (for video editing).

Some screenshots of the created videos are given below. The animated video used voice-over narration. The figure captions indicate the voice-over narration (in English) that accompanies some of the images (Figures 12–16).

Figure 12. Screenshots from the animated video on “Plastic Pollution”.

Figure 13. Screenshots from an animated video on “Acid rain”.

Plastic pollution is the accumulation of plastic objects in the environment such as plastic bottles, bags, and microplastics which affect both animals and humans.

In the same way, many more marine species can get confused, eat plastic, get sick, and eventually die.

Consider a sea turtle in the sea, searching for food. It finds a white bag and eats it thinking it is a delicious jellyfish. This will lead to its death.

So it is obvious that millions of animals can be killed in the same way, such as fish, birds, and other living things organisms.

Acid Rain

It is known that clouds consist of water but sometimes gases such as nitric oxide and sulfur oxide react with water in the atmosphere and fall back to earth in the form of acid rain.

The gases reach the atmosphere through a natural source such as decaying vegetation and volcanic eruptions.

The type of acid rain that contains water is called wet disposition while the type that contains dust or gases is called dry disposition.

But also through human activity such as burning of fossil fuels, car exhausts as well as factory fumes.
Figure 14. Screenshots from an animated video on “Ozon layer”.

Figure 15. Screenshots from the animated video on ‘Global Warming’.

The teacher who created these animations was not employed in the educational sector when he completed his thesis, and therefore, he did not have the opportunity to apply his audiovisual production and the knowledge he acquired in classroom settings. He believes, however, that he will be given the chance to apply this knowledge in the future.
4.1.3. Creating Animated Videos to Explain “The Ecosystem”

Another postgraduate student expressed an interest in creating a video for environmental education, creating 11 short, animated videos on the “Ecosystem”, the “Food chain”, and the “Endangered land and sea animals”. The total duration of all the videos was 10 min. These animations were targeted at preschool students since the creator of these audiovisual productions was a kindergarten teacher. Below some screenshots of the production are presented (translated in English) (Figures 17–21). The figure captions indicate the voice-over narration that accompanies some of the images.

Figure 16. More screenshots from the animated video on ‘Global Warming’.

Figure 17. Screenshots of the animated video “The Ecosystem”.

Figure 18. More screenshots of the animated video “The Ecosystem”.
Living organisms are called biotic elements of an ecosystem and they are humans, animals, plants, algae and microorganisms, which live in nature, such as fungi and bacteria. Living organisms need a number of other abiotic organisms in order to live which are called abiotic factors. An abiotic element is the soil which gives living organisms nutrients, phosphates and nitrates, water and especially supports the plants.

Another abiotic element is the atmosphere. The atmosphere offers carbon dioxide to help in the growth of plants and oxygen for the respiration of all living organisms.

Figure 18. More screenshots of the animated video “The Ecosystem”.

Food Chains

2nd food chain
The small fish eats the phytoplankton. The big fish eats the small fish, while man eats the big fish.

3rd food chain
The mouse eats the wheat. Then the snake eats the mouse. And in the end, the eagle eats the snake.

Figure 19. Screen shots of the animated video “The Food Chains”.
Figure 20. More screenshots of the animated video “The Food Chains”.

Figure 21. Screenshots of the animated video on “Endangered land and sea animals”.

The software tools used in these productions were the following:

- Animaker,
- Canva,
Inkscape.

Animaker and Canva were used to produce the animations, and Inkscape was used to create a number of vector images in cases where relevant images were not available in Animaker and Canva libraries. Stock vector images were also obtained from Pexels (https://www.pexels.com accessed on 19 April 2024) and Pixabay (https://pixabay.com accessed on 20 April 2024). These images were edited in Inkscape.

After the videos were produced, they were uploaded to a website. Furthermore, using the H5P software (https://h5p.org/ accessed on 19 April 2024), the videos were enriched with interactive activities.

The educational video created as part of the MA thesis was used in the educational process in a kindergarten class where the educator worked with a small number of pupils (9 pupils). Through observation, it was evident to the teacher that the children who watched the animated videos assimilated the knowledge imparted to them and enriched their previous knowledge about the aforementioned topics. More specifically, the children managed to acquire more cognitive skills on issues related to the ecosystem, biotic organisms, and abiotic elements of the environment. It was also evident that the children that took part in this educational intervention, understood, to a great extent, concepts such as the food chain, food pyramid, and endangered land and sea animals.

The educator most certainly believes that she will continue to create animated videos for her classes in the future.

4.1.4. Creating an Animated Video to Explain the Concept of Gravity

Another teacher created an animated video explaining a physics topic, the concept of gravity (Figure 22). The software tools used in this case were the following:

- Canva (for graphics and animations),
- Photopea (for bitmap image editing),
- Inkscape (for vector image creation and editing),
- Clipchamp (for video editing), and
- Audacity (for sound editing).

![Figure 22. Screenshots from the animated video on “Gravity”](image)

Photopea (https://www.photopea.com/ accessed on 19 April 2024) is a free online editing software, Clipchamp (https://clipchamp.com/en/ accessed on 19 April 2024) is an online video editing platform, and Audacity is a well-known open-source sound editing software tool.
Some images were obtained from the Canva library, while most images (mainly vector graphics) were obtained from Pixabay. Many vector graphics were edited in Inkscape, while a number of bitmap images were edited in Photopea. Canva was also used for creating animations. Audacity was used to record the narrations and to synchronize the narration with music and sound effects. Sound effects were obtained from repositories such as Pixabay and Freesound (https://freesound.org/ accessed on 19 April 2024).

4.1.5. Learning Mathematical Theorems by Animations—The Pythagorean Theorem

Another student attempted to create an animated video for Mathematics. As we have seen in the Section 3.6, a significant number of the animated video productions encountered in the literature concern mathematical topics. This animated video provides an introduction to the Pythagorean theorem (Figure 23). The animated video contains historical facts about the theorem and the various proofs that have been recorded in history, as well as examples from real life where the theorem can be applied. The animation also contains a story about a father who wanted to divide pieces of land fairly among his children. In order to see if the division was fair the Pythagorean theorem was applied. Through theory and practical examples, the animation aims to aid in the comprehension of the mathematical theorem.

The software tools used in this production were the following:
- Inkscape (for vector image creation and editing),
- Audacity (for sound editing), and
- Openshot (for video editing).

The educator worked in a Greek high school and used this animated video to educate 75 students in the 4th grade. After the intervention, the students were asked to evaluate the video through a questionnaire consisting of closed- and open-ended questions. Many students described the video as interesting and comprehensive. A characteristic student’s response is the following: “This animated explanatory video tutorial was excellent! I think it has fully covered the topic and really helped me to understand the important points and proofs of the Pythagorean theorem. The images and explanations were easy to understand, and the structure of the video made it easy to watch. I appreciate how the information was presented; it was an interesting and engaging experience. I would definitely like to see more video tutorials like this!”.

However, it is worth noting that some suggestions for improvements were also included in the students’ comments. Some students expressed the need for clearer explanations for points that seem difficult to comprehend. Other students ask for more interactive activities or games. Interactivity is, in most cases, absent from animated videos due to their linear nature. However, there are ways to make an animated video interactive, by embedding quizzes and drag-and-drop activities in the video and branching scenarios. Regarding interactivity, H5P is a software tool that can help in this direction. Other students noted that they wanted more examples and applications. These suggestions can be taken into account in order to improve the instructional video.
The educator found the production experience very useful, and she is certain that she will continue to produce animated videos for her classes in the future.

4.1.6. Creating an Animated Story to Raise Awareness of Disability Issues

In another example, a student created an animated story to raise awareness about disability issues. More specifically, the particular postgraduate thesis focused on the daily life of children with visual impairments through animation technology. The aim of this work was to create an engaging animation that follows a typical story plot and the stages of the Freytag triangle. Through storytelling, the creator was aiming to attract the students’ interest and convey in a relaxed and pleasant way messages that will help the students gain empathy about the problems that children with visual impairments encounter in their daily lives. It is worth saying that the particular student who is a primary education teacher supported ah high school student with visual impairment for one year, a student who attended a regular school through an initiative called “Parallel Support”. Parallel Support is an established initiative in the Greek educational system, where children with special educational needs can attend mainstream schools as long as a qualified teacher in special education supports them. Therefore, the teacher (and postgraduate student) had a personal experience with the difficulties encountered by a high school student with no eyesight in everyday activities in school, on an emotional and physical level. The teacher used the software platform Muvizu (https://www.muvizu.com/ accessed on 19 April 2024), a platform for creating 3D animations. In Figure 24, we can see some snapshots of the animated video. The plot of the animated video is about the daily life of Maria, a blind girl. The title of the production is “With the eyes of Maria”. The animated video is accompanied by voice-over, and also sound effects (wherever appropriate).

![Figure 24. Snapshots from the 3D animated video “With the eyes of Maria”](image-url)
The software tools used for the production were the following:

- Muvizu (for 3D animation creation),
- Audacity (for sound editing), and
- Pinacle studio (for video editing).

4.1.7. Creating a 3D Animation for Teaching Mythology in Primary School—The Legends of Theseus

Another student attempt concerned an animation production for the story of Theseus, a divine hero from Greek mythology (Figure 25). The myths surrounding Theseus, his journeys, exploits, and accomplishments have provided material for storytelling throughout the ages. In Greek Primary education, the legends of Theseus are taught in the third grade of primary school.

The student used Muvizu as the primary tool for creating the 3D animation. She mainly utilized the 3D models provided by the Muvizu library and also added 3D models to the story found on online 3D image repositories such as SketchFab. In some parts of the animated video, 2D content was also used, and this content was created in GIMP.

The tools used in this case were

- Muvizu (online 3D animation platform),
- Wodershare Filmora (video editing software), and
- GIMP (image editing software).

4.2. Evaluating the Software Tools Adopted by the Teachers for Producing the Animated Videos

We asked the educators to evaluate the software tools they adopted to create their animated videos. In the Tables 2–4, we can see the tools used and the rank each educator gave to these tools on a scale from 1 to 5 in terms of user-friendliness and effectiveness for the purpose they serve.

Table 2. Online platforms for animation creation.

<table>
<thead>
<tr>
<th>Online Platforms for Creating Animations</th>
<th>Canva</th>
<th>Animaker</th>
<th>Muvizu</th>
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<td>Animations</td>
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</table>
Table 3. Software for image editing and vector graphics creation.

<table>
<thead>
<tr>
<th>Vector Graphics and Bitmap Image Editing Software</th>
<th>Animations</th>
<th>Illustrator</th>
<th>Inkscape</th>
<th>Photopea</th>
<th>Gimp</th>
<th>Photoshop</th>
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</table>

Table 4. Software tools for video and sound editing.

<table>
<thead>
<tr>
<th>Video and Sound Editing</th>
<th>Animations</th>
<th>Wevideo</th>
<th>Openshot</th>
<th>Filmora</th>
<th>Clipchamp</th>
<th>Audacity</th>
<th>Pinacle Studio</th>
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4.3. Discussion

In this section, we will discuss some insights gained through the teacher animation creation efforts described in the previous sections based on what was reported in their thesis and their interviews.

As already mentioned, producing animated videos is often an elaborate task. It is also a task that is feasible for professionals or people who have spent a significant amount of time acquiring the necessary expertise in software tools such as Adobe Animate, Adobe After Effects, Blender, and 3D Studio Max after following a steep learning curve.

Creating animations was not feasible in the past for most educators due to the advanced expertise needed for such a task. Today, software platforms such as Animaker, Canva, and Powtoon enable ordinary teachers without expertise to create animations for their lessons. These software tools provide a broad range of illustrations (e.g., characters, objects, animals, and plants) and animation effects. However, their free versions provide access only to a subset of these capabilities and both the free and the more advanced versions available on subscription plans may not be enough to cover all individual needs. Educators may need to access other repositories in order to find suitable images, or they might need to create them. Creating and editing vector images may be necessary in cases where visualizations have to be descriptive rather than decorative in order to enhance learning performance and reduce cognitive load [7].

The teachers who created animated videos and used these productions in their classrooms observed certain benefits. Students showed increased levels of motivation, engagement, satisfaction, and enjoyment, making classroom management easier. Animation also impacted the learning outcomes, which improved after the use of animation.

Focusing on teachers’ perceptions, it was reported that new platforms enhance teacher creativity. Teachers can create their own audiovisual content tailored to their needs rather than relying on videos that are created by others and are available on the internet and video-sharing sites like YouTube. Furthermore, the educators mentioned that the process of animation development, during which they were trying to find the best way to explain a topic sufficiently through a combination of visuals, narration, and text, improved their
skills in communication. Creating their own visualizations and animations gives educators more freedom to communicate their knowledge and ideas in their own way, while tailoring the information and messages conveyed to the needs of the target audience. This ability boosts their multimedia communication proficiency. Therefore, in addition to the enhancement of their technical skills, animation creation has a positive impact on teacher communication skills and creativity. Moreover, all of the educators found the experience of producing their own animated educational videos valuable and satisfying. They all believe that they will continue to create animated videos for their classes in the future.

In subjects related to Physics (e.g., energy and gravity) and environmental education, students can visualize how natural phenomena and processes occur through animations created by their educators. Visualization can help students understand and memorize these processes. Moreover, in cases where the task was to convey social content to students, such as content related to disability issues, then this could be achieved through storytelling using 3D animation. It is well documented in literature that stories help humans store concepts in their long-term memory and have a broad usage in education.

3D animation was reserved only for professionals in the past, and its production was expensive. Software platforms such as Muvizu have made the creation of 3D animated stories possible for ordinary teachers. Muvizu, as we have seen, can also be used for visualizing stories from history or mythology. Muvizu content can also be made available through virtual reality headsets in cases where such headsets are available for classroom use.

The only disadvantage that emerged from creating and using animation is the time factor. The creation process of animated videos, even in platforms that allow rapid animation development (such as Animaker, Canva, and Muvizu), is still more time-consuming than producing other forms of educational material such as PowerPoint slides, notes or educational activities in platforms such as WordWall and H5P. Moreover, while many open-source or freely available tools exist for video and sound editing, such as ShotCut, Kdenlive, CapCut, and Audacity, the same is not true for tools that allow rapid animation development. Software tools such as Animaker and Canva have subscription plans with many features and options for the creator and free versions with limited options in the availability of stock images, visual and sound effects. If a teacher wants to use the free versions, then he/she will have to dedicate extra time to find appropriate images in open repositories or create these images either from scratch or by synthesizing new images from existing ones.

As we have presented in the first sections of this study (Sections 1 and 2), there can be disadvantages associated with the adoption of animations, such as increased cognitive load. This can be a consequence, especially if the production does not follow the multimedia principles [7, 96]. However, in the teacher efforts described in the previous sections, attention has been given in order for the productions to follow the basic multimedia principles. For example, in all explanatory videos, the images were not decorative. Decorative images, while visually appealing, can distract learners and reduce the cognitive resources available for processing essential information. Instead, visuals were purposeful, directly related to the content, and served to clarify key concepts and dynamic processes. Narration was generally preferred to on-screen text (modality and redundancy principle) except in cases where new terminology was introduced. Extraneous material such as irrelevant sounds and text was not present (coherence principle) and conversational language and human-like avatars were used to facilitate user-friendly interactions (personalization principle).

The purpose of this study, however, is not to draw conclusions on the efficiency of animations in learning but rather to showcase that today, animated videos can also be produced by ordinary schoolteachers and used in their daily lessons. As already mentioned, there is a lack of studies that report on teacher experiences from producing their own animations and using them to aid their instruction. Animations created by teachers can boost their creativity and enhance their digital communication skills. Animations created by teachers can also aid the students’ performance if multimedia principles are followed in
the creation process and if the animated videos are utilized as part of a well-organized study plan. Animations can also achieve better student satisfaction, enjoyment, and engagement.

During the postgraduate course teachers obtained several skills. More specifically, they were acquainted with various editing tools such as the online platform Photopea, the open-source software Inkscape for vector graphics creation, and the video editing tools Wevideo and Openshot. The teachers were not, however, taught any animation creation tools; therefore, the decision of what tools to select in order to create the educational animations was left to them. The teachers had to conduct research and examine the available options in order to come up with decisions on the appropriate tools.

Canva proved to be the most popular tool used in 4 (out of 7) cases, receiving an average rank of 4.5 (Table 2). Canva started as a platform for creating graphics for posters, social media, and presentations. Nowadays, it has evolved into a tool for designing various multimedia productions, including videos and animations. Canva also incorporates a generative AI assistant for creating images and short video clips.

Other popular tools were Audacity for sound editing and Animaker and Muvizu for animation creation. Inkscape was used in four cases, but in three cases, those who used it did not consider it user-friendly or easy to learn (Table 3). Several different software tools were selected for video editing, such as Wevideo, Openshot, Climchamp, and Pinnacle Studio (Table 4). Audacity was the most popular tool for sound editing.

5. Conclusions

As mentioned in the introduction, the aim of this paper is twofold—to provide a comprehensive literature review focusing on the last decade and to present animated videos produced by educators and their experiences from the development process and classroom use.

The literature review reports on issues such as the educational fields in which animated videos have been utilized over the last ten years, the countries where these research efforts took place, the types of animated videos used in these studies, the software tools used to create the educational animations, the research methods used, and the educational level for which the videos were produced. This paper also attempts to provide insights about the findings of these studies.

Although the literature examines a large number of papers (seventy-seven) it is by no means exhaustive, and this is a limitation of this paper In this study, the author searched for articles using the Google Scholar search engine and the Scopus Database. Animation in education is, however, a very large research field, and other databases, such as Springer, Web of Science, ERIC, EBSCO, and IEEE Xplore, could have been used to search for research articles. The reference section of the research articles could also have been investigated to find even more articles and more keywords could have been employed to broaden the search and obtain more results.

In the second part, this study presents animated videos produced by teachers, as well as details from the development process, and the software tools used. Although the creation of animated videos was a complicated task in the past and very few educators had the required skills to accomplish it, today, there are software platforms that are suitable for people without technical expertise or prior experience. Canva and Animaker are two platforms that proved to be popular amongst the educators whose video productions are briefly presented in this study. Both platforms proved to be user-friendly and effective in producing animated videos. This study also revealed that the animation creation process can boost educator creativity and enhance teacher communication skills. All the educators enjoyed the animation creation process, and in cases where the animated videos were used in class, the results were very positive.

Finally, it has to be highlighted that generative AI tools, which are a recent phenomenon, are affecting the way multimedia is produced, including educational animations. As these tools continue to evolve, they are bound to transform the multimedia production landscape.
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