Development of Instructional Videos for The Principles of 3D Computer Animation

S Pambudi¹, I Hidayatulloh², H D Surjono³ and T Sukardiyono⁴
Universitas Negeri Yogyakarta, Indonesia

Email: ¹sigitpambudi@uny.ac.id

Abstract. Understanding the principles of animation is an important factor and determines the quality of animation that can be produced. However, explanation of the principles of animation in many books are still specifically to traditional animation, not 3D computer animation that mostly used today. Students have difficulty applying traditional animation principles to 3D computer animation principles. Therefore, the purpose of this research is to develop thirteen instructional videos for the topic of Principle of 3D Computer Animation and to determine the effectiveness of these videos on student understanding. Video development uses the Research and Development Four-D model (Define, Design, Develop, and Disseminate). Based on the results of product testing, these thirteen learning videos were declared "very good". The paired t-test results showed that the product developed was effective in increasing students' understanding of the Principle of 3D Computer Animation.

1. Introduction

The rapid advancement of technology provides many opportunities [1]. There are many positive impacts resulting from technological innovation [2], one of them is the potential that comes from creativity [3]. Creativity has a very important role in the creative industry [4]. The creative industry or also known as the creative economy [5], is now becoming a hot topic in various countries and is growing very rapidly throughout the world. UNCTAD (United Nations Conference on Trade and Development) explains that the value of creative industry products has increased to $ 509 billion in 2015 from the previous $ 208 billion in 2002 [6]. The growth of the creative industry also occurs in Indonesia. Indonesian demographics play a role in the growth of the creative industry in Indonesia. According to data from BAPPENAS (Ministry of National Development Planning of the Republic of Indonesia), from a total population projection of 297 million in the period 2030-2040, it is predicted that 64 percent will be of productive age (15-64 years) [7].

One of the creative industry sectors that is growing and continues to be optimized in Indonesia is animation [8]. The animation industry has a very good potential with growth of up to 6.68% in the period 2014-2015 [9]. However, the enormous potential of the animation industry is not supported by human resources. The only weakness of the animation industry lies in the skill gap of animators [10]. An animator is called skilled if he is able to form a good series of animated motion.

In forming a series of animated movements (poses, timing, and motion), there is a main process called animating [11]. An animation maker or often called an animator has a responsibility in creating movements that look real and do not seem stiff, either from the character's movements or from their body language [12]. To be able to produce good quality motion animation, an
animator needs to be able to understand the principles of animation [13]. Therefore, in animator job vacancies written qualifications that prospective animators must already understand the twelve principles of animation as written in the book "The Illusion of Life: Disney Animation" [14]. Even so, it turns out that the explanation of the principles of animation in the book is only intended for traditional animation which is still drawn by hand and is 2-dimensional (2D). It is necessary to explain the principles of animation that are relevant to the technology used today, namely 3D Computer Animation [15].

From the results of observations on students who took Computer Graphics and Animation courses at Universitas Negeri Yogyakarta, it was found that students did not understand how to apply traditional animation principles to 3D Computer Animation. Based on an interview with a lecturer who teaches Computer Graphics and Animation courses, several facts were found. These facts include a lack of literacy which addresses the problem of applying traditional animation principles to 3D Computer Animation. In addition, a new breakthrough is needed in making learning media in the form of attractive and easy-to-use video learning media.

Based on the findings in the pre-research stage, it is necessary to have video-based media facilities in order to overcome the problems that occur. It is hoped that the learning video will be able to improve students' understanding in mastering the animation principle material and applying it to 3D Computer Animation.

2. Literature review

2.1. Learning Video

Media can be defined as an intermediary or a conveyor [16]. In the field of education, the media serve as an intermediary that has a role to convey information from teachers to students. For this reason, in the learning process, media is needed. The media used in learning must be based on student needs, learning objectives, materials, and learning methods. If all the elements have been achieved, then the utilization of the media will be more optimal.

With the influence of technology on education, teachers can take advantage of many variations of media, both audio and visual based. One of the most developed media is video based. Video is an audio-visual based media that can be heard and seen. As a learning medium, video is proven to be effective in the mass or independent learning process [17].

Edgar Dale mapped the level of students' understanding in the form of a cone which is called Dale's cone of experience theory [18]. Video-based media is included in the "Television" category. Based on Figure 1, the position of the television is in the middle. This means that video-based media is superior to media that is only audio or images only.
Videos can be the answer to problems in overcoming students' lack of conceptual understanding. Videos can be easily played back at any time, this helps students in learning. Structured presentation of content will help students understand content, especially those related to concepts [19]. Both of these advantages prove that videos are effective in improving students' abilities.

There are many studies that prove that videos can increase student motivation [20] and are effective in providing positive scores for learning achievement [21][22]. Learning activities that use videos can provide a fun atmosphere so that it helps students to keep concentrating on learning [23]. In addition, videos are also able to present an event that is difficult to explain with a physical simulation so that it helps students to understand it easily. Video can fulfill all aspects that students need from audio, visual and audio visual. Video is an effective learning media implemented in learning activities, because it is proven to have a positive impact on improving student learning achievement.

2.2. The Principles of Animation

Two animators from Walt Disney Studio, namely Ollie Johnston and Frank Thomas in the book "The Illusion of Life: Disney Animation" introduced twelve principles of animation, including Squash and Stretch, Anticipation, Staging, Straight Ahead Action and Pose to Pose, Follow Through and Overlapping Action, Slow In and Slow Out, Arcs, Secondary Action, Timing, Exaggeration, Solid Drawing, and Appeal [14]. The main objective of the principle of animation is that animators can develop a more realistic illusion of characters by following the basic laws of physics [24]. In addition, abstract elements, such as emotionality and character appeal, are also added, so that animation results are not only

![Figure 1. Dale’s Cone of Experience](image-url)
realistic, but also interesting, dynamic and not boring. In Table 1, the definitions of each animation principle are described in detail.

| Principles of animation | Definition |
|-------------------------|------------|
| Squash and Stretch      | To illustrate the rigidity and mass of an object by distorting a form on an act |
| Anticipation            | Movement square off in preparation for further action |
| Staging                 | The presentation of an idea so that it is absolutely clear |
| Straight Ahead Action and Pose to Pose | Refers to the two processes of drawing between drawing a scene frame by frame or using multiple key frames |
| Follow Through and Overlapping Action | Two techniques that are closely related to making movement more realistic, and give the impression that the character follows the laws of physics. |
| Slow in and Slow out    | Refers to how an object accelerates and slows down motion |
| Arcs                    | Represent the values of an objects parameters for natural movement |
| Secondary Action        | The action of an object that results directly from another action |
| Timing                  | Spacing actions to define and the personality of characters and the weight and size of objects |
| Exaggeration            | Accentuating the essence of an idea with add more drama and appeal to an action |
| Solid Drawing           | Refers to the ability to create a three-dimensional character in two-dimensional space by giving it balance, depth, and weight |
| Appeal                  | Designing the charisma of an actor |

The description of the principle of animation from the book The Illusion of Life: Disney Animation was widely applied by animation studios around the world until the book was labeled "Bible of animation" [25]. In 1999, this book was named the "best animation book of all time". The animation principles of The Illusion of Life: Disney Animation are devoted to being applied to traditional hand-drawn animation. As computer technology advances, the principles of animation have evolved so that they can be applied to 3D computer animation [15].

3. Materials and Methods

The product produced in this study is a video as a learning tool for Computer Graphics and Animation courses. The product development stage uses the Four-D Model introduced by Thiagarajan et al [26]. The Four-D model consists of 4 development stages, including Define, Design, Develop, and Disseminate. The product development stages are described in Figure 2.
Figure 2. Four-D Model for the development of instructional videos [27]

Product development begins with the define stage, namely by analyzing the current situation of lecturers and students, considering the competencies of the targeted subjects and concepts, then formulating targets and specifications for the objectives to be achieved. This study uses the method of observation, interviews, and instrument questionnaires. As a consideration in product development, it is necessary to study the Semester Learning Plan (SLP) for the Computer Animation Graphics Course at Universitas Negeri Yogyakarta.

Product testing includes testing by experts and continued product testing with respondents on a larger scale. Testing by experts includes the material validation process and media validation. It aims to get the needed feedback. Suggestions from experts are then taken into consideration in product development. The final test involved all respondents, as many as 33 Yogyakarta State University students who took Computer Graphics and Animation courses. To test the level of effectiveness of a product, it is necessary to compare the results of the pretest and posttest and also continue with the t test.

4. Result and discussion

Product development to improve understanding of the basic principles of computer animation has been completed. The development of this research product resulted in thirteen instructional videos which in general can be seen in table 2. The composition of the video is based on the order of content listed in the Semester Learning Plan (SLP) in Computer Graphics and Animation courses.
Table 2. Instructional video details

| No. | Video Title                                           | Duration                    |
|-----|-------------------------------------------------------|----------------------------|
| 1   | Introduction to Basic Principles of Animation         | 6 Minutes 34 Seconds        |
| 2   | Animation Principle of Squash & Stretch               | 5 Minutes 17 Seconds        |
| 3   | Animation Principle of Anticipation                   | 3 Minutes 42 Seconds        |
| 4   | Animation Principle of Staging                        | 6 Minutes 11 Seconds        |
| 5   | Animation Principle of Straight Ahead Action & Pose to Pose | 5 Minutes 44 Seconds  |
| 6   | Animation Principle of Follow Through & Overlapping Action | 5 Minutes 40 Seconds  |
| 7   | Animation Principle of Slow in & Slow out             | 3 Minutes 54 Seconds        |
| 8   | Animation Principle of Arcs                           | 2 Minutes 45 Seconds        |
| 9   | Animation Principle of Secondary Action               | 3 Minutes 11 Seconds        |
| 10  | Animation Principle of Timing                          | 3 Minutes 13 Seconds        |
| 11  | Animation Principle of Exaggeration                   | 3 Minutes 46 Seconds        |
| 12  | Animation Principle of Solid Drawing                  | 3 Minutes 17 Seconds        |
| 13  | Animation Principle of Appeal                          | 3 Minutes 50 Seconds        |

The learning video display is designed in such a way that users (lecturers and students) are interested in using the product. The technique of presenting learning videos consists of two ways, including single shot and animation. It is expected that students are interested and willing to listen to all the content presented with variations in the presentation of the video. Display of learning videos can be seen in Figure 3.

![Figure 3. Single Shot & Animation](image-url)
From the content expert testing on product quality in terms of learning design and linguistic aspects, it gets an average score of 4.56 with the "Very Good" category. The results of the media expert's test of product quality in terms of text quality, image quality, animation quality, audio quality, and media reliability aspects scored an average of 4.42 in the "Very Good" category. The results of the overall assessment of aspects of the beta test carried out on the development of this learning video show that the aspects of learning design, language, text quality, image quality, animation quality, audio quality, and media reliability score an average of 4.23 with category "Very Good". Taking into account some of the results of these assessments, it can be concluded that the product developed at almost all testing stages is in the "Very Good" category so that it can be stated that it is very suitable for use.

The t test was conducted to test the effectiveness of the research product. The results of the paired sample t-test analysis get a t value of -12.103 with a probability of 0.000. Because the probability <0.025, so the two population averages are not identical (the mean value of the protest and posttest is significantly different). Refer on these data, the increase in the competence of students by comparing the pretest and posttest scores and the t test analysis carried out showed that the pretest value was lower than the posttest value. So that learning using learning videos is proven effective in increasing student understanding in understanding the Principle of 3D Computer Animation.

| Pair 1 | Pretest - Posttest | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | t | df  | Sig. (2-tailed) |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2.212.121 | 1.049.928 | 182.769 | -2.584.409 | -1.839.833 | -12.103 | 32 | .000 |

5. Conclusion

The development of instructional videos to improve understanding of the basic principles of computer animation has been successfully developed by adopting the Four-D Model. The results of the alpha test and beta test on the research products get a "Very Good" value. This means that the product is suitable for use as teaching material for studying the Principles of 3D Computer Animation. Referring to the results of the pretest and posttest as well as paired sample t-test analysis, it is proven that the research product in the form of instructional videos is truly effective in increasing students' understanding in understanding the Principles of 3D Computer Animation.

Development related to the principle of animation is still being carried out. These principles are constantly being developed to make animation look more realistic but still entertaining. The principles of 3D computer animation are an example of the development of traditional animation principles. However, understanding something new from the results of these developments is not easy. It is hoped that the presence of this learning video can contribute to educational technology. A little suggestion for the development of further research related to this research is to make better use of the latest technology and improvements in the aspects of navigation and interactivity with students. Moreover, the development of smartphone features
that are getting richer and more sophisticated as well as a high interest in learning media in the form of games [28] may also be explored to improve engagement in the learning process of animation principles.

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