Enhancing Learning Outcomes by Implementing Segmentation Principles and Generative Activities in Instructional Videos

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***Abstract*—Combining design and pedagogy aspects was pivotal for enhancing active student engagement. This research aimed to develop an innovative instructional video by implementing the principles of segmentation and generative activity. The resultant video was intended to be valid, compelling, and effective in enhancing learning outcomes. Employing a development research approach utilizing the 4D model, the video underwent rigorous evaluation across four stages: an expert review, a one-to-one evaluation, a small group evaluation, and a field evaluation. The study engaged two experts—one media expert who also served as an instructional design expert and one content expert—as well as three students for individual evaluation, 12 students for small-group evaluation, and 19 students for field evaluation. Data were obtained through questionnaire instruments administered to both experts and students, and a multiple-choice test was used to assess the video's effectiveness. Utilizing a one-group pretest-posttest design, the study employed a correlated sample t-test to analyze pretest and posttest data. Findings from expert evaluations indicated exceptional validity in instructional design and media elements, with content quality deemed appropriate. Furthermore, the video's attractiveness was classified as being in the good category. The t-test demonstrated a significant improvement in student learning outcomes ($p = 0.003$), underscoring the video's effectiveness in enhancing comprehension through segmented content presentation and interactive features such as questioning, explanations, descriptions, and summarizations.**

***Keywords*—instructional video, segmentation, generative activity, students' interaction, student engagement**

I. INTRODUCTION

Learning videos hold a pivotal role in the digital age. The rapid advancement of information technology, along with the widespread utilization of the internet, has spurred a significant surge in educational video content, particularly following the COVID-19 pandemic. To effectively meet the needs of future learners, learning videos must be continuously innovated and transformed to align with the distinct characteristics of their target audience. Elementary school students, often referred to as Alpha generation, were born after 2011 [1]. The learning preferences of the Alpha generation are intricately connected to technology [2]. This generation is characterized by its dependence on electronic devices, reduced face-to-face social interactions, innovative thinking, and a strong sense of individuality [3]. These attributes pose a barrier for educators in the delivery of educational materials, including instructional videos. Based on the results of interviews with teachers and principals of elementary schools, students need video media. This is because videos are able to present messages or materials visually and audibly. Videos are also very appropriate for presenting messages containing procedural materials so that the material becomes easier to understand before students do direct practice.

Technological advancements have fundamentally transformed the learning process of students. Education across various levels, from primary school to university, has incorporated multimedia technologies—such as video, music, animation, and interactive graphics—as essential pedagogical tools [4]. Historically, learners heavily depended on the physical presence of educators within the classroom. However, in the current digital technology era, students can initiate their learning journeys through digital media, websites, and YouTube videos. This shift empowers students with the autonomy to select their preferred learning materials, control the pace of their learning, and access resources at any time and from any location. This evolution underscores the critical importance of developing digital content, particularly in video format. Recent studies highlight that video has become the primary and most widely utilized medium for learning [4, 5]. Digital platforms, such as YouTube, play a crucial role in facilitating the learning process, with approximately 30 million videos viewed daily, of which nearly half are educational content [6]. The field of learning technology has increasingly emphasized video-based learning due to its exceptional ability to enhance learning outcomes through engaging, interactive, and effective methods [7].

The extensive use of digital video contrasts with the profound engagement of students. Moreno-Marcos *et al.* [8] indicates that student involvement in self-directed online learning through video is limited to a maximum of 10%. Video-based learning often leads to a decline in learning motivation, negatively impacting student engagement [9]. However, certain educational videos have the potential to significantly enhance student motivation and comprehension [10]. The effectiveness of a video is intricately linked to how the content is presented. Displaying complex and detailed information on a solitary video screen can discourage learners and impose a high cognitive load [11]. Such elaborate video messages not only deter engagement but also necessitate additional support for learners to comprehend information, further reducing their involvement with the video.

The pedagogical and messaging design of a video is critical in facilitating learning. Effective pedagogical design enhances learner motivation and competency by fostering

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interaction between learners and content [12]. However, the current video designs often fail to incorporate essential elements such as interaction and technology [7]. Many instructional videos do not optimize information processing for learners, resulting in passive observation rather than active engagement with the educational material. For meaningful learning to occur, learners must actively engage with both the visual and auditory content of the video. When the students are not engaged, they remain mere spectators, missing out on substantial educational benefits [13]. Additionally, there is a notable scarcity of instructional videos that apply robust design concepts in their production [14]. This deficiency negatively impacts learners by hindering knowledge acquisition, impairing cognitive processing of complex information, overwhelming cognitive capacity, and diminishing their motivation [15, 16]. Managing cognitive load is a significant factor in the design of digital and multimedia educational materials [17].

The pedagogical and message design in educational videos plays a crucial role in facilitating learning. Effective pedagogical design enhances student motivation and facilitates competency attainment by promoting active engagement with the learning material [12]. However, many video designers have yet to fully integrate essential features such as interactivity and advanced technology [7]. Optimal information processing in instructional videos is often neglected, resulting in passive observation rather than active learning. Learners must engage actively with both the visual and auditory content presented in the videos. Mere access to video content without fostering meaningful interaction does not lead to substantial learning outcomes [13]. Furthermore, only a limited number of instructional videos incorporate comprehensive design principles, significantly impacting learners' ability to acquire knowledge [14]. This deficiency contributes to difficulties in processing complex material, cognitive overload, and reduced motivation [15, 16]. Therefore, understanding and managing cognitive load is essential in the design of digital and multimedia educational materials [17].

The inherent complexity of educational material can significantly affect students' comprehension [11]. The intricacy of the material directly influences the efficiency of students' learning time. To address these challenges, cognitive load theory can be employed as a framework to assess and enhance the quality of the material, leading to more efficient learning [18]. This approach is closely tied to the principles of educational technology, which are influenced by the specific characteristics of human cognitive architecture [19]. By implementing segmentation principles, video-based learning can effectively reduce cognitive load. Mayer [20] indicates that individuals acquire knowledge most effectively when information is presented in manageable, tailored segments.

Another crucial factor in video design is the incorporation of pedagogical elements that actively engage learners. When creating instructional videos, it is essential to incorporate the concept of active learners in a digital environment. Numerous online videos lack intentional integration of pedagogical components, learning theories, information processing theories, or multimedia theories. For instance, presenting information in a more concise and complex manner can enhance students' comprehension [21]. Similarly, the absence of information processing theory applications can hinder students' understanding [22]. There remains a significant need to develop learning videos that effectively promote learner engagement. Active student engagement in learning can enhance educational outcomes when media is utilized effectively [23]. A compelling educational video not only imparts knowledge but also significantly stimulates students to actively engage in the learning process.

The principles of message design and pedagogy that are believed to reduce cognitive load and enhance student engagement include segmentation and generative activity. Segmentation involves organizing information into discrete pieces or sections, providing a structured framework for content delivery [17, 24]. Generative activity encourages learners to engage actively both during and after viewing the videos. Generative learning comprises three stages: Selecting, Organizing, and Integrating (SOI) [25]. Instructional videos that employ segmentation and generative activity principles help students select relevant knowledge from digital content, organize it in their working memory, and integrate it into long-term memory or apply it in practical tasks. These videos incorporate eight specific activities: (1) summarizing, (2) mapping, (3) sketching, (4) picturing, (5) self-testing, (6) explaining, (7) teaching, and (8) creating or performing [25]. Utilizing video design principles grounded in segmentation and generative activity is expected to reduce cognitive load and stimulate student engagement effectively.

Incorporating segmentation principles and generative activities, particularly in primary school education, remains uncommon despite the existence of additional research focusing on generative learning models or methodologies within classroom settings [26]. The investigation of segmentation is essential due to its documented positive impact on learning outcomes [13, 27–29]. Similarly, integrating generative activities into instructional media shows promising aspects for enhancing the learning process [23, 30]. Applying segmentation principles and generative activities in learning videos aligns with information processing theory, enhancing message clarity and effectiveness in educational activities [31, 32]. Moreover, the shift from printed content to digital videos is imperative in the context of the Fourth Industrial Revolution, where digital video materials demonstrate greater impact compared to traditional print formats [33]. This study addressed the following questions: 1) How does the validity of instructional videos improve with the application of segmentation and generative activity principles? 2) What is the perceived attractiveness of instructional videos based on student feedback? 3) To what extent do segmentation and generative activities in instructional videos enhance learning outcomes?

II. Literature Review

A. Segmentation Principle

The principle of segmentation guides the design of instructional messages by suggesting that students learn better when information is presented in organized segments [17]. Segmentation involves presenting material in short, organized units across a series of learning events, such as topics or lessons. Video segmentation utilizes a dynamic audiovisual format to present information in manageable segments that students can process effectively, covering factual, conceptual, and procedural knowledge. Videos are widely utilized in education to present content, facilitate remedial activities, and enhance learning through engagement and interactivity [7]. Implementing segmentation principles in videos not only influences learning outcomes (cognitive) but also affects emotional states. Segmented videos reduce cognitive load compared to non-segmented ones by presenting fewer steps or pieces of information per segment, thereby simplifying the message or task [34, 35]. Therefore, applying segmentation principles in videos suggests that shorter, segmented videos demand less cognitive load due to their reduced information complexity [15, 17].

B. Generative Activity

Generative learning theory, rooted in Bartlett's perspective of learning as knowledge construction, posits that students integrate new experiences with existing knowledge, akin to Piaget's concepts of assimilation and accommodation. This theory emphasizes the meaningful construction of knowledge structures and their application to novel situations. This approach delineates eight types of learning activities within generative learning [25]: summarizing, mapping, drawing, imagining, self-testing, explaining, teaching, and performing/acting. These activities are designed to facilitate deep understanding and effective application of learned material across diverse contexts.

In other research, generative learning activities encompass tasks such as understanding (explaining, visualizing, or performing action) and related functions (generalizing, visualizing, and executing) [36]. These activities are crucial as they empower students to take an active role in constructing knowledge. It is essential that students engage in active tasks following the reception of information from media sources [37, 38].

Generative learning strategies aim to foster cognitive processes such as selecting, organizing, and integrating information through generative processing [25]. These processes are constrained by the limited processing capacity of the human information processing system [19]. Generative processing, as delineated by generative learning theory, aligns closely with the constructive interaction mode in the Interactive, Constructive, Active, and Passive (ICAP) framework [39]. The ICAP framework categorizes engagement into four hierarchical modes based on levels of learning: interactive, involving constructive dialogue; constructive, which entails generating or synthesizing new knowledge or ideas; active, involving physical or manipulative actions; and passive, where students primarily receive information without engaging in other active learning behaviours [39]. Activities such as creating, summarizing, explaining, and mapping fall under interactive, constructive, and active modes. Additionally, collaborative activities are also important as they can enhance effectiveness more than individual generative activities [40].

III. MATERIALS AND METHODS

This research falls within the domain of development research and employs the 4D model, comprising the stages of Define, Design, Develop, and Disseminate. The selection of this model was based on its systematic approach and extensive utilization in developing instructional products. The Define stage encompassed several key actions: a) establishing clear objectives, b) scrutinizing and categorizing content into subjects and sub-topics, and c) evaluating the student characteristics. During the Design stage, precise specifications for the digital video architecture were established. Tasks include a) categorizing the digital content, b) creating storyboards, and c) incorporating generative activities. Creating a storyboard aims to provide a comprehensive framework for delivering educational content to the audience. The Development stage focused on translating the storyboard into an educational video. Production followed the storyboard created in the Design stage, organizing various materials such as text, graphics, animation, sound, and video based on their specific functions. The Dissemination stage involved video testing through formative evaluation procedures as outlined by Dick and Carey [41].

This assessment process included expert evaluation by two experts (one design expert as well as one media expert, and one content expert), one-to-one evaluations with three participants, small group evaluation with twelve participants, and field evaluation with nineteen participants. The video's effectiveness was assessed using a quasi-experimental design at this stage. The research design used was a one-group pretest and posttest design (O_1 X O_2). This design provides a pretest (O_1 = initial observation) before the video media is applied. After that, the video is applied to learning in several meetings (X = treatment). At the end of the learning, students are given a posttest (O_2 = final observation). Then, the results of the pretest and posttest are compared to determine the difference in scores between before and after the video media is applied.

The production process of educational videos necessitates undergoing rigorous trials to assess their validity, attractiveness, and effectiveness. Expert reviews, individual testing, and small group tests were employed to evaluate these aspects. Preliminary experiments were conducted to gauge the efficacy of the video content.

Data collection involved multiple methods including observation, questionnaires, and tests. The preliminary investigation utilized both observational and questionnaire-based approaches. Questionnaires were administered to experts and students, employing both one-to-one and small-group evaluations. To ensure the validity of the questionnaire, a grid table was implemented during the development of the instrument. Table 1 outlines the framework of assessment tools utilized for evaluating the validity and attractiveness of instructional videos.

The data obtained through the questionnaire method is further examined using descriptive statistical analysis. The formula utilized to get the proportion of each respondent is as follows.

$$\frac{\sum x}{IMS} \times 100$$

IMS: ideal maximum score

The rules utilized for assigning significance and making decisions are given in Table 2.

Table 1. Aspects of learning video validity test instruments [42, 43]

Stages Formative Evaluation	Aspect	Number of Items
Instructional media Aspect validation	1. Typography 2. Graphic 3. Audio 4. Video 5. Systematics	15
Instructional design aspect validation	1. Instructional design 2. Message delivery strategy 3. Display design	
Content aspect validation	1. Correctness 2. Breadth 3. Novelty/current 4. Systematics	11
One-to-one evaluation	1. Clarity of text and visual messages 2. Attractiveness 3. Readability 4. Language 5. Motivating ability 6. Technical Quality 7. Clarity of activity	7
Small group evaluation	1. Clarity of text and visual messages 2. Attractiveness 3. Readability 4. Language 5. Motivating ability 6. Technical Quality 7. Clarity of activity	7

Table 2. Achievement level conversion guidelines on a scale of 5 [44]

Achievement Level (%)	Qualification	Description
90–100	Very good	No need to revise
75–89	Good	Slightly revised
65–74	Fair	Revised sufficiently
55–64	Deficient	Many things revised
0–54	Very little	Repeated making of the product

The effectiveness of the video was tested using a multiple-choice test consisting of 20 questions. The validity of the test items was tested on 60 students. The test item validity test results used the product-moment correlation test with a 5% error rate. The results of the test item validity are presented in Table 3.

Table 3. Multiple choice test item validity results

Item	r-xy	r-tabel (df = 58)	Status
X1	0.294	0.254	Valid
X2	0.965	0.254	Valid
X3	0.965	0.254	Valid
X4	0.946	0.254	Valid
X5	0.641	0.254	Valid
X6	0.946	0.254	Valid
X7	0.307	0.254	Valid
X8	0.965	0.254	Valid
X9	0.965	0.254	Valid
X10	0.965	0.254	Valid
X11	0.965	0.254	Valid
X12	0.965	0.254	Valid
X13	0.946	0.254	Valid
X14	0.965	0.254	Valid
X15	0.575	0.254	Valid
X16	0.641	0.254	Valid
X17	0.611	0.254	Valid
X18	0.965	0.254	Valid
X19	0.929	0.254	Valid
X20	0.929	0.254	Valid

The results of the internal reliability test using the Kuder Richardson 20 formula obtained 0.974. The criteria that can be referred to are if the reliability coefficient is equal to or greater than 0.80, then the test is acceptable [45]. Furthermore, tests that have been declared valid and reliable can be used to measure the effectiveness of video media. Data collected from testing using test instruments are then evaluated using inferential statistics, especially the t-test for correlated samples with n1 = n2.

IV. Result and Discussion

A. Result

The creation of educational videos adhered to the 4D paradigm, encompassing four stages: define, design, develop, and disseminate. Each stage represents a distinct phase in the process or development cycle. During the Define stage, several actions were executed, including a) setting objectives, b) organizing content by topics and sub-topics, and c) evaluating student characteristics. The outcomes of these actions are detailed in Table 4.

Table 4. Results of material analysis on one of the topics

Topic 1	Learning Objective	Segment sequence number	Activity Generative Type	Content
Making Decorative Flags from Paper	Students can discern and categorize flags according to their shape and purpose.	Video Segment 1	Explain the concept of an ornamental flag	A *flag* is a textile or parchment object utilized to represent a nation, organization, entity, etc. Flags are artistic creations characterized by their distinct shape and vibrant colour. The shape may exhibit rectangular, triangular, or even figurative forms, resembling animals and humans.
	Students can conceive and create a concept and design for a decorative flag.	Video Segment 2	Explain the idea of an ornamental flag	In order to create a decorative flag, friends should seek inspiration. Friends can utilize visually appealing hues and create captivating flag formations.
	Students may enumerate the necessary resources for creating their flag.	Video Segment 3	Classify the tools and materials for making decorative flags	Essential tools for creating beautiful flags include scissors, a cutter, and snaps. Required materials for creating decorative flags are paper, adhesive, string, and plastic.
	Students possess the ability to elucidate the procedure involved in fabricating ornamental banners.	Video Segment 4	Summarized the steps to make an ornamental flag	The procedure for creating decorative flags involves the following steps: 1) Identifying the flag design. 2) Structuring the paper based on the designated format. 3) Performing paper cutting. 4) Securing the flag to the rope, 5) Mounting the ornamental flag.

Design stage. During this stage, a detailed architecture specification for the learning video was developed. Activities in this phase primarily focused on crafting a storyboard for the video. The design of video architecture involved applying principles of segmentation and engaging in generative activities. Fig. 1 illustrates the segmentation and generating design processes.

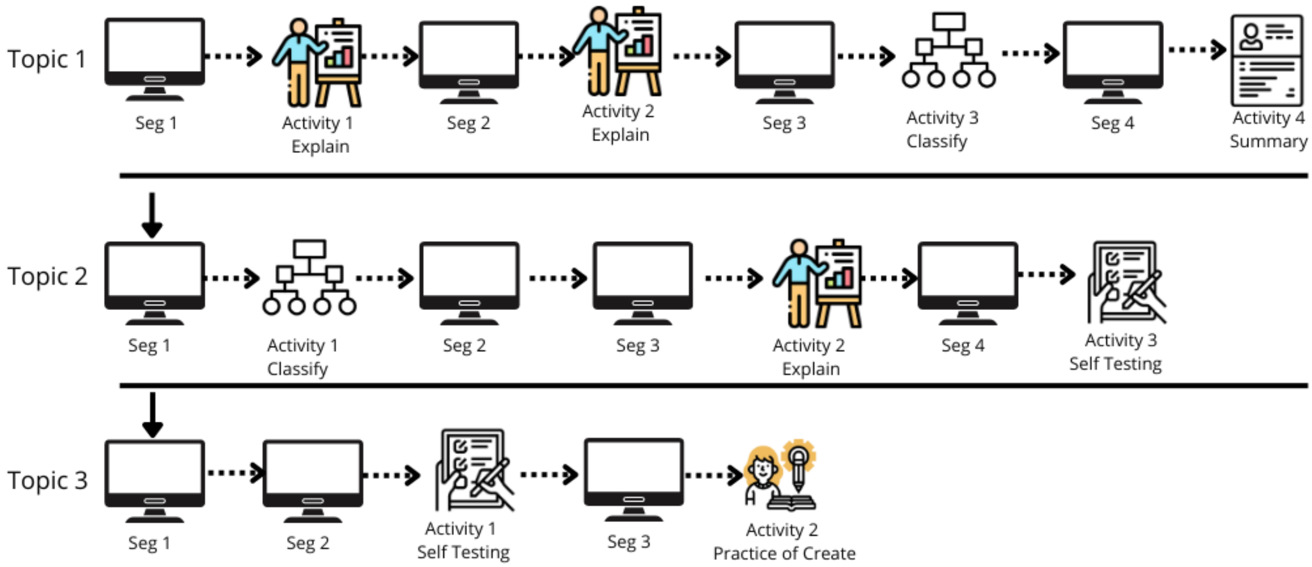

Fig. 1. Design of the application of segmentation principles and generative activity.

Develop stage. In the development stage, the storyboard transitions into an instructional video. This video is constructed based on the storyboard conceived during the design stage. Various elements such as text, graphics, animation, music, and video are meticulously arranged according to their respective functions. The digital video depicted in Fig. 2 is an example of the integration of the segmentation principle. Fig. 3 shows a generative activity in the form of giving a quiz after students watch the video.

Fig. 2. Video footage on the topic of fine arts

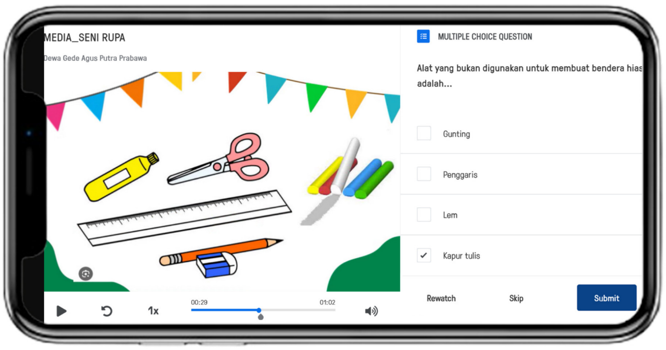

Fig. 3. An example of implementing generative activities is taking a test or quiz in the video.

1) How valid is instructional video when the principles of segmentation and generative activity are used?

Dissemination stage. In this stage, the evaluation of instructional videos employed formative evaluation methodologies [41]. This evaluation process entailed expert evaluations conducted by two specialists (one specializing in instructional design and media and one in content), one-to-one evaluations with three participants, small group evaluations with twelve participants, and field evaluations with nineteen participants. The findings of the content expert evaluation of the instructional materials are presented in Table 5.

Table 5. Results of content expert assessment of digital video

Statement	Score (1–4)
Clarity of topic or title of digital content	4
Clarity of learning objectives	4
Suitability of the material with the curriculum/learning objectives	4
The accuracy of the coverage or scope of the material	3
The sophistication of the material	3
Appropriateness between text and images	3
Appropriateness of narration or narrator explanation of the topic/sub-topic/description of material	4
Attractiveness of video content presentation	3
Easy to understand message	3
Encourages student curiosity	4
Appropriateness of generative activity with content characteristics	3
Total	38
Score	86.36

According to the evaluation by content specialists, the digital content generated has a validity score of 86.36, which falls within the excellent range. The findings from the evaluation conducted by design and instructional media specialists are displayed in Table 6.

The expert assessment of the design and media components of the prepared learning video achieved a validity score of 93.33, categorizing it as excellent.

Specialists with expertise in digital content contributed to this evaluation. To enhance the comprehensiveness of information, contextual prompts stimulating deeper understanding were included. Recommendations from these specialists guided revisions of the digital content. Furthermore, the effectiveness of the video was evaluated through educational testing involving students.

Table 6. Results of expert assessment of instructional design and media aspects

Statement	Score (1–4)
Clarity of topic or title of digital content	4
Clarity of learning objectives	3
Appropriateness of text and image positioning	4
Clarity and attractiveness of images	3
Appropriateness of font type and size	4
Appropriateness of the character and intonation of the narrator's voice	4
The attractiveness of the background used	3
Accuracy of animation	4
Appropriateness of the use of color	4
The clarity of the application of the generative activity principle	4
The accuracy of the presentation of generative activity in the video segment	4
The accuracy of breaking the material into units	4
The accuracy of the video flow	3
Accuracy of video duration	4
Variety of presentation	4
Total	56
Score	93.33

2) How attractive is the instructional video based on student feedback?

The video media attractiveness test was conducted through two stages: the one-on-one evaluation stage and the small group trial stage. In Table 7 are the results of the attractiveness test through one-on-one evaluation.

Table 7. One-to-one trial results

Aspects	R1	R2	R3
Attractiveness	3	3	2
The message can be understood	2	3	2
Feeling when learning	3	3	3
Readability of text	2	2	3
Clarity of audio elements	3	3	3
Clarity of visual elements	3	3	3
Clarity of required activities or tasks	2	2	2
Total	18	19	18
Score	85.71	90.48	85.71
Average Score		87.30	

According to the data presented in Table 6, the average score attained is 87.30, which is categorized as excellent. Consequently, students generally perceive the instructional video as acceptable despite providing feedback indicating challenges in comprehending certain written materials and areas needing improvement. The feedback gathered from students was subsequently used to revise the media content prior to conducting the small group trial. Table 8 presents the outcomes from the study conducted with a small group.

Table 8. Small group trial results

Aspects	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
Attractiveness	3	2	3	3	3	3	3	3	3	3	3	3
The message can be understood	3	3	3	3	3	2	2	3	2	3	3	2
Feeling when learning	3	3	3	2	2	2	2	2	3	2	3	3
Readability of text	2	2	3	2	2	2	3	3	2	3	3	3
Clarity of audio elements	3	3	2	2	2	3	3	2	3	3	3	3
Clarity of visual elements	3	3	3	3	3	3	2	3	2	3	2	3
Clarity of required activities or tasks	2	3	3	3	3	2	2	2	3	3	3	3
Total	19	19	20	18	18	17	17	18	18	20	20	20
Score	90.4	90.4	95.2	85.7	85.7	80.9	80.9	85.7	85.7	95.2	95.2	95.2
Average Score							88.89					

According to the data presented in Table 8, the learning video achieved an average score of 88.89, placing it within the excellent range. Students expressed positive attitudes towards learning through videos, reporting a high level of comprehension and enjoyment of the subject matter. However, some students noted that the pace of certain videos was excessively rapid, which hindered their comprehension. Furthermore, specific videos lacked clarity, requiring an additional explanation of the accompanying text. The feedback from students was used to identify and address these remaining deficiencies in the instructional video through subsequent revisions.

3) To what extent do segmentation and generative activity on instructional video enhance learning outcomes?

The instructional video was implemented over one month for study purposes, with 2–3 weekly sessions conducted. The efficacy assessment of the video was conducted with a single class at the elementary school level. Generative activities were integrated in two formats: embedded within the video itself and implemented in real-world classroom activities. Fig. 4 illustrates an example of a generative activity where students engage in discussions or tasks following video viewing.

Fig. 4. Students explain how to make decorative flags after watching the video.

Students demonstrate enhanced comprehension when instructional material is presented in segmented video formats. This approach facilitates understanding and proficiency in practical tasks, such as creating decorative flags, thereby improving students' ability to articulate the processes involved. The study employed a one-group pretest-posttest research design to investigate the impact of a direct learning model utilizing instructional video materials as an independent variable on student learning outcomes. Detailed research findings are presented in Table 9.

Table 9. Data description

Observation		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	56.5789	19	11.79131	2.70511
	Posttest	67.1053	19	8.38580	1.92383

According to Table 9, the mean score of the students' pretest was 56.57, whereas the mean score of the posttest was 67.10. This indicates a mean increase following the implementation of digital video. Furthermore, a t-test for correlated samples was performed to assess the statistical significance of the difference in means. Prior to the hypothesis testing, tests for normality and homogeneity, as detailed in Tables 10 and 11, were carried out to ensure the validity of the analysis.

Table 10. Normality test results

Observation	Kolmogorov-Smirnov (a)			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre	0.131	19	0.200 (*)	0.981	19	0.952
Post	0.125	19	0.200 (*)	0.926	19	0.148

* This is a lower bound of the true significance.
a Lilliefors Significance Correction

According to the Table 10, the significance value obtained in the Kolmogorov-Smirnov test is 0.200 for both the pretest and posttest data sets. This value exceeds the threshold of 0.05, indicating a higher level of significance. Consequently, it can be inferred that both data sets are derived from the same population and conform to a normal distribution. Additionally, the results of the homogeneity test are presented in the subsequent table, supporting the consistency of variance between the groups.

Table 11. Homogeneity test

Dependent Variable	Homogeneity Test Base on	Levene Statistic	df1	df2	Sig.
Learning outcome	Based on mean	1.135	1	36	0.294
	Based on media	1.018	1	36	0.320
	Based on the median and with adjusted df	1.018	1	31.424	0.321
	Based on trimmed mean	1.149	1	36	0.291

According to Table 11, the mean value derived from the data yields a significance level of 0.294. This significance level, being greater than the threshold of 0.05, suggests that there is no statistically significant difference in the variance between the pretest and posttest data. Moreover, the results of the hypothesis testing are presented in Table 12.

According to Table 12, the obtained *p*-value is 0.003, which is below the conventional threshold of statistical significance ($\alpha = 0.05$). Consequently, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted. This result indicates a statistically significant difference in the mean scores before and after the intervention, which utilized video-based instruction adhering to the segmentation principle and generative activity approach

Table 12. Paired sample t-test results

Observation	Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pretest-Posttest	−10.53	13.63	3.12	−17.09	−3.95	−3.36	18	0.003

B. Discussion

The t-test results revealed a significant disparity in learning outcomes between periods before and after the implementation of generative activity-based digital videos. Instructional videos that integrate segmentation and generative activity concepts have a substantial impact on students' comprehension and engagement with the subject matter. The results of this study are as follows. Segmentation-based learning videos deliver content compactly using visual and auditory elements tailored to students' cognitive capacities. This approach reduces cognitive load by presenting information in a less dense format, thereby easing the burden of information processing [15, 17]. Segmentation aims to direct students' attention to essential content cues, facilitating comprehension and aligning with the advantages of video media, which allow for repeated viewing. Some students requested video replays during study sessions to aid their comprehension. Mayer and Moreno [17] indicates that incorporating both verbal and visual elements in videos enhances students' cognitive processing of information. Breaking down the material into smaller segments facilitates more effective knowledge transfer compared to presenting it in larger blocks [46, 47]. By implementing the segmentation concept, learners can regulate the pace of information delivery according to their learning speed, thereby enhancing their overall learning experience [48].

The produced video is effective for conveying procedural knowledge through segmentation and narration. Employing a concise and logically structured narrative to present segmented material has a significant impact [11, 49]. Procedural knowledge spans a wide range of disciplines, including the artistic domain of crafting decorative flags. Instructional videos are an effective medium for demonstrating the process involved in creating such ornamental items. Empirical observations indicate that students found it more manageable to create decorative flags when they were provided with step-by-step procedural guidance. These videos allow students to listen to, comprehend, and repeatedly access the instructional material. The segmentation of procedural steps within each video segment has been shown to reduce the complexity of the tasks [34, 35]. Additional research indicates that segmented instructional messages enhance memory retention and procedural skills more effectively than unsegmented messages [13, 50, 51].

Video media functions not only as a medium for presenting information but also as a catalyst for student engagement and participation, primarily due to the generative activity incorporated within the videos. Following video segments, students engage in various activities, including 1) providing explanations, 2) offering descriptions, 3) practising or creating, 4) classification or mapping, 5) learning through summarization, 6) taking quizzes, 7) teaching, and 8) producing original work. Incorporating interactive quizzes into videos and regulating their duration can enhance student engagement and motivation. This finding supports other research that shows indicates that embedding hyperlinks and online quizzes within videos significantly enhances the learning experience and overall educational quality compared to standard video formats [52]. Additionally, providing hints regarding generating activities can optimize cognitive processes during learning, facilitating the integration of novel information with pre-existing knowledge in long-term memory [15, 23]. Active learner engagement fosters creative processes and deepens the understanding of concepts at an advanced cognitive level.

Engaging in generative activities while watching videos has been shown to elicit positive emotions, thereby enhancing learner engagement. The incorporation of essential auditory and visual components plays a pivotal role in establishing an emotional connection with educational content. These elements are crucial since they capture learners' attention, stimulate their interest, and enhance their motivation [53, 54]. Generative activities are particularly effective in inspiring students to acquire knowledge and in promoting favourable emotional states [55]. Methods such as interrogative or case-based activities can further stimulate active participation among students. According to message design theory, the introduction of challenging elements can enhance motivation for learning [56]. This theory supports the inclusion of generative activities to stimulate active participation and comprehension of educational content [37].

Incorporating generative activities within video content can significantly enhance students' concentration on comprehending the core material [40]. Engaging activities elicit focused attention from students, prompting them to listen attentively to the subject. Throughout the video's duration, the inclusion of questions necessitates sustained concentration. According to Knoster and Goodboy [57], generative activities that adhere to the principles of the Cognitive Theory of Multimedia Learning (CTML) have a direct impact on student engagement. These activities facilitate direct student interaction with provided stimuli, thereby enhancing feelings of accomplishment, concentration, and overall engagement.

Engaging in generative activities through video can significantly enhance experiential learning by requiring students to actively perform or enact tasks demonstrated in the content. This approach enables students to engage in practical exercises based on the instructional video, allowing them to replicate the procedures shown. This method aligns with the finding by Castro-Alonso [58], who assert that students exhibit enhanced learning outcomes when they are allowed to apply their knowledge actively. The instructional video serves as a guide for students to apply theoretical knowledge in practice scenarios, resulting in superior work performance compared to those who have not engaged with the video content. These findings align with the research results emphasizing the importance of follow-up activities after an instructional video [23]. The role of generative activities is essential in reinforcing and complementing other educational actions, such as explaining and visualizing concepts [36]. Hence, while generative activities are necessary, it is also crucial for students to engage in practical application. Engaging in such activities promotes profound cognitive engagement, characterized by deep and contemplative thinking. Students are encouraged to engage in critical thinking, establish connections between facts, cultivate comprehension, and generate or engage in learning materials.

An important finding in this study is that the message design for the video is very important to make it easier for students to understand the contents of the video. Presenting messages briefly and concisely is easier for students to remember. Each video segment emphasizes essential points, reducing confusion and cognitive overload. Shorter videos are more able to attract the attention of the audience than long videos. Then, to strengthen student understanding, it is important to have generative activities such as explaining, asking questions, and practising what students have watched. By involving students in generative activities, students can transfer knowledge into various new situations. For example, after watching a video, students can practice making decorative flags, practice making miniature traditional houses, and do other similar activities. This means that students not only remember the information but can also apply it effectively.

V. Conclusion

Segmentation and generative activity-based instructional videos prioritize students as proactive participants in their learning, promoting knowledge construction. The primary function of media is to facilitate students' comprehension of the subject matter. The media's design and validity are sound from both design and media perspectives, with the learning content rated as high quality. The incorporation of student feedback significantly enhances the attractiveness of these instructional videos. Empirical evidence suggests that these videos can improve students' academic performance, with a mean increase in learning outcomes observed post-intervention. This finding underscores the importance of considering students' cognitive capabilities when presenting material through video. Segmentation is a fundamental notion that helps reduce cognitive load, thereby improving learners' comprehension of the content. Active student engagement is a crucial component of effective learning, and incorporating generative activities within instructional videos is designed to stimulate such engagement after viewing.

The limitations of this research include:

1) The testing of instructional videos for learning purposes was conducted with a restricted sample size, necessitating further studies with a larger sample.
2) This research measures only one dependent variable—learning outcomes. Future research should control for other variables, such as student motivation, to better understand the instructional video's effect.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

D.G.A.P.P conducted the research and wrote the paper; I.W.S, N.N.P, I.K.S provided input on writing the background, methodology, result, and discussion. All authors had approved the final version.

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