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Developing Educational Animation on Food Additives for Young Learners Using the 4D Model

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Abstract: Modern dietary patterns have increased children's consumption of processed foods containing food additives, namely preservatives, flavor enhancers, sweeteners, and colorants (4Ps), which may increase the risk of degenerative diseases in the future. Although many studies discuss unhealthy food consumption among children, limited educational media specifically address food additives in a form that is engaging and suitable for elementary school students. This study aimed to fill this gap by developing an animated educational video on 4P foods as an innovative medium for school-based health promotion. This study used a Research and Development (R&D) approach with the 4D model (Define, Design, Develop, Disseminate) and applied a pre-test–post-test design to evaluate its effectiveness. The developed animation was validated by media and material experts and then tested on 23 elementary school students to assess feasibility, acceptance, and knowledge improvement. The results showed that the animation was highly feasible and well accepted by students. Students reported that the video was interesting, easy to understand, and helpful in learning about healthy food choices. After watching the video, students' knowledge about food additives increased compared to before the intervention, indicating that the animation effectively supported learning. This study demonstrates that animated educational media can be an effective and practical tool for school health promotion, helping teachers deliver health messages in an engaging way and supporting early prevention of unhealthy eating habits among children.

Keywords: Health Promotion, Animated Video, Food Additives, Elementary Student, Degenerative Disease Prevention

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1. Introduction

Changes in modern consumption patterns have led to an increase in the consumption of processed foods high in additives such as preservatives, flavorings, sweeteners, and excessive food coloring. This phenomenon is known as the 4Ps (Preservatives, Flavorings, Sweeteners, and Food Coloring). Long-term consumption of these foods has the potential to increase the risk of degenerative diseases such as diabetes mellitus, hypertension, obesity, and cardiovascular disease [1]. Degenerative diseases, previously more common in older adults, are now starting to appear in productive age groups, even children [2].

According to World Health Organization (WHO) data, approximately 71% of all global deaths are caused by non-communicable diseases, including degenerative diseases [3]. In Indonesia, the prevalence of non-communicable diseases such as hypertension and diabetes mellitus has been increasing year after year. The 2018 Basic Health Research (Riskesdas) showed that the prevalence of diabetes in those aged 15 years and older increased to 10.9%, while the prevalence of hypertension reached 34.1% [4]. This situation demonstrates the urgency of early promotive and preventive efforts, including among elementary school children who are beginning to develop their eating habits.

Initial analysis revealed that many students do not understand the dangers of foods and drinks containing the 4Ps. Recent observations show that a majority of students tend to purchase foods and beverages containing the 4Ps (preservatives, flavor enhancers, sweeteners, and colorants) during school breaks, as well as before and after school hours. These products are commonly sold in both school canteens and food stalls surrounding the school environment. This pattern is consistent with findings from the UNICEF *Nutrition Environment Assessment Toolkit for Schools (NEAT-S)* in Indonesia, which reported that ultra-processed products are widely sold and promoted within school settings (UNICEF, 2024). A study by Khomsan et al. (2023) also found that most popular snacks consumed by Indonesian students contain high levels of artificial additives and lack nutritional value [5]. Similarly, a systematic review by *Public Health Nutrition* (2022) highlighted that the availability of ultra-processed foods around schools contributes significantly to unhealthy dietary habits among adolescents [6].

In addition, health promotion activities within schools remain limited, often relying solely on conventional lecture-based methods with minimal interactive or media-based approaches. Strengthening school-based health promotion that integrates engaging educational media is therefore essential to encourage healthier eating behaviors among students. Therefore, innovative and accessible health promotion media that are appropriate for the cognitive level of elementary school students are needed.

Elementary school-aged children are a critical age group in developing healthy lifestyle behaviors [7]. However, in reality, children are highly vulnerable to exposure to 4P foods due to a lack of knowledge and awareness of the negative impacts of consuming unhealthy foods on long-term health. Furthermore, health education strategies implemented in schools still often use conventional lecture methods, which tend to be less engaging for children, thus reducing their effectiveness [8]. Therefore, innovative health promotion media that are more suited to children's learning characteristics—visual, interactive, and fun—are needed. Audiovisual-based media, particularly animated videos, have proven effective in improving children's comprehension and retention of information [9]. Animated videos can package health messages in engaging visuals, simple narratives, and characters familiar to children, thereby increasing their motivation to learn [10]. Furthermore, the use of animated media also makes complex educational material easier to understand and well-received [11]. However, most existing educational animations focus on general topics such as nutrition or hygiene, while specific education about food additives (4Ps) is still very limited. This shows a research gap in providing animated media that specifically explains preservatives, flavor enhancers, sweeteners, and colorants in a form that is suitable for elementary school students.

The development of an educational animated video about the dangers of 4P foods as a health promotion medium in elementary schools is highly relevant in the current context. Through this approach, children not only receive accurate information about the impacts of consuming unhealthy foods but are also encouraged to develop healthier eating behaviors through creative and interactive learning methods. Therefore, this intervention is expected to contribute to long-term efforts to prevent degenerative diseases from an early age, supporting the achievement of the Sustainable Development Goals (SDGs) in the health sector, particularly the target of reducing mortality from non-communicable diseases [12].

This study focuses on the use of animated media that specifically discusses 4P foods (preservatives, flavor enhancers, sweeteners, and colorants) as a school-based health promotion tool. Food additive education is delivered through child-friendly storytelling animation, making abstract chemical concepts more concrete and easier to understand by elementary school students. Based on this background, this study aimed to develop an educational animated video about the dangers of 4P foods using the 4D model and to evaluate its feasibility, acceptance, and effectiveness as a health promotion medium in elementary schools.

2. Materials and Methods

2.1 Research Design

This study used a research and development (R&D) approach to develop an educational animated video about 4P foods. The development process followed the 4D model (Define, Design, Develop, Disseminate) proposed by Thiagarajan. The 4D model was chosen because it provides clear, practical, and sequential stages for developing educational media, starting from needs analysis to product dissemination. Compared to other instructional design models such as ADDIE or Dick and Carey, the 4D model is more concise and suitable for small-scale educational product development in school settings with limited time and resources.

2.2 Subject and Sampling

The subjects of this study were 23 fifth-grade elementary school students. This number represents one intact class, which is commonly used in limited-scale trials in R&D studies to test feasibility, clarity, and initial effectiveness of a developed product. Subjects were selected using purposive sampling with the following criteria:

1. students were enrolled in grade five
2. students were able to follow learning activities independently
3. students were willing to participate with school approval

This sample size was considered sufficient for preliminary evaluation before wider implementation.

2.3 Development Procedure

The development process followed four stage: [13] [14]

1. *Define*

   At this stage, needs analysis was conducted through observation and discussion with teachers to identify problems related to students' snack consumption habits and low understanding of food additives. Learning objectives were formulated based on these findings.

2. *Design*

   In the Design stage, learning content was prepared based on key concepts of 4P foods. The term 4P foods refers to foods containing preservatives, flavor enhancers, sweeteners, and colorants, common categories of food additives used to improve shelf life, taste, and appearance. While regulated use of additives is considered safe, excessive and long-term consumption has been linked to various health issues, including obesity, allergic reactions, and behavioral disorders in children [15] [5]. Studies in Indonesia show that many school-aged children frequently consume snacks and beverages that contain high levels of artificial additives, especially around school environments [16]. This condition indicates a lack of awareness about food safety and nutrition among students, emphasizing the need for educational content that promotes critical thinking about packaged food products.

3. *Develop*

   The animated video was produced using digital animation software. The product was then reviewed by media and material experts to assess its feasibility. Revisions were made based on expert suggestions. A limited trial was conducted with students to test clarity, attractiveness, and understanding.

4. *Disseminate*

   The final revised product was implemented in the school to evaluate acceptance and effectiveness and shared with teachers as part of school health promotion activities.

2.4 Instrument and Data Collection

*T*his study used four types of instruments: a media feasibility questionnaire for media experts, a material feasibility questionnaire for content experts, a student acceptance questionnaire, and a knowledge test administered as a pre-test and post-test. The feasibility questionnaires employed a Likert scale to assess aspects such as visual quality, clarity, suitability, attractiveness, and accuracy of the content. The student acceptance questionnaire measured students' perceptions of interest, clarity, usefulness, and enjoyment when using the animated media. The knowledge test consisted of multiple-choice questions related to 4P foods. Data were collected through expert assessment sheets completed by media and material experts, student questionnaires administered after the learning activity, and students' pre-test and post-test scores. These data were then used to evaluate the feasibility, acceptance, and effectiveness of the developed animated media.

2.5 Data Analysis

Data processing included editing, coding, scoring, and tabulation. Pre-test and post-test scores were analyzed using a paired sample t-test with a significance level of 0.05 to determine differences in students' knowledge before and after using the animated media. Descriptive analysis was used to interpret feasibility and acceptance data.

3. Results and discussion

The development of an educational animation video on food additives (4P: preservatives, colorants, sweeteners, and flavor enhancers) followed the 4D model. The results and their interpretation are presented in four interconnected stages: Define, Design, Develop, and Disseminate.

3.1 Define

The initial stage involved identifying the needs of elementary school students at SDN Karangrejo 6. Observations and interviews revealed that students often consumed brightly colored snacks, sweetened beverages, and preserved foods, yet had little understanding of their potential health risks. Teachers also reported that no specific educational media had ever been used to teach about food additives. This gap highlighted the importance of providing engaging and age-appropriate health education. From a theoretical perspective, this finding aligns with Piaget's cognitive development theory, which stated that children in the *concrete operational stage* (ages 7–11) learn best through tangible and relatable representations. Without concrete examples and engaging formats, abstract concepts such as food additives remain difficult for children to grasp. Therefore, the analysis stage confirmed the need for a visual, narrative-based medium to effectively communicate health information.

3.2 Design

Based on the need's analysis, a storyboard and script were created. The storyline featured "Rara," a relatable child character, and "Mini Doctor," who explained the health risks of food additives. To simplify complex concepts, each additive was personified as a "monster" character. This design aimed to capture students' attention while making the topic memorable. The video was planned to last about eight minutes, with bright colors, simple language, and interactive narration. This approach reflected Bruner's theory of representation, which emphasized the effectiveness of combining iconic (visual/animation) and symbolic (language/narration) modes of learning. The use of character-driven stories also supported Heinich's principles of instructional media, which argued that media must be accurate, attractive, and appropriate to learners' characteristics to maximize effectiveness.

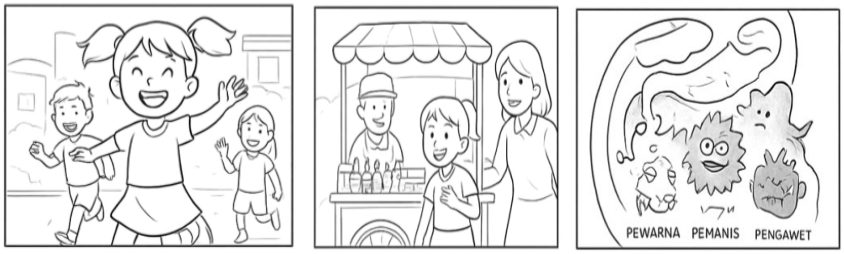


Figure 1. Storyboard

3.3 Develop

In this development stage, the animated video was developed according to the **planned** concept. The first step in developing the animated video was creating the animated video design and providing the voiceover. The format for developing the animated video is as follows.



Figure 2. Storyboard of the Animated Learning Video Development

The development stage produced the first prototype, which was then validated by experts. Media experts rated the video at **91%** and content experts at **93%**, both categorized as "very good." This indicated that the media was scientifically accurate, visually appealing, and suitable for use in primary schools. This finding highlights the importance of integrating creative design principles into health education media for children. Beyond visual appeal, the animation's effectiveness also lies in its narrative structure that simplifies abstract health concepts into relatable daily experiences. Previous research by Harahap et al. (2020) emphasized that student-centered media, which combines humor, color, and contextual storytelling, increases message retention and emotional connection. Thus, the developed animation not only fulfills technical feasibility standards but also strengthens the pedagogical dimension of health promotion by aligning content with children's cognitive and emotional development stages [11].

The prototype was then tested with students through an acceptance test, which resulted in a **92%** rating ("very good"). Children reported that the video was fun, easy to understand, and useful. This finding is consistent with Cognitive Learning Theory**,** which suggests that learner engagement significantly enhances attention, comprehension, and memory retention. Effectiveness testing further demonstrated the impact of the video. Before the intervention, only 43% of students achieved "good" knowledge scores, while **35%** were in the "poor" category. After watching the video, the proportion of students with "good" knowledge rose to 61%**,** and those in

the "poor" category dropped to 13%**.** Statistical analysis confirmed a significant improvement **(**p = 0.0025**).** These results are consistent with findings by Setiawan & Kurniasari (2021) and Wahyuni & Utami (2022), which reported that animated educational videos significantly improved children's understanding of health-related content. However, unlike those studies that focused on nutrition and hygiene, this research extends the use of animation into the topic of food additives, an area less explored in child health education. This broadens the evidence base for the effectiveness of audiovisual media in preventive health promotion and demonstrates that even complex topics such as chemical additives can be effectively communicated through visual storytelling. These results align with the Health Belief Model (HBM)**,** which posits that increasing knowledge enhances perceptions of risk (perceived susceptibility) and benefit (perceived benefit), thereby encouraging positive behavior change in this case, healthier food choices.

3.4 Disseminate

The positive outcomes of this study imply that animated media can serve as an alternative learning tool for health educators and teachers in elementary schools. By embedding health messages in familiar storylines and characters, educators can create enjoyable yet informative experiences that foster lifelong healthy behaviors. The final stage involved sharing the validated and revised product with teachers at SDN Karangrejo 6 as part of school health education activities. Plans were also made for online dissemination, such as uploading the video to YouTube, to expand its reach beyond the classroom. The use of digital platforms reflects the principle of sustainable health promotion, where educational interventions should be accessible, scalable, and adaptable to various contexts. Compared with traditional approaches like posters or lectures, animated videos are more interactive, retain attention longer, and allow repeated use. Despite its promising results, this study has several limitations. The number of participants was relatively small and limited to a single school, which may affect the generalizability of findings. In addition, the evaluation focused mainly on short-term knowledge improvement, while long-term behavioral outcomes were not assessed. Future research should involve larger and more diverse samples, longitudinal assessments, and integration with teachers' curricula to examine sustained behavioral change.

4. Conclusion

This study demonstrates that the animated video on 4P foods is feasible, well accepted, and effective in improving elementary school students' knowledge. Expert validation showed that the media and content met quality standards, while student responses indicated that the animation was interesting, clear, and useful. These findings suggest that the developed media is suitable for school-based health education. The increase in students' knowledge after the intervention indicates that animated storytelling is effective for delivering health information to children. Characters, visuals, and simple narration help transform abstract concepts about food additives into understandable messages. This supports the idea that audiovisual media can be more effective than conventional lecture-based approaches in engaging young learners.

This study contributes to preventive health promotion by introducing food additive education at an early age. By increasing children's awareness of 4P foods, the animation supports healthier food choices and strengthens early health literacy. Early understanding of unhealthy eating patterns is essential to prevent long-term risks of degenerative diseases. In practice, this media can be used by teachers and school health officers as part of regular learning activities or school health programs. Because it is digital, the animation can be reused and distributed through online platforms, allowing wider access beyond the research site. Future research should involve larger and more diverse samples to improve generalizability. Long-term studies are also needed to examine whether

increased knowledge leads to sustained behavior change. Further development of similar media on other health topics can strengthen preventive health promotion for children.

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