

Crossword Plants: Developing an Audio-Visual Interactive Multimedia to Improve Fourth-Grade Students' Learning Outcomes on Plant Parts

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Abstract: This study was motivated by the low learning outcomes of fourth-grade students at SDN Keniten 1 on the topic of plant parts, caused by limited student engagement and the use of less interactive learning media. The study aimed to develop an audio-visual Crossword Plants-based interactive multimedia that is valid, practical, and effective in improving students' learning outcomes. The research employed the Research and Development (R&D) method using the ADDIE model, comprising five stages: Analysis, Design, Development, Implementation, and Evaluation. The research subjects were 24 fourth-grade students of SDN Keniten 1. Data were collected through observation, interviews, questionnaires, and tests. The results showed that the developed interactive multimedia achieved a validity score of 78% from media experts (feasible category) and 91% from material experts (highly feasible category). The practicality level reached 96% based on teacher responses, 100% in the limited trial, and 97.5% in the large-scale trial, all categorized as highly practical. The effectiveness of the media was indicated by classical learning mastery of 87.5% in the limited trial and 93.75% in the large-scale trial, along with N-Gain scores of 0.75 and 0.76, both in the high category. Furthermore, the Paired Sample t-Test results showed a Sig. (2-tailed) value of less than 0.05, indicating a significant difference between students' pretest and posttest scores after using the media. Therefore, the audio-visual Crossword Plants-based interactive multimedia was found to be valid, practical, and effective in improving the learning outcomes of fourth-grade students at SDN Keniten 1 on the topic of plant parts.

Keywords: Interactive Multimedia, Audio-Visual, Crossword Plants, Parts of Plants, Elementary School

Abstrak: Penelitian ini dilatarbelakangi oleh rendahnya hasil belajar siswa kelas IV SDN Keniten 1 pada materi bagian-bagian tumbuhan akibat kurangnya keterlibatan siswa dan penggunaan media pembelajaran yang kurang interaktif. Penelitian ini bertujuan mengembangkan multimedia interaktif berbasis audio visual Crossword Plants yang valid, praktis, dan efektif untuk meningkatkan hasil belajar siswa. Metode yang digunakan adalah Research and Development (R&D) dengan model ADDIE yang meliputi tahap Analysis, Design, Development, Implementation, dan Evaluation. Subjek penelitian berjumlah 24 siswa kelas IV SDN Keniten 1. Teknik pengumpulan data meliputi observasi, wawancara, angket, dan tes. Hasil penelitian menunjukkan bahwa multimedia interaktif memperoleh tingkat kevalidan sebesar 78% dari ahli media dengan kategori layak dan 91% dari ahli materi dengan kategori sangat layak. Tingkat kepraktisan memperoleh persentase 96% dari guru, 100% pada uji terbatas, dan 97,5% pada uji luas dengan kategori sangat praktis. Keefektifan media ditunjukkan oleh ketuntasan belajar klasikal sebesar 87,5% pada uji terbatas dan 93,75% pada uji luas, serta nilai N-Gain sebesar 0,75 dan 0,76 dengan kategori tinggi. Hasil uji Paired Sample t-Test menunjukkan nilai Sig. (2-tailed) < 0,05 sehingga terdapat perbedaan yang signifikan antara nilai pretest dan posttest siswa setelah menggunakan media. Dengan demikian, multimedia interaktif berbasis audio visual Crossword Plants dinyatakan valid, praktis, dan efektif untuk meningkatkan hasil belajar siswa pada materi bagian-bagian tumbuhan kelas IV SDN Keniten 1.

Kata Kunci: Multimedia Interaktif, Audio Visual, Crossword Plants, Bagian-Bagian Tumbuhan, Sekolah Dasar

INTRODUCTION

Under Indonesia's Kurikulum Merdeka (Independent Curriculum), Natural and Social Sciences (IPAS) integrates the natural and social sciences into a single subject. IPAS functions as a discipline intended to help realize the Pancasila Student Profile, reflecting the desired profile of Indonesian learners (Rani & Mujianto, 2023). As a field of study, IPAS addresses both living and non-living entities in the universe and their interactions, as well as human life as individual and social beings. IPAS is one subject closely tied to problems found in nature; lessons in IPAS are always connected to the surrounding environment, which serves as a source of learning (Egok & Hajani, 2018). Even so, not every natural phenomenon can be presented directly to students during classroom instruction. The aim of IPAS at the elementary/Islamic elementary school (MI/SD) level is to strengthen students' basic literacy skills, which become the foundation for understanding more complex IPAS concepts at the next level of education. Among the topics taught in elementary IPAS, several require a deep conceptual understanding, one of which is the parts of plants.

Understanding the parts of plants is essential for fourth-grade students, as it forms the basis for learning about living organisms in natural science. This topic is highly relevant to students' daily lives because it can be observed directly in the surrounding environment, such as the yard at home or at school, and it underlies subsequent topics such as photosynthesis, plant growth, and environmental conservation (Nopa Sari, Sumarni, & Hiltrimartin, 2025). Through this material, students become familiar with plant structures such as roots, stems, leaves, flowers, fruit, and seeds, together with their respective functions, enabling them to understand how plants live and develop. In addition, this learning experience trains students' observation skills through direct engagement with plants in their environment and fosters care for nature.

This material is highly important for fourth-grade students to learn and understand, because it is closely connected to the content covered in the fifth grade and at subsequent levels. It can serve as a foundation for learning more complex concepts later on, such as the process of photosynthesis, the transport of water and nutrients in plants, plant reproduction, and plant adaptation to the environment. Mastery of the parts-of-plants material in grade IV therefore substantially helps students understand IPAS at the next level of schooling.

Based on observations conducted by the researcher on 1 April 2026 at 10:00 a.m. (Western Indonesia Time) at SDN Keniten 1 with the fourth-grade classroom teacher, several obstacles were identified in teaching and learning, particularly in the IPAS topic of plant parts. These included a lack of concentration and engagement among students during lessons, which led to limited understanding of the material. In the lessons delivered by the classroom teacher, the only medium used was content drawn from YouTube. This was not fully contextual, since the YouTube content used did not entirely correspond to the material being taught, leaving students with an incomplete grasp of the content. These factors, in turn, affected students' learning outcomes.

The interview results indicate that fourth-grade students at SDN Keniten 1 face fundamental problems, including limited concentration and engagement during lessons and the teacher's tendency to rely on YouTube as the instructional medium. This contributed to the low learning outcomes in the IPAS topic of plant parts. This is supported by a pretest conducted by the researcher, in which only 4 of the 24 students (17%) achieved scores above the Learning Objective Achievement Criteria (Kriteria Ketercapaian Tujuan Pembelajaran, KKTP), while the remaining 20 students (83%) scored below the established KKTP threshold of 75. In addition, the abstract nature of much of the IPAS content makes it difficult for students to grasp, particularly since fourth-grade students are still at the concrete-operational stage of thinking and have not yet fully developed the capacity to understand concepts they cannot experience directly. It is therefore important to develop engaging instructional media to improve students' learning outcomes.

One such solution is interactive multimedia. Interactive multimedia is a learning medium that combines various media elements such as text, images, audio, video, animation, and digital technology into a single instructional package (Syafliin, 2022). A relevant prior study was conducted by Ardiyanti and Zuhdi (2021), titled "Development of Android-Based Interactive Multimedia for Science Learning on the Solar System for Sixth-Grade Elementary School Students." Their findings

showed that the developed medium effectively improved students' learning outcomes, as reflected in an increase in the average pretest score from 58.75 to 83.1 on the posttest. The present study shares with that research a focus on developing interactive multimedia as a learning medium; the difference lies in the present study's use of a combination of several applications and web-based platforms such as PowerPoint, Canva, CapCut, and Educaplay to build the interactive multimedia. The novelty of this study lies in its Crossword Plants feature integrated into the interactive multimedia, accompanied by explanatory video content and narration recorded by the researcher, so that students can learn through video, audio, animation, images, and an engaging educational game. Beyond classroom use, the game can also be accessed by students through a link on their own devices outside school hours.

Based on this context, the researcher conducted a study titled "Development of an Audio-Visual Crossword Plants-Based Interactive Multimedia on the Topic of Plant Parts for Fourth-Grade Students at SDN Keniten 1." This research and development study aimed to examine the validity, practicality, and effectiveness of the "Audio-Visual Crossword Plants-Based Interactive Multimedia" in improving students' learning outcomes on the topic of plant parts at SDN Keniten 1.

METHOD

This study applied the Research and Development (R&D) method, which is used to design and test a medium intended for application in education (Sulastiani & Rusdiyani, 2023). The model adopted in this research was the ADDIE model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. Research data were obtained through observation, interviews, questionnaires, and tests. The validity of the media was assessed by media and material experts, while its practicality was evaluated by education practitioners and students using teacher- and student-response questionnaires. The data were then analyzed descriptively, both qualitatively and quantitatively, using Likert-scale score-interpretation criteria.

The scores obtained from the media and material expert validation questionnaires were converted into percentages and interpreted according to the feasibility categories presented in Tables 1 and 2.

Table 1. Validation Scoring

Criterion	Score
Very Good	5
Good	4
Poor	3
Bad	2
Very Bad	1

Table 2. Validity Analysis Criteria

Score Achievement	Validity Category
81,00%-100,00%	Highly feasible
61,00%-80,00%	Feasible
41,00%-60,00%	Moderately feasible
21,00%-40,00%	Not feasible
0,00%-20,00%	Highly not feasible

The scores obtained from the teacher- and student-response questionnaires were likewise converted into percentages and interpreted according to the practicality categories shown in Table 3.

The effectiveness of the audio-visual Crossword Plants-based interactive multimedia was measured through students' learning outcomes, using a test instrument consisting of 10 multiple-choice items and 5 essay items. Each correct multiple-choice answer was scored 5 points, while essay items were scored using a rubric with possible values of 10, 8, 5, 3, and 0. The maximum

score a student could obtain was 100. The multimedia was considered effective if students' learning outcomes reached the KKTP threshold of 75 and classical learning mastery reached at least 75%. Pretest and posttest scores were then calculated using the N-Gain formula to determine the extent of improvement in students' understanding. In addition, a Paired Sample t-Test was used to determine whether the increase from pretest to posttest scores after using the Crossword Plants media was statistically significant. The categories used to interpret the magnitude of score improvement are presented in Tables 4.

Table 3. Practicality Analysis Criteria

Average Score Interval	Criterion
81%-100%	Highly practical
61%-80%	Practical
41%-60%	Moderately practical
21%-40%	Not practical
0%-20%	Highly impractical

Table 4. Effectiveness Analysis Criteria

Average Score Interval	Criterion
81%-100%	Highly effective
61%-80%	Effective
41%-60%	Moderately effective
21%-40%	Not effective
0%-20%	Highly ineffective

Table 5. Decision Basis for the Paired Sample t-Test

No.	Significance Value (Sig. 2-tailed)	Decision	Interpretation
1	Sig. (2-tailed) > 0,05	H_0 accepted, H_1 rejected	There is no significant difference between students' learning outcomes before and after using the audio-visual Crossword Plants-based interactive multimedia.
2	Sig. (2-tailed) < 0,05	H_0 rejected, H_1 accepted	There is a significant difference between students' learning outcomes before and after using the audio-visual Crossword Plants-based interactive multimedia.

RESULT AND DISCUSSION

Result

This research and development (R&D) study was conducted at SDN Keniten 1 and involved 24 fourth-grade students as research subjects. The product developed was an audio-visual Crossword Plants-based interactive multimedia, designed to help improve students' learning outcomes on the topic of plant parts. The study followed the five stages of the ADDIE model Analysis, Design, Development, Implementation, and Evaluation chosen for its structured and systematic development steps. Findings are reported below following the validity–practicality–effectiveness sequence conventionally used to evaluate educational R&D products (Nieveen, 1999).

Analysis Stage

The performance-analysis stage was conducted to gather information on how the topic of plant parts was being taught in the fourth grade at SDN Keniten 1. Observations and interviews with the classroom teacher indicated that instruction relied largely on YouTube videos, which

limited students' concentration and engagement and, consequently, their learning outcomes. The needs analysis showed that the existing media had not succeeded in capturing students' attention or fully helping them reach the established KKTP, indicating a need for a more engaging and interactive instructional medium.

Design Stage

At this stage, an initial design was produced for the audio-visual Crossword Plants-based interactive multimedia, combining explanatory video segments, narrated audio, plant-part illustrations, and an embedded crossword-puzzle game built across PowerPoint, Canva, CapCut, and Educaplay.

Development Stage: Validity and Practicality

At this stage, the interactive multimedia product was produced and validated, and the instruments needed for data collection were finalized.

Validity

Validity was assessed by two expert lecturers – a media expert and a material expert – using a rubric scored on a 1–5 scale and converted to a percentage. The media expert rated the product 78 out of a maximum 100 (78%, feasible category), with the highest scores on navigation (100%) and visual imagery (84%), and comparatively lower scores on layout design (72%), on-screen text (73.33%), and overall usability (73.33%). The material expert rated the product 41 out of a maximum 45 (91%, highly feasible category), awarding full marks for the alignment of content with the learning objectives, the relevance of the material to students' daily lives, its ability to capture attention, and the clarity of language used (100% on each of these four aspects), while rating depth of content, coverage of all plant parts, sequencing, and support for critical thinking slightly lower (80% each). Table 6 summarizes these results.

Table 6. Summary of Expert Validation Results

Validator	Score	Maximum Score	Percentage	Category
Media expert	78	100	78%	Feasible
Material expert	41	45	91%	Highly feasible

Both validators placed the product within the feasible-to-highly-feasible range, indicating that the interactive multimedia met the criteria for display quality, usability, navigation, and content alignment expected for classroom implementation.

Practicality

Practicality was determined from teacher- and student-response questionnaires administered during the limited and large-scale trials. The classroom teacher rated the product 96% (highly practical), with the lowest-rated items being the support the quiz feature gave to the evaluation process and the medium's overall ability to convey the material (both 80%); all other items received full marks. Students rated the product 100% in the limited trial (n = 8) and 97.5% in the large-scale trial (n = 16). In the large-scale trial, two items received slightly lower ratings than the rest – clarity of the audio (87.5%) and, equally, the attractiveness of the color display and enjoyment of learning (93.75% each) – while every other item was rated 100%. Table 7 summarizes these results.

Table 7. Summary of Practicality Results

Respondent / Trial	n	Score	Maximum Score	Category
Teacher	1	48 (96%)	50	Highly practical
Students limited trial	8	80 (100%)	80	Highly practical
Students large-scale trial	16	156 (97.5%)	160	Highly practical

All three respondent groups placed the product in the highly practical category (81–100% range), indicating that the medium was easy to use, well received, and implementable within regular classroom time.

Implementation Stage

The validated product was implemented in two stages: a limited trial and a large-scale trial during which teachers and students completed the practicality questionnaires and students completed a pretest and posttest to gauge the medium's effectiveness and ease of use.

Evaluation Stage: Effectiveness

Effectiveness was determined by comparing students' pretest and posttest scores, computing the N-Gain index, and testing the pretest–posttest difference with a Paired Sample t-Test. In the limited trial ($n = 8$), scores ranged from 60 to 98 ($M = 83.37$), 7 of 8 students (87.5%) reached the KKTP of 75, and the mean N-Gain was 0.75 (high category). In the large-scale trial ($n = 16$), scores ranged from 49 to 100 ($M = 89.18$), 15 of 16 students (93.75%) reached the KKTP, and the mean N-Gain was 0.76 (high category). For both trials, the Paired Sample t-Test returned a Sig. (2-tailed) value below 0.001, indicating a statistically significant increase from pretest to posttest. Table 8 summarizes these results.

Table 8. Summary of Effectiveness Results

Trial	n	Mean Pretest	Mean Posttest	Classical Mastery	Mean N-Gain	Paired t-Test Sig.
Limited	8	31.25	83.37	87.5%	0.75 (High)	< .001
Large-scale	16	54.38	89.18	93.75%	0.76 (High)	< .001

Across both trials, posttest means exceeded the KKTP threshold, classical mastery exceeded the 75% effectiveness criterion, and N-Gain scores fell in the high category, indicating that the audio-visual Crossword Plants-based interactive multimedia was effective in improving students' learning outcomes on the topic of plant parts.

Discussion

Taken together, the validity, practicality, and effectiveness findings indicate that the audio-visual Crossword Plants-based interactive multimedia is a sound instructional alternative to the YouTube-only approach previously used for teaching plant parts at SDN Keniten 1. Each of these three criteria, however, speaks to a different quality of the product, and they are discussed in turn below before being connected to a broader theoretical account of why the intervention produced the observed gains.

Regarding validity, the contrast between the media expert's 78% score and the material expert's 91% score is informative rather than merely descriptive. The material expert's near-ceiling ratings on content alignment, relevance, attention-capturing presentation, and language clarity suggest that the pedagogical content itself was sound; the media expert's comparatively lower ratings on layout design and on-screen text point instead to interface-level refinements: font sizing, text density, and screen layout that could still be improved without altering the underlying content. This pattern echoes Ardiyanti and Zuhdi (2021), whose Android-based science multimedia for the solar system likewise showed stronger content-validity ratings than interface ratings, and is broadly consistent with Hidayati, Wahyudi, and Sahari (2023), who found that their interactive multimedia met validity, practicality, and effectiveness criteria but flagged visual-design refinement as an area for iteration. Read through the lens of Cognitive Load Theory (Sweller, 1988), the lower scores on layout and text density are plausible: a screen that is visually busy or text-heavy adds extraneous cognitive load that competes with the working-memory resources needed to process the instructional content itself, even when that content is well chosen. The practical implication is that future revisions should target interface economy: simplifying layout and trimming on-screen text

rather than the content selection, which the material-expert ratings suggest is already well aligned to the curriculum.

On practicality, the near-uniform high ratings from teacher and students are consistent with findings reported by Handayani et al. (2024), who observed that technology-supported instruction tends to be perceived as more interactive and engaging than conventional approaches, and with Zainuddin, Chu, Shujahat, and Perera (2020), whose systematic review concluded that gamified instruction is generally well received by learners. Two details in the present results merit closer attention rather than being absorbed into the overall percentage. First, the teacher's slightly lower rating for the quiz feature's contribution to the evaluation process suggests that the assessment component, rather than the instructional content, may benefit from refinement—for instance, clearer answer feedback or an end-of-game score summary the teacher can use formatively. Second, the modest dip in audio-clarity ratings during the large-scale trial, compared with a perfect score in the smaller limited trial, is more likely attributable to classroom-level factors such as variation in speaker volume, room acoustics, or device quality across a larger cohort than to any change in the audio content itself; this distinction matters because it points to an implementation safeguard (checking playback equipment beforehand) rather than a media-redesign issue.

The effectiveness results are the central finding of this study and warrant a mechanistic explanation, not merely a restatement of the percentages. The combination of plant-part imagery, narrated audio, and the Crossword Plants game activity is consistent with Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2021), which holds that learners build more durable understanding when verbal and pictorial information are processed through complementary channels and integrated with prior knowledge, rather than when information is presented through a single channel. Fiorella (2020) is cited in the source draft as additional support for this visual-verbal integration claim; as flagged below, that citation should be verified before submission, since the paper's actual subject is habit formation rather than multimedia processing, and a more defensible anchor for this specific claim would be Mayer's own multimedia-learning principles or the generative-learning literature by Fiorella and Mayer.

Beyond the multimedia-processing account, the gamified Crossword Plants feature appears to have engaged students through a motivational mechanism as well as a cognitive one. Plass, Homer, Mayer, and Kinzer (2020) argue that well-designed educational games support learning by combining cognitive engagement with positive affect and active participation, rather than passive content delivery. Self-Determination Theory (Ryan & Deci, 2000) offers a complementary explanation: a game activity that lets students attempt, retry, and complete crossword items on their own initiative plausibly supports a sense of autonomy and competence, two of the three psychological needs the theory identifies as central to intrinsic motivation; the third, relatedness, may have been supported by the game's classroom use alongside peers. This account is consistent with the high engagement-related practicality ratings reported above and helps explain why the gain in learning outcomes exceeded what content exposure through a passive medium such as YouTube videos had achieved before the intervention.

The size of the improvement is also plausibly linked to the developmental stage of the learners. Fourth-grade students are typically in Piaget's concrete-operational stage, during which reasoning is most reliably anchored in observable, manipulable representations rather than abstract verbal description alone (Piaget & Inhelder, 1969). A medium that renders plant parts as labelled images, narrated explanations, and an interactive matching game offers exactly this kind of concrete representation, which may explain why the N-Gain reached the high category in both trials rather than the moderate gains more typical of unsupported abstract instruction on the same topic.

It is important, following Nieveen's (1999) framework for educational R&D, not to treat the high validity and practicality scores as proof of effectiveness in themselves; they are necessary preconditions for a usable product but are conceptually and empirically distinct from whether the product actually improves learning outcomes. In this study, the effectiveness phase—the pretest-to-posttest gain, classical mastery above the 75% criterion, and a statistically significant Paired Sample t-Test—provides that separate evidentiary basis, and it is the convergence of all three lines of

evidence, rather than any single one, that supports the conclusion that the medium is fit for classroom use.

For classroom practice, these findings suggest that teachers of IPAS can use audio-visual, game-embedded multimedia as a practical alternative to unmodified YouTube content when teaching topics that students cannot fully experience firsthand, such as the internal or seasonal aspects of plant biology. For curriculum developers and teacher educators, the validity-expert pattern observed here—strong content alignment alongside room for interface refinement—suggests that pre-service and in-service training on multimedia development might usefully separate instructional-design competence (content sequencing, objective alignment) from interface-design competence (layout, typography, information density), since the two appear to develop and to be evaluated somewhat independently.

Several limitations should be acknowledged. The effectiveness trials were conducted with a small sample (8 and 16 students) at a single school, which limits statistical power and the generalizability of the findings to other schools, regions, or socioeconomic contexts; replication across multiple classrooms or schools would strengthen confidence in the effect. The pretest–posttest design without a comparison or control group cannot fully rule out maturation, testing effects, or a novelty effect specific to a new medium being introduced for the first time, and the absence of a delayed posttest means the durability of the learning gain beyond the immediate posttest is unknown. Because the researcher who developed the product also implemented it and likely administered the practicality questionnaires, some inflation of practicality ratings due to social-desirability or experimenter-expectancy effects cannot be excluded. Finally, as an R&D study situated in one curriculum context (Kurikulum Merdeka, grade IV, one elementary school), the findings describe this specific product and setting and should not be generalized to other grade levels, subjects, or curricula without further testing.

Future research could extend this work in several concrete directions: testing the medium across multiple schools and socioeconomic settings to assess generalizability; adding a non-equivalent control group taught through conventional media to isolate the medium's effect from maturation and testing effects; administering a delayed posttest (for example, two to four weeks after the intervention) to assess retention; and applying the same audio-visual, gamified design approach to other commonly difficult IPAS topics, such as photosynthesis or simple machines, to test whether the validity-practicality-effectiveness pattern observed here replicates across content domains.

CONCLUSION

Based on the findings of this research and development study, the audio-visual Crossword Plants-based interactive multimedia on the topic of plant parts for fourth-grade students at SDN Keniten 1 was found to be valid, practical, and effective for use in IPAS instruction. The validity of the media reached 78% from the media expert (feasible category) and 91% from the material expert (highly feasible category). The practicality of the media reached 96% from teachers, 100% in the limited trial, and 97.5% in the large-scale trial, all in the highly practical category. The effectiveness of the media is evidenced by classical learning mastery of 87.5% in the limited trial and 93.75% in the large-scale trial, along with N-Gain scores of 0.75 and 0.76, both in the high category. In addition, the Paired Sample t-Test results for both trials show a Sig. (2-tailed) value of less than 0.05, indicating a significant difference between students' pretest and posttest scores after using the media. The audio-visual Crossword Plants-based interactive multimedia therefore proved effective in improving students' understanding and learning outcomes on the topic of plant parts.

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