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Research Article

Human-Centered Interactive Animated Video for Learning Enthusiasm in Primary Human Digestive System Instruction

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Abstract

Human digestive system concepts are difficult for primary students because the process is internal, dynamic, and not directly observable. This classroom action research investigated whether an interactive animated video, embedded with pause prompts, worksheets, and small-group discussion, could strengthen learning enthusiasm among 21 fifth-grade students at an Islamic primary school in Jambi, Indonesia. Two cycles of planning, action, observation, and reflection were implemented. Data were drawn from a 10-item four-point questionnaire, student and teacher observation sheets, and classroom documentation. Questionnaire results improved from a pre-cycle mean of 2.26 (low) to 3.40 (very high) after Cycle II; positive responses rose from 36.2% to 89.0%. Student-enthusiasm observations increased from 2.00 (low) in the pre-cycle to 3.00 (high) in Cycle I and 4.00 (very high) in Cycle II. The strongest post-cycle responses concerned conceptual help and willingness to use animated video again (each mean = 3.48). The findings indicate that enthusiasm improved when animation functioned as a teacher-facilitated learning sequence rather than a stand-alone viewing activity. The study offers a low-cost, human-centered model for visualizing dynamic science processes while supporting attention, participation, and enjoyment.

Keywords: Classroom Action Research; Digital Learning Media; Human-Centered Learning; Interactive Animated Video; Learning Enthusiasm; Primary Science.

INTRODUCTION

Primary science education frequently requires learners to reason about processes that are invisible, dynamic, and difficult to observe directly. Multimedia instruction can support conceptual visualization when verbal explanation, relevant imagery, and purposeful sequencing are coordinated to reduce unnecessary cognitive demands [1], [2], [3]. A human-centered approach therefore treats digital media not as decorative technology but as a learning environment designed around children's attention, working-memory limits, opportunities to respond, and need for meaningful participation [4].

The human digestive system is an appropriate context for this design problem. Learners must connect organ names with the movement and transformation of food across a continuous process, yet conventional explanations or isolated textbook diagrams can encourage fragmented recall rather than system-level understanding. Instructional animation can be useful when it represents change over time and space, although its benefits depend on task characteristics and on whether learners are guided to process the animation actively [5], [6], [7]. Video-based learning is similarly most effective when it is intentionally embedded in pedagogy rather than simply played for students [8], [9].

For primary learners, interaction should make viewing cognitively generative. Pause prompts, guided questions, self-explanations, worksheets, and peer discussion can direct attention to relevant features and require learners to articulate what they observe [10], [11], [12]. The value of such guidance is supported by evidence that structured inquiry and active learning can strengthen participation and learning in science-related settings [13], [14], [15], [16].

The present study focuses on learning enthusiasm, a classroom construct closely related to behavioral, emotional, and cognitive engagement. Engagement encompasses participation, psychological investment, affective response, and sustained task involvement [17], [18], [19], [20], [21]. In this study, learning enthusiasm is operationalized as readiness to learn, interest and attention, active involvement, learning initiative, enjoyment, and response to instructional media. These indicators reflect whether students are willing to concentrate, respond to prompts, collaborate, and sustain engagement during science learning.

Prior work in Indonesian primary education suggests that interactive media, multimedia, and animated video can support science learning, motivation, interest, and process skills when they are aligned with instructional aims [22], [23], [24], [25], [26], [27]. However, much of this literature emphasizes product development, test outcomes, or one-off media use. Less attention has been given to how teacher facilitation, classroom management, and reflective refinement across action cycles enable animated video to move students from passive viewing to more equitable, enjoyable participation.

Research on simulations and digital visualizations likewise indicates that learning benefits depend on design quality and integration with instruction [28], [29]. Positive affect and perceived usability may support engagement, but visual appeal must remain subordinate to the learning task [30], [31]. From motivational and social-cognitive perspectives, students' engagement is also shaped by perceived competence, autonomy-supportive participation, and reciprocal classroom interaction [32], [33]. Accordingly, the present study addresses three questions: (1) how was an interactive animated video lesson implemented and refined across two classroom action cycles; (2) how did students' learning enthusiasm change from the pre-cycle to Cycle II; and (3) which post-cycle responses were most strongly endorsed? The study's novelty lies in documenting a human-centered, action-cycle model in which visualization, structured participation, and teacher-led reflection are treated as interdependent conditions for strengthening enthusiasm in primary science learning.

METHODS

Research Design

This study used Classroom Action Research (CAR) to improve an authentic classroom problem through iterative planning, action, observation, and reflection [34]. CAR was appropriate because the purpose was not to estimate a population-level causal effect of animated video, but to improve a specific science-learning process in which students had displayed limited attention and participation. The study used descriptive quantitative evidence, supported by classroom documentation, to trace change across a pre-cycle stage and two action cycles.

Participants and Setting

The study involved 21 Grade 5 students at SDIT Al-Muthmainnah, an Islamic primary school in Jambi, Indonesia. The class was selected purposively because the teacher had identified low enthusiasm during science lessons, including passive participation, distractibility, and limited willingness to ask or answer questions. The topic was the human digestive system, taught during the second semester of the 2024/2025 academic year. Classroom action activities were conducted from January to March 2025.

Intervention and Classroom Action Procedure

The intervention was a short interactive animated video, approximately 10 minutes in duration, illustrating the food pathway through the mouth, esophagus, stomach, small intestine, large intestine, and anus. The resource combined narration, moving illustrations, organ labels, and embedded prompts. Students completed an organ-sequence worksheet and participated in small-group discussion. In Cycle II, the teacher refined the lesson by clarifying instructions, pausing the video at conceptually important points, using smaller groups, and inviting more evenly distributed responses.

Table 1. Classroom Action Procedure Across Two Cycles

Cycle stage	Cycle I implementation	Cycle II refinement
Planning	Prepared animated video, worksheet, observation sheets, and group discussion tasks.	Revised video flow, clarified teacher prompts, and organized smaller groups.
Action	Played the video, assigned the worksheet, and conducted group discussion about digestive organs.	Paused at key moments, used clearer instructions, and invited all students to respond.
Observation	Observed attention, responses to prompts, participation, initiative, and enjoyment.	Observed whether participation became more evenly distributed and attention was sustained.

Cycle stage	Cycle I implementation	Cycle II refinement
Reflection	Identified remaining passivity and the need for stronger facilitation.	Confirmed improved attention, classroom order, and student-centered interaction.

Measures, Data Collection, and Analysis

Learning enthusiasm was assessed through a 10-item student questionnaire and an observation sheet. The questionnaire used a four-point response scale: strongly agree (4), agree (3), disagree (2), and strongly disagree (1). Student-enthusiasm and teacher-implementation observation sheets also used four-point ratings. Instrument content was organized around observable classroom behaviors and clear item wording, in line with established questionnaire-development and scale-quality guidance [35], [36]. The study did not include a separate psychometric validation study; therefore, the scores are interpreted as classroom-improvement evidence rather than as a standardized measure of a general population construct.

Table 2. Operational Definition and Evidence Sources for Learning Enthusiasm

Construct	Indicator	Observable classroom evidence	Primary data source
Learning enthusiasm	Learning spirit	Readiness, energy, and willingness to follow the lesson.	Questionnaire; observation
Learning enthusiasm	Interest and attention	Focus on the teacher, video, and science content with limited distraction.	Questionnaire; observation
Learning enthusiasm	Active involvement	Questions, responses to prompts, discussion, and adherence to instructions.	Questionnaire; observation
Learning enthusiasm	Learning initiative	Effort to understand material and complete tasks without repeated prompting.	Questionnaire; observation
Learning enthusiasm	Enjoyment	Positive affect and low visible boredom during learning.	Questionnaire; observation
Learning enthusiasm	Response to media	Perceived usefulness and interest in using animated video.	Questionnaire; documentation

Data were collected at three points: the pre-cycle, Cycle I, and Cycle II. Questionnaire data were available for the pre-cycle and Cycle II. Observation data were available for all three stages. Questionnaire means were calculated as total score divided by the number of student-item responses ($21 \times 10 = 210$). Observation means were calculated as total observation score divided by the number of rated indicators. The categories were: 1.00–1.75 very low, 1.76–2.50 low, 2.51–3.25 high, and 3.26–4.00 very high. Descriptive comparisons were used because CAR aims to document practical improvement in the focal classroom. Short verbal exchanges and classroom documentation informed reflection; however, because transcript-level interview records were not retained, they are not reported as a separate qualitative dataset.

Ethical Considerations

The classroom action activities were conducted with school permission as part of regular science instruction. Participation involved the class's usual learning activities, and the article reports only aggregated, anonymized results. No student names or personally identifying information were included. The study did not involve a treatment that withheld instructional support from any student.

RESULTS AND DISCUSSION

Results

Pre-cycle Profile and Questionnaire Change

Before the intervention, the class showed low reported enthusiasm. Of 210 pre-cycle item responses, only 76 (36.2%) were positive (strongly agree or agree), whereas 134 (63.8%) were negative (disagree or strongly disagree). The pre-cycle total of 475 produced a mean of 2.26, categorized as low. After Cycle II, the total increased to 713, equivalent to a conventionally rounded mean of 3.40 and categorized as very high. Positive responses rose to 187 of 210 (89.0%), while negative responses fell to 23 of 210 (11.0%). The raw-score change corresponds to an increase of 1.13 points when calculated from unrounded means. This descriptive result indicates a clear improvement in reported enthusiasm within the focal class.

Table 3. Distribution of Student Questionnaire Responses Before and After the Intervention

Stage	Strongly agree	Agree	Disagree	Strongly disagree	Total score	Mean	Category	Positive responses
Pre-cycle	23	53	90	44	475	2.26	Low	36.2%
Post-Cycle II	106	81	23	0	713	3.40	Very high	89.0%

Note. *The post-Cycle II mean is based on 713/210 = 3.395 and is reported as 3.40 after conventional rounding. Positive responses combine strongly agree and agree.*

Observed Improvement Across the Action Cycles

Observation data show a stepwise change in visible classroom behavior. The student-enthusiasm observation mean increased from 2.00 in the pre-cycle to 3.00 in Cycle I and 4.00 in Cycle II. Teacher-implementation observations increased from 3.00 in Cycle I to 4.00 in Cycle II. The Cycle I reflection indicated that some students remained less involved; the Cycle II changes, particularly strategic pausing, clearer prompts, and smaller groups, were intended to make participation more accessible across the class. Questionnaire scores are not reported for Cycle I because a complete intermediate raw questionnaire record was not retained.

Table 4. Observation Trends Across Classroom Action Stages

Indicator	Pre-cycle	Cycle I	Cycle II	Interpretation
Student-enthusiasm observation mean	2.00 (Low)	3.00 (High)	4.00 (Very high)	Visible attention, participation, and enjoyment increased across cycles.
Teacher-implementation observation mean	N/A	3.00 (High)	4.00 (Very high)	Facilitation and classroom management became more consistent.
Questionnaire mean	2.26 (Low)	N/A	3.40 (Very high)	Pre-post self-reported enthusiasm increased; no Cycle I questionnaire total was retained.

Figure 1. Human-Centered Classroom Action Pathway for Animated Video-Supported Primary Science Learning

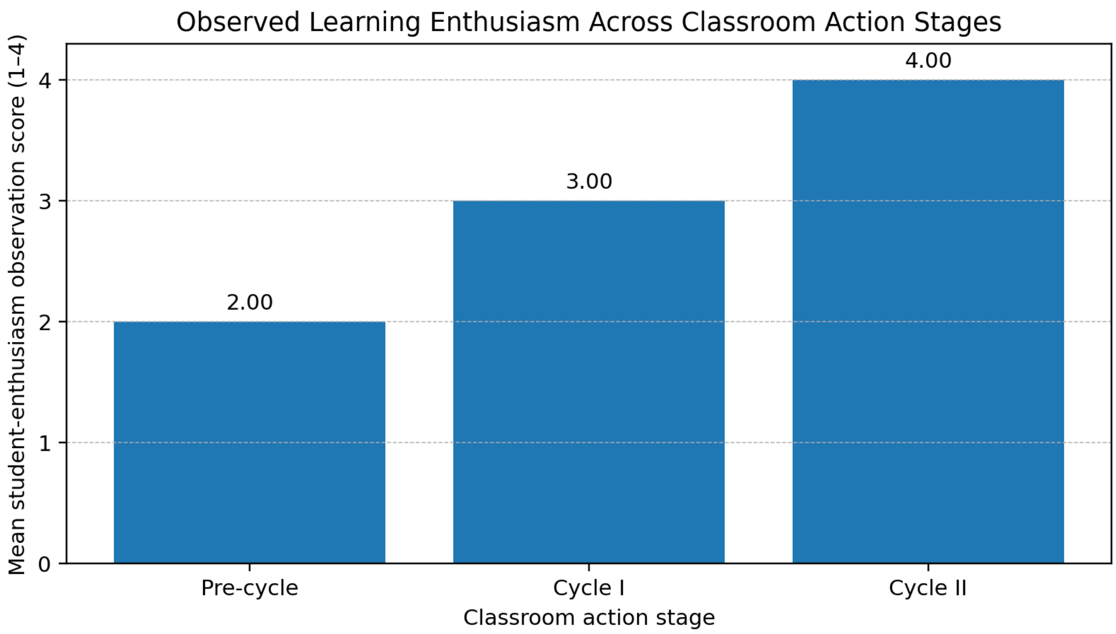

Figure 2. Observed Student Learning Enthusiasm Across Classroom Action Stages

Post-Cycle II Item-Level Responses

All ten post-cycle item means were in the very high category. The highest scores were recorded for the statements that animated video helped students understand the digestive system and that students wanted animated video to be used again in science learning (each score = 73; mean = 3.48). The comparatively lowest, yet still very high, score concerned increased activity in asking and answering questions (score = 69; mean = 3.29). This pattern suggests that the intervention was especially successful in making the content understandable and enjoyable, while verbal participation remained an area in which teacher facilitation continued to matter.

Table 5. Post-Cycle II Student Questionnaire Item Scores

No.	Post-Cycle II item	Score	Mean	Category
1	I enjoy learning science using animated video.	72	3.43	Very high
2	Animated video makes me more enthusiastic about learning.	71	3.38	Very high
3	I am more focused during learning.	70	3.33	Very high
4	Animated video helps me understand the human digestive system.	73	3.48	Very high
5	I am more active in asking and answering questions.	69	3.29	Very high
6	Science learning feels more enjoyable.	72	3.43	Very high
7	I do not get bored easily when learning with animated video.	71	3.38	Very high
8	I am interested in following the lesson from beginning to end.	70	3.33	Very high
9	I want science learning to use animated video again.	73	3.48	Very high
10	Animated video makes me more enthusiastic about learning science.	72	3.43	Very high

Discussion

Why the Animated Video Supported Enthusiasm

The findings suggest that the animated video supported enthusiasm because it made a dynamic and otherwise invisible biological process perceptible in a temporally organized form. The observation trajectory and strong item-level endorsement of conceptual usefulness are consistent with multimedia-learning accounts in which coordinated words and relevant visuals help learners select, organize, and integrate information [1], [2], [3]. The intervention also aligns with evidence that animation can be useful for representing change over time, particularly when it is not treated as a passive display [5], [6], [7]. In this classroom, the animation provided a shared visual reference for discussing the organ sequence and functions of the digestive system.

However, the improvement should not be attributed to animation alone. The lesson incorporated pause prompts, worksheet tasks, and discussion, meaning that students were asked to predict, explain, sequence, and respond while watching. These design features reflect generative-learning and active-processing principles [4], [10], [11], [12]. They also address an established limitation of video use: without pedagogical integration, learners may watch attentively without constructing a coherent explanation [8], [9]. The change from Cycle I to Cycle II supports this interpretation. After the teacher refined prompts, pauses, and group arrangements, student-enthusiasm observations reached the very high category, while teacher implementation also improved.

Participation, Engagement, and Human-Centered Classroom Design

The observed gains in attention, responses to teacher prompts, and enjoyment are consistent with the multidimensional view of engagement advanced in the literature [17], [18], [19], [20], [21]. The result is particularly meaningful because the post-cycle item pattern did not only indicate enjoyment; it also indicated perceived conceptual support and stronger willingness to engage in future video-supported science lessons. In a human-centered learning design, these outcomes are connected: a student who can follow a complex process, recognize where to focus, and participate in manageable tasks is more likely to sustain attention and experience learning as approachable.

The intervention also responds to the importance of guided participation in science learning. Meta-analytic evidence indicates that inquiry and active learning are more productive when learners receive appropriate support rather than being left to discover complex content without structure [13], [14], [15], [16]. In the present study, smaller groups and strategic pauses likely distributed opportunities to respond more equitably, although the study did not formally measure participation equity. This instructional refinement is relevant for inclusive primary classrooms, where a visually accessible shared resource can be paired with teacher scaffolding to reduce reliance on extended verbal explanation alone.

Relationship to Prior Indonesian Studies

The findings are broadly aligned with Indonesian studies reporting positive roles for interactive media and animation in elementary learning [22], [23], [24], [25], [26], [27]. The present study extends this body of work in two ways. First, it reports enthusiasm as a pattern of both self-reported and observed classroom behavior, rather than relying solely on achievement outcomes or media feasibility. Second, it shows the instructional pathway across a pre-cycle and two action cycles, documenting how video design was adjusted through teacher reflection. The contribution is therefore not a claim that any animation will produce enthusiasm, but an operational model in which multimedia visualization, structured participation, and facilitative teaching operate together.

Novelty and Implications

The novelty of this study is the human-centered action pathway displayed in Figure 1. It positions animated video as one component in a three-layer design: (1) cognitively accessible visualization of a dynamic science process; (2) structured student participation through pauses, prompts, worksheets, and group discussion; and (3) iterative teacher facilitation based on classroom observation. This model is compatible with research emphasizing that digital visualizations require integration with instruction [28], [29], and that affective design should support, not distract from, learning goals [30], [31]. It also accords with motivational perspectives that emphasize competence-supportive and participatory learning environments [32], [33].

For practice, primary science teachers can use short animated videos as low-cost visual anchors while designing moments for prediction, explanation, peer interaction, and feedback.

School leaders can support this approach through teacher development focused on multimedia lesson planning, classroom questioning, and reflective use of observation data. At a broader level, the study speaks to equitable learning opportunities by showing how a shared, age-appropriate digital resource can make difficult scientific processes more accessible without replacing teacher judgment. Such an approach is also consistent with calls for teaching that equips learners with active, reflective capabilities rather than passive exposure to information [37].

CONCLUSION

This classroom action research found that a human-centered interactive animated video lesson was associated with improved learning enthusiasm among 21 Grade 5 students studying the human digestive system. Pre-cycle questionnaire results were low (2.26), whereas the post-Cycle II result was very high (3.40); positive responses increased from 36.2% to 89.0%. Observed student enthusiasm also rose from 2.00 in the pre-cycle to 4.00 in Cycle II. The strongest post-cycle endorsements concerned the video's conceptual usefulness and students' willingness to use it again. The findings indicate that animated video is most productive when it is combined with pause prompts, simple learner tasks, small-group discussion, and responsive teacher facilitation. The study contributes a practical model for primary science teachers who seek to make dynamic scientific processes more visible, participatory, and enjoyable through low-cost, human-centered digital media.

LIMITATIONS

This study was conducted in one Grade 5 classroom with 21 students and used an action-research design; its findings should therefore be interpreted as context-specific improvement evidence rather than population-level causal proof. The study did not include a comparison group, longitudinal follow-up, or formal psychometric validation of the questionnaire. Complete Cycle I questionnaire totals were not retained, so only pre-cycle and post-Cycle II questionnaire comparisons are reported. In addition, transcript-level interview records were unavailable and were therefore not used as a separate analytic dataset. Future research should test the proposed pathway across multiple schools, include validated engagement measures, capture student talk systematically, and examine whether enthusiasm gains are accompanied by durable conceptual understanding and more equitable participation patterns.

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AUTHOR CONTRIBUTION

F.F.K. conceptualized the study, conducted classroom data collection, organized the intervention, analyzed the initial data, and prepared the first manuscript draft. T. supervised the research design, provided methodological guidance, reviewed the classroom action procedure, and strengthened the theoretical framing. P.A. contributed to instrument refinement, data interpretation, and critical revision of the manuscript for academic coherence. All authors approved the final manuscript and agree to be accountable for the integrity of the work.

CONFLICT OF INTEREST

"The authors declare no conflict of interest."

DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

The authors used ChatGPT during manuscript preparation to support language refinement, structural editing, and reference-style standardization. The tool was not used to generate research data, conduct the classroom intervention, or determine the study findings. The authors critically reviewed and edited the manuscript and assume full responsibility for its accuracy, integrity, and originality.

REFERENCES

[1] R. E. Mayer, "Applying the science of learning: Evidence-based principles for the design of multimedia instruction," *American Psychologist*, vol. 63, no. 8, pp. 760–769, 2008. https://doi.org/10.1037/0003-066X.63.8.760

[2] R. E. Mayer and R. Moreno, "Nine ways to reduce cognitive load in multimedia learning," *Educational Psychologist*, vol. 38, no. 1, pp. 43–52, 2003. https://doi.org/10.1207/S15326985EP3801_6

[3] R. Moreno and R. E. Mayer, "Interactive multimodal learning environments," *Educational Psychology Review*, vol. 19, no. 3, pp. 309–326, 2007. https://doi.org/10.1007/s10648-007-9047-2

[4] L. Fiorella and R. E. Mayer, "Eight ways to promote generative learning," *Educational Psychology Review*, vol. 28, pp. 717–741, 2016. https://doi.org/10.1007/s10648-015-9348-9

[5] T. N. Höffler and D. Leutner, “Instructional animation versus static pictures: A meta-analysis,” *Learning and Instruction*, vol. 17, no. 6, pp. 722–738, 2007. https://doi.org/10.1016/j.learninstruc.2007.09.013
[6] S. Berney and M. Bétrancourt, “Does animation enhance learning? A meta-analysis,” *Computers & Education*, vol. 101, pp. 150–167, 2016. https://doi.org/10.1016/j.compedu.2015.10.005
[7] R. Ploetzner, S. Berney, and M. Bétrancourt, “When learning from animations is more successful than learning from static pictures: Learning the specifics of change,” *Instructional Science*, vol. 49, pp. 497–514, 2021. https://doi.org/10.1007/s11251-021-09541-w
[8] C. J. Brame, “Effective educational videos: Principles and guidelines for maximizing student learning from video content,” *CBE—Life Sciences Education*, vol. 15, no. 4, Art. no. es6, 2016. https://doi.org/10.1187/cbe.16-03-0125
[9] M. Noetel *et al*., “Video improves learning in higher education: A systematic review,” *Review of Educational Research*, vol. 91, no. 2, pp. 204–236, 2021. https://doi.org/10.3102/0034654321990713
[10] B. B. de Koning, H. K. Tabbers, R. M. J. P. Rikers, and F. Paas, “Improved effectiveness of cueing by self-explanations when learning from a complex animation,” *Applied Cognitive Psychology*, vol. 25, no. 2, pp. 183–194, 2011. https://doi.org/10.1002/acp.1661
[11] C. I. Johnson and R. E. Mayer, “Applying the self-explanation principle to multimedia learning in a computer-based game-like environment,” *Computers in Human Behavior*, vol. 26, no. 6, pp. 1246–1252, 2010. https://doi.org/10.1016/j.chb.2010.03.025
[12] M. T. H. Chi and R. Wylie, “The ICAP framework: Linking cognitive engagement to active learning outcomes,” *Educational Psychologist*, vol. 49, no. 4, pp. 219–243, 2014. https://doi.org/10.1080/00461520.2014.965823
[13] A. W. Lazonder and R. Harmsen, “Meta-analysis of inquiry-based learning: Effects of guidance,” *Review of Educational Research*, vol. 86, no. 3, pp. 681–718, 2016. https://doi.org/10.3102/0034654315627366
[14] E. M. Furtak, T. Seidel, H. Iverson, and D. C. Briggs, “Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis,” *Review of Educational Research*, vol. 82, no. 3, pp. 300–329, 2012. https://doi.org/10.3102/0034654312457206
[15] S. Freeman *et al*., “Active learning increases student performance in science, engineering, and mathematics,” *Proceedings of the National Academy of Sciences*, vol. 111, no. 23, pp. 8410–8415, 2014. https://doi.org/10.1073/pnas.1319030111
[16] E. J. Theobald *et al*., “Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and mathematics,” *Proceedings of the National Academy of Sciences*, vol. 117, no. 12, pp. 6476–6483, 2020. https://doi.org/10.1073/pnas.1916903117
[17] J. A. Fredricks, P. C. Blumenfeld, and A. H. Paris, “School engagement: Potential of the concept, state of the evidence,” *Review of Educational Research*, vol. 74, no. 1, pp. 59–109, 2004. https://doi.org/10.3102/00346543074001059
[18] J. J. Appleton, S. L. Christenson, D. Kim, and A. L. Reschly, “Measuring cognitive and psychological engagement: Validation of the Student Engagement Instrument,” *Journal of School Psychology*, vol. 44, no. 5, pp. 427–445, 2006. https://doi.org/10.1016/j.jsp.2006.04.002
[19] E. A. Skinner, C. Furrer, G. Marchand, and T. Kindermann, “Engagement and disaffection in the classroom: Part of a larger motivational dynamic,” *Journal of Educational Psychology*, vol. 100, no. 4, pp. 765–781, 2008.

https://doi.org/10.1037/a0012840
[20] R. Azevedo, "Defining and measuring engagement and learning in science: Conceptual, theoretical, methodological, and analytical issues," *Educational Psychologist*, vol. 50, no. 1, pp. 84–94, 2015. https://doi.org/10.1080/00461520.2015.1004069
[21] E. R. Kahu, "Framing student engagement in higher education," *Studies in Higher Education*, vol. 38, no. 5, pp. 758–773, 2013. https://doi.org/10.1080/03075079.2011.598505
[22] N. Nafi'a and T. Taufiqurrahman, "Development of interactive learning media for natural science based on Adobe Flash for elementary school," *Jurnal Pendidikan IPA Indonesia*, vol. 9, no. 4, pp. 567–577, 2020. https://doi.org/10.15294/jpii.v9i4.25718
[23] D. R. Dewi, A. S. Egok, and R. Febriandi, "Pengembangan multimedia interaktif berbasis Powtoon pada pembelajaran tematik di sekolah dasar," *Jurnal Basicedu*, vol. 5, no. 5, pp. 3799–3813, 2021. https://doi.org/10.31004/basicedu.v5i5.1382
[24] M. Lubis, "Digital learning media in elementary science: Stimulating or demotivating?," *Assyfa Journal of Multidisciplinary Education*, vol. 1, no. 1, pp. 18–26, 2024. https://doi.org/10.61650/ajme.v1i1.497
[25] B. S. Sinambela and I. Pratiwi, "The effect of interactive media based on animated video on natural science process skills in elementary school," *Edunesia: Jurnal Ilmiah Pendidikan*, vol. 5, no. 3, 2024. https://doi.org/10.51276/edu.v5i3.921
[26] D. U. N. Diah, A. F. Surya, and E. Susiloningsih, "Application of animated video learning media to enhance elementary students' ability to understand intrinsic elements of short stories," *EduStream: Jurnal Pendidikan Dasar*, vol. 8, no. 2, pp. 100–112, 2024. https://doi.org/10.26740/eds.v8n2.p100-112
[27] L. A. Caella and S. Yulianto, "The effectiveness of animation video media to increase interest and learning outcomes in science subjects," *Jurnal Penelitian Pendidikan IPA*, vol. 10, no. 9, pp. 6621–6630, 2024. https://doi.org/10.29303/jppipa.v10i9.8445
[28] N. P. G. Rutten, W. R. van Joolingen, and J. T. van der Veen, "The learning effects of computer simulations in science education," *Computers & Education*, vol. 58, no. 1, pp. 136–153, 2012. https://doi.org/10.1016/j.compedu.2011.07.017
[29] L. K. Smetana and R. L. Bell, "Computer simulations to support science instruction and learning: A critical review of the literature," *International Journal of Science Education*, vol. 34, no. 9, pp. 1337–1370, 2012. https://doi.org/10.1080/09500693.2011.605182
[30] J. L. Plass, S. Heidig, E. O. Hayward, B. D. Homer, and E. Um, "Emotional design in multimedia learning: Effects of shape and color on affect and learning," *Learning and Instruction*, vol. 29, pp. 128–140, 2014. https://doi.org/10.1016/j.learninstruc.2013.02.006
[31] E. R. Um, J. L. Plass, E. O. Hayward, and B. D. Homer, "Emotional design in multimedia learning," *Journal of Educational Psychology*, vol. 104, no. 2, pp. 485–498, 2012. https://doi.org/10.1037/a0026609
[32] R. M. Ryan and E. L. Deci, "Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions," *Contemporary Educational Psychology*, vol. 61, Art. no. 101860, 2020. https://doi.org/10.1016/j.cedpsych.2020.101860
[33] A. Bandura, "Social cognitive theory: An agentic perspective," *Annual Review of Psychology*, vol. 52, pp. 1–26, 2001. https://doi.org/10.1146/annurev.psych.52.1.1
[34] S. Kemmis, R. McTaggart, and R. Nixon, *The Action Research Planner: Doing Critical Participatory Action Research*. Singapore: Springer, 2014. https://doi.org/10.1007/978-981-4560-67-2
[35] A. R. Artino Jr., J. S. La Rochelle, K. J. Dezee, and H. Gehlbach, "Developing questionnaires for educational research: AMEE Guide No. 87," *Medical Teacher*, vol.

36, no. 6, pp. 463–474, 2014. https://doi.org/10.3109/0142159X.2014.889814
[36] G. O. Boateng, T. B. Neilands, E. A. Frongillo, H. R. Melgar-Quiñonez, and S. L. Young, "Best practices for developing and validating scales for health, social, and behavioral research: A primer," *Frontiers in Public Health*, vol. 6, Art. no. 149, 2018. https://doi.org/10.3389/fpubh.2018.00149
[37] A. R. Saavedra and V. D. Opfer, "Learning 21st-century skills requires 21st-century teaching," *Phi Delta Kappan*, vol. 94, no. 2, pp. 8–13, 2012. https://doi.org/10.1177/003172171209400203