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Developing smart fractions as a learning media assisted by ispring suite 9 and geogebra for escalating students' computational thinking skills

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Abstract:
In the era of the Industrial Revolution 4.0, learning mathematics puts more demands on students' computational thinking skills. This research responds to this challenge by developing learning media assisted by iSpring Suite 9 and GeoGebra Software, known as the Smart Fractions. This development method employed Borg and Gall's ten-stage method. These stages included preliminary research, product planning and development, preliminary product design, product validation, preliminary product revision, user trial, product revision, effectiveness tests, final product and mass production, and product dissemination and implementation. The research data corroborated the validity, effectiveness, and practicality of the Smart Fractions interactive learning media. Media experts, material and learning experts, and students as users have acknowledged these properties. A validity test demonstrated a value of V_a = 3.53, which implied a decent extent of validity. The practicality test through questionnaire and observation generated a practicality score of 86.67%, another decent product property. The product's effectiveness was tested by assessing students' learning outcomes, which indicated an N-Gain score of 0.8. This inferred a noteworthy increase in computational thinking skills after implementing learning media. A t-test (2-tailed) also confirmed a significant difference in students' computational thinking skills before and after using learning media, as indicated by p = 0.000. The findings have concluded that Smart Fractions is a highly appropriate learning medium to improve students' computational thinking skills and help them visually understand fractions. The recommendation is to encourage students to use the learning media with the aid of manuals and tutorials on using the media. Teachers are also advised to combine the media with appropriate models, methods, strategies, and approaches.

Keywords: Computational Thinking Skills; Fractions; Ispring Suite 9.

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Introduction

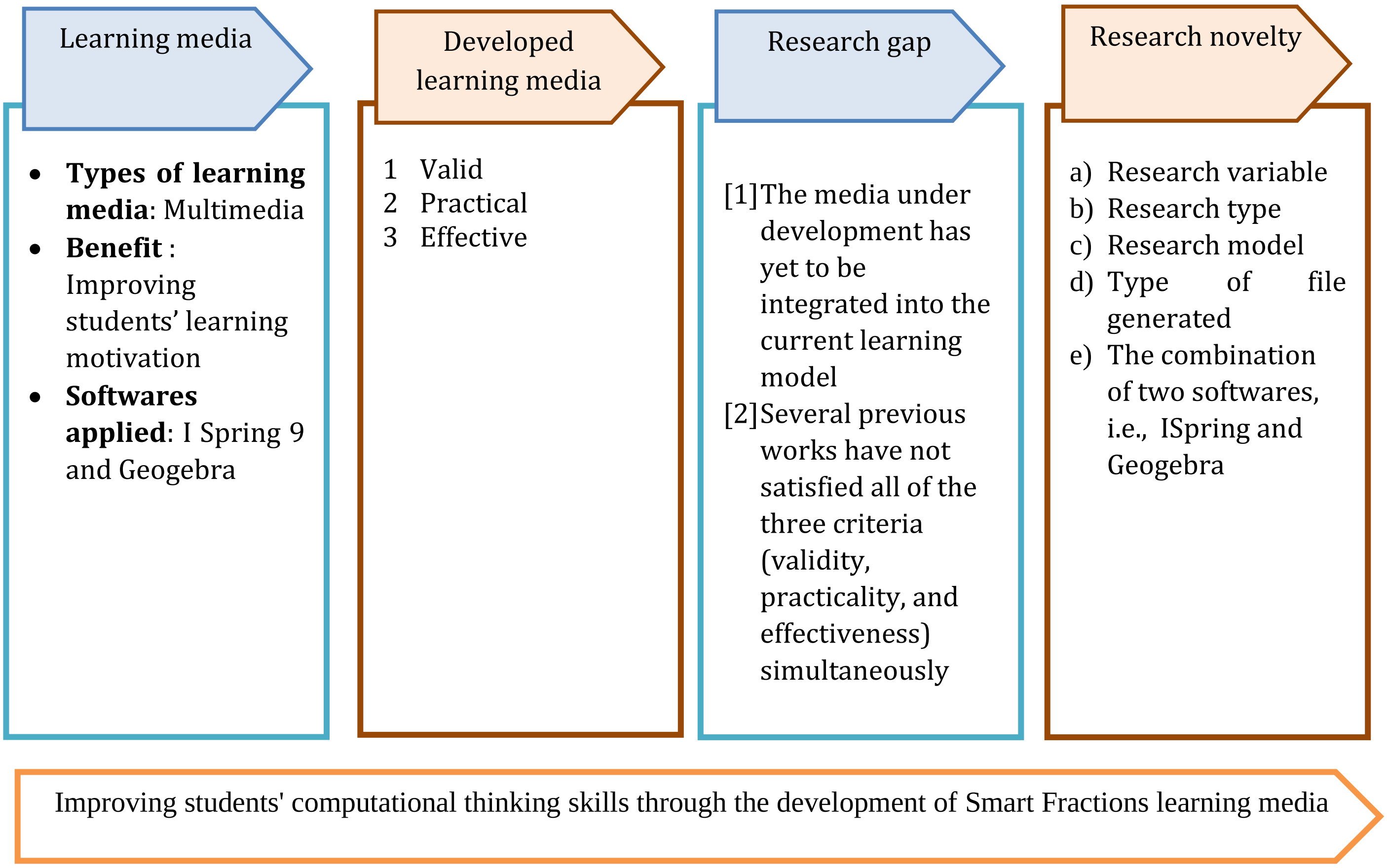
The recent developments in technology have posed significant impacts on education. The integration of technology into the learning process has opened up new opportunities for innovative and effective learning methods and media. Rapidly developing technologies, such as computer software and applications, have enabled a variety of attractive alternatives to escalate the teaching and learning process (Nurkanti et al., 2018). As such, information and communication technology (ICT) has an increasingly important role in education. The use of technology in learning not only facilitates access to information and learning resources but also develops students' technological skills and adaptability to emergent societal changes. The integration increases student motivation and interest and expands the scope of learning through more active, creative, and collaborative interactions (Nurkanti et al., 2018). Technology development today has led to the advancement of learning media day by day. Learning media is a tool to assist the learning process, making it more easily and clearly understood by students as an essential precursor to reaching instructional objectives effectively and efficiently. According to Gagne and Briggs (Aksa, 2017), learning media includes any physical tools used to convey learning content, which consists of books, tape recorders, cassettes, videos, video recorders, films, slides (framed images), photos, drawings, graphics, television, and computers. The relationship between media and learning technology is very close because technology enables teachers to deliver lessons through advanced media while helping student comprehension. Without learning media, teachers will likely struggle to deliver their lessons and achieve the learning objectives.

One skill essential for students to compete amidst the rapid development of technology was computational thinking (Tabesh, 2017). It is defined as a series of abstract mental activities that include reasonings such as abstraction, decomposition, pattern mapping, pattern recognition, algorithmic thinking, automation, modeling, simulation, assessment, testing, and generalization (Yağcı, 2020). It also pertained to problem-solving through systematic activation of logic, which was important in computer programming andarius fields, including mathematics (Nickerson et al., 2015). In mathematics, computational thinking is included in higher-order thinking (HOT), which is necessary to solve problems and improve student mathematics achievement (Lapawi & Husnin, 2020; Zakwandi & Istiyono, 2023; Zhang et al., 2023). Computational thinking also determines students' decision-making expertise and mathematical problem-solving skills (Benluo & Shuguang, 2008). In response to this increasingly vital role of computational thinking, in 2014, several developed countries began updating the education curriculum in schools to 189 introduce and train students' computational thinking skills from an early age (Lestari & Annizar, 2020). It is based on the belief that computational thinking can stimulate students to think logically and systematically (Cahdriyana & Richardo, 2020). This ability was very important in facing challenges in the digital era, where thinking logically, creatively, and analytically in solving problems held a prominent role (Lamb et al., 2017; Sentance & Csizmadia, 2017; Wati, 2020).

Notwithstanding, in reality, teachers' instructional praxis narrows the space for students to develop computational thinking skills (Cahdriyana & Richardo, 2020). In addition, previous works show that students' computational thinking skills are still low. The research found that most Indonesian students struggle to develop computational thinking (Supiarmo et al., 2022). Such factors as teachers' lack of awareness and understanding of computational thinking, limited resources, and access to technology posed challenges to improving students' computational thinking skills. Supiarmo et al. (2022) also explained that computational thinking has yet to receive focal emphasis, especially in Indonesia. This is mainly because the prevalent learning approaches overlook the opportunities to increase students' computational thinking. They envisaged the potential to improve students' computational thinking skills as students in the experimental class were higher than those in the control class. The right media can support the interaction between students, teachers, and learning resources. Interactive multimedia can be one of the most promising learning media to improve students' understanding and learning outcomes. However, previous research has documented that most interactive multimedia in learning do not use programming so they hardly tap into students' computational thinking skills. In response, this study aimed to develop interactive multimedia in the form of Ispring and Geogebra and make it accessible via computer to introduce computational thinking skills, such as abstraction, decomposition, pattern recognition, and algorithmic and computational thinking. Developing computational thinking as a foundational skill of the entire curriculum empowers students to learn abstract concepts, algorithmic and logical thinking processes, and strategies to solve complex and infinite problems. In reality, computational thinking is a basic learning skill for everyone and thus represents important preparation for training young people to think with the aid of computers in the future.

This research aimed to improve students' computational thinking skills through developing and testing Smart Fractions as a learning media assisted by iSpring Suite 9 and Geogebra. Ispring Suite 9 had several advantages in developing interactive learning media, especially in improving computational thinking skills; one was that it enabled students to create interesting, interactive, and easily accessible learning artifacts. In addition, Ispring Suite 9 has an intuitive interface and compatibility with various devices, which improves its applicability (Yusfa & Guspatni, 2021). This study used the modified version of Borg and Gall's research method. It includes structured and systematic stages for quality learning media (Aziz & Amidi, 2021; Putri & Wardoyo, 2017; Ratnawati et al., 2020).

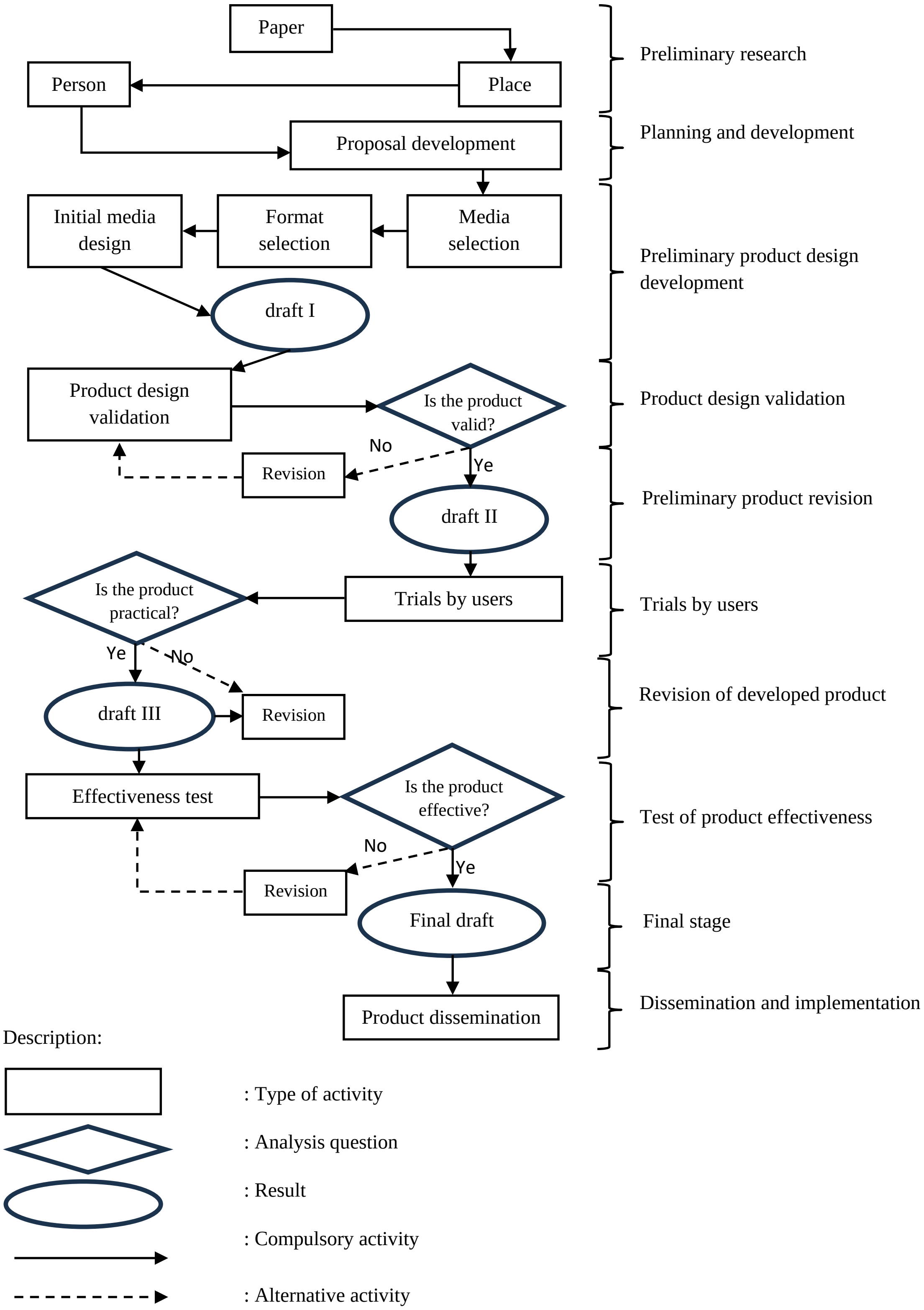
Chaeroni et al. (2020) showed that using iSpring Suite in learning mathematics can improve students' computational thinking skills. Previous research has also examined the use of iSpring Suite 9-assisted learning media. For example, Martiningsih (2018) reported higher learning outcomes in understanding sets through the assistance of the iSpring Suite 8 application without animation in the first cycle. Furthermore, in the second cycle, she uses a range of animation, videos, and interesting backgrounds in iSpring Suite 8. Increased learning outcomes were evident in the first and second cycles. Other research related to the development of ISpring-assisted media includes (Firdha & Zulyusri, 2022; Santi & Guspatni, 2022; Saputra & Alipia, 2022). A learning media on learning Geogebra is also documented in a study focusing on students' spatial skills to build flat side spaces of cubes and beams at Public Junior High School 1 of Sunggal, which also leads to higher learning outcomes (Hia & Nainggolan, 2023). Lumbantobing et al. acknowledge significant differences in learning outcomes of the two types of learning. The learning process assisted by GeoGebra interactive media led to more decent learning outcomes. Another line of research also documents the advantage of GeoGebra media (Hasibuan et al., 2023; Nurhayati et al., 2020; Silwana & Qohar, 2022; Yohannes & Chen, 2021). Following the above discussion, this study holds its novelty in developing media assisted by Ispring and Geogebra to improve students' computational thinking skills. Congruent with previous works, the state-of-the-art in the study is defined below.



Picture 1. The state-of-the-art study

Research Method

This study was a Research-and-Development project assisted by iSpring Suite 9 and GeoGebra software. Darmayanti et al. (2022) viewed a study of this nature as an attempt to develop learning media, teaching materials, tools or devices, and learning models to solve problems or improve learning quality. As shown in Picture 2, the research procedure involved designing, developing, and evaluating programs, processes, and learning products against three important criteria, i.e., validity, practicality, and effectiveness, all evident in Borg and Gall's model. This model includes ten stages, i.e., preliminary research, planning, and product development, preliminary product design, product validation, preliminary product revision, trial by users, product revision, effectiveness testing, final product and mass production, and product dissemination and implementation. Developing a learning media must fulfill three parameters of quality media: validity, practicality, and effectiveness. Several research instruments were developed to collect data on these parameters. The instrument used at the product validation stage was a questionnaire sheet focused on content and linguistic aspects. In addition, students were given a user response questionnaire at the practicality test stage. To determine the product's effectiveness, an assessment of students' computational thinking skills was conducted by using pre-test and post-test question sheets.



Picture 2. Modified Borg and Gall's Research Procedure

The first stage, preliminary research, is carried out to obtain relevant data. This stage is divided into three steps: (1) Paper, reading various literature; (2) Place, visiting the research site; and (3) Person, consulting experts to obtain recommendations and input during the research. The subsequent stage is to plan and develop products based on the collected data and information. The next stage is developing the initial product design. This stage aims to develop learning media assisted by iSpring Suite 9 software through media selection, format selection, and initial media design. The next stage, validation, involves experts' validation of the current product.

After the learning media (draft I) had gone through the validation, the weaknesses and strengths of the media were documented. An initial product revision stage is carried out to address the weaknesses based on the validators' suggestions through validation questionnaires. After the first revision, another round of validation is carried out, resulting in the draft II version of the product. Validated learning media (draft II) is tested on the students in a small-scale test. They will assess the practicality of learning media. This assessment was obtained from the students' user response questionnaire after using learning media. After the learning media (draft II) had gone through the small-scale test, the weaknesses and strengths of the media were identified. Another revision was carried out to address the weaknesses by referring to the students' assessment. The improved media, draft II, went through the last validation to reach a further improved product, or draft III.

The newly improved media (draft III) was tested for effectiveness. The test was conducted to ensure that the third version of developed media could potentially escalate students' computational thinking skills. The effectiveness was determined by the differences in the learning motivation questionnaire results before and after using media. Interview is also involved to investigate further what students deem to be the media strengths. After the media (draft III) had gone through the large-scale effectiveness test, complete information as to its weaknesses and strengths was identified. This test leads to the final product revision to address any remaining issues or weaknesses. The last stage is product dissemination and implementation.

The researchers analyzed collected data to interpret research results and draw research implications. The targeted validity level of learning media is "High" or "Very High." It is determined based on the validity coefficient in Table 1 (Hobri, 2020).

Table 1. The categories of validity score

∝ Scores	**Categories**
$0,80 < \lvert\propto\rvert \leq 1,00$	Very high
$0,60 < \lvert\propto\rvert \leq 0,80$	High
$0,40 < \lvert\propto\rvert \leq 0,60$	Fair
$0,20 < \lvert\propto\rvert \leq 0,40$	Low
$\lvert\propto\rvert \leq 0,20$	Very low

The next process was the practicality test, which operated on users' responses to the questionnaire. According to the rubric, the instructional media is deemed practical when it reaches the "Good" or "Very Good" category.

Table 2. The categories of practicality score

Scores	Categories
$P > 90\%$	Very good
$80\% < P \leq 95\%$	Good
$65\% < P \leq 80\%$	Fair
$50\% < P \leq 65\%$	Poor
$P \leq 50\%$	Very poor

The effectiveness of learning media is determined by using computational thinking skill questionnaires. The test put the effectiveness score threshold in the "Good" or "Very Good" category, according to the effectiveness category in Table 3 (Safitri et al., 2020).

Table 3. The Categories of Effectiveness Score Based on Total Average

Scores	Categories
$3 < S \leq 4$	Very good
$2 < S \leq 3$	Good
$1 < S \leq 2$	Poor
$S \leq 1$	Very poor

The increment in students' computational thinking skills was obtained based on N-Gain before and after using the media. These skills comprise five aspects: decomposition, abstraction, algorithm, generalization, and debugging. The following indicators of computational thinking skills are employed in the analysis.

Table 4. The indicators of computational thinking skills

Dimensions	Indicators
Decomposition	Students can identify a problem accurately.
Abstraction	Students can differentiate between essential and inessential information.
Algorithm	Students can mention the steps required to formulate a relevant solution.
Generalization	Students can generalize a problem into a new context and decide the apt solution based on a lesson learned.
Debugging	Students can quickly construct a relevant solution accurately and troubleshoot any accompanying issues therefrom.

The formula Arikunto (2013) developed is employed to identify the percentage of errors for each indicator of mathematical computational thinking skills.

Table 5. The categories of computational thinking skills

Categories	Competence indicators
Very good	$X \geq (M + 1{,}5Sdi)$
Good	$(M + 0{,}5Sdi) < X < (M + 1{,}5Sdi)$
Fair	$(M - 0{,}5Sdi) < X < (M + 0{,}5Sdi)$
Poor	$(M - 1{,}5Sdi) < X < (M - 0{,}5Sdi)$
Very poor	$X < (M - 1{,}5Sdi)$

Where:
M = Mean
Sdi = Ideal standard deviation
X = Student's score

Increasing students' computational thinking skills are analyzed based on the N-Gain difference between the pre-test and post-test scores. There is an increase in students' computational thinking skills using the formula for the normalized average gain or *N-Gain* as follows.

$$N - Gain = \frac{Score_{posttest} - Score_{pretest}}{Score_{max} - Score_{pretest}}$$

Where:
N-Gain = Normalized gain
$Score_{post\text{-}test}$ = Post-test score
$Score_{pre\text{-}test}$ = Pre-test score
$Score_{max}$ = Ideal maximum score

Table 6. The criteria of normalized N-Gain

N-Gain range	Categories
$g < 0{,}3$	Low
$0{,}7 > g \geq 0{,}3$	Moderate
$g \geq 0{,}7$	High

This study used a t-test to compare the pre-test and post-test scores. The results of the analysis laid the foundation for drawing the implication of a significant difference between both tests and the effectiveness of Smart Fractions media.

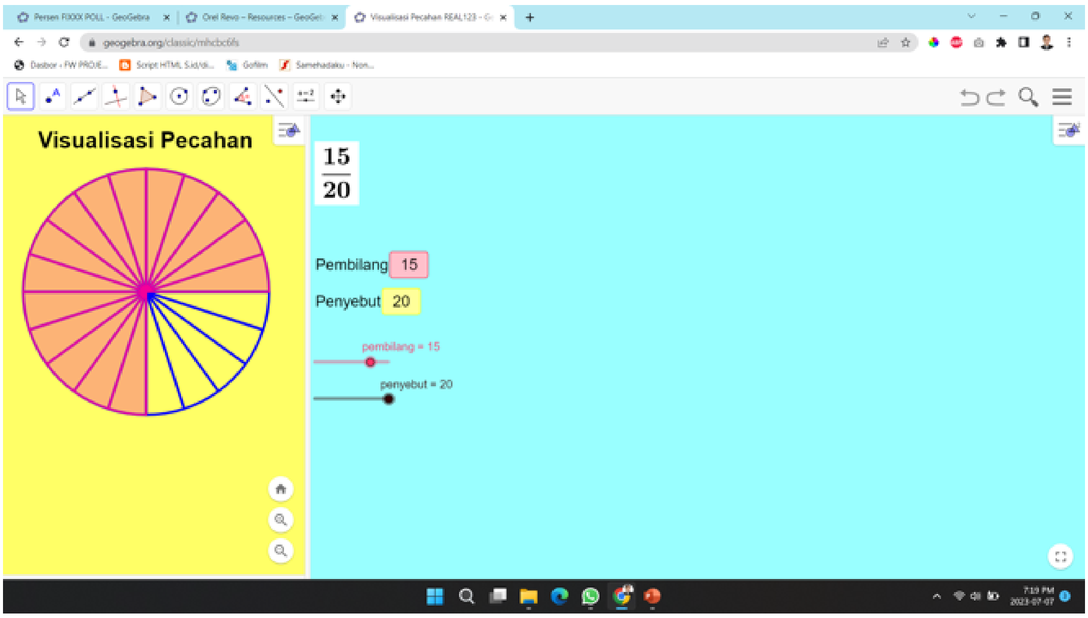
Results and Discussions

The method proposed by Borg and Gall comprises ten stages, *interalia,* preliminary research, product planning and development, preliminary product design, product validation, preliminary product revision, user trial, product revision, effectiveness tests, final product and mass production, and product dissemination and implementation. This research was conducted in a fourth-grade class at Public Elementary School 2 of Curahkalong. It strived to determine the validity, practicality, and effectiveness of the learning media assisted by Ispring 9 and Geogebra. This objective was achieved through Borg and Gall's procedure with ten stages. Preliminary research included paper, place, and person. The paper was a review of related literature, and it revealed the absence of learning media assisted by the iSpring suite 9 combined with GeoGebra to improve students' computational thinking skills in fractions. The place was about identifying the school conditions and characteristics. The learning process at the school was widely characterized by conventional methods and the overemphasis of textbooks, leading to low student engagement and understandably suboptimal computational thinking skills, especially in learning fraction material. This is in line with Satria, who states that many abstract concepts pose challenges to learning science (Satria et al., 2022). Next, the person dimension was concerned with exploring students' and teachers' needs in developing iSpring suite 9 learning media combined with GeoGebra.

The preliminary product design development included media selection, format selection, and preliminary media design. The media selection resulted in the employment of iSpring Suite 9 and GeoGebra to develop the desired learning media. The format selection determines the use of .html format to make the learning media accessible online through a computer or laptop. The preliminary design produces the first draft of the learning media. The first draft is then validated by three validators: two lecturers from the Mathematics Education Study Program of Jember University and one teacher at the school. These experts serve as interactive media experts and material experts, respectively. Validity is based on format, content, and language. At the validation stage, the first draft was declared valid due to a correlation coefficient (α) of 0.95. Referring to Table 1, the media has satisfied a very high level of validity. Interactive learning media developed using iSpring have been reported to be suitable for learning (Firdha & Zulyusri, 2022). The first draft is revised based on the validators' feedback. It is followed by the revision of the first draft, leading to the newer version of the media, hereby, the second draft. The second draft is put into a trial by users. In light of the objective to improve students' computational thinking skills, the core of this trial is assessing the extent of students' achievement against the indicators in computational thinking skills. These indicators also serve as the stepping stones to media development.

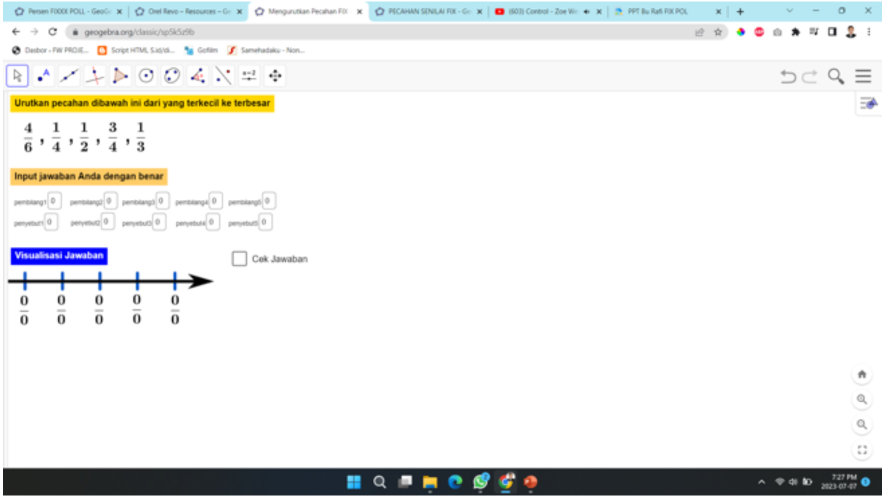
Picture 3. Media Design for the Decomposition Indicator

The media application was adjusted to the decomposition indicator stage, at which students encountered a problem related to fractions in real-life contexts. It aimed to familiarize students with the intertwinement between fractions and daily-life problems.



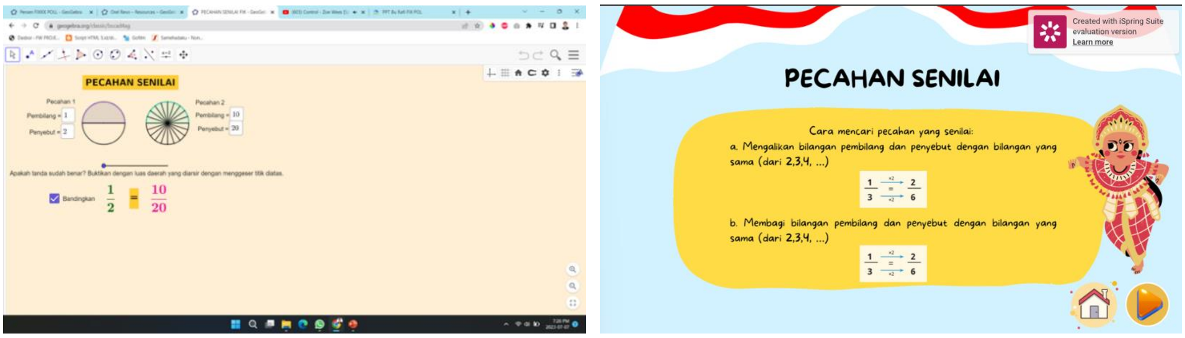
Picture 4. Media Design for the Abstraction Indicator

The media application at this stage emphasized the need to identify and understand fractional parts, such as the denominator and numerator. Fractions can be interpreted as parts of a whole. In Picture 4, the part marked with shading is called the numerator, while the whole part denotes a unit called the denominator.



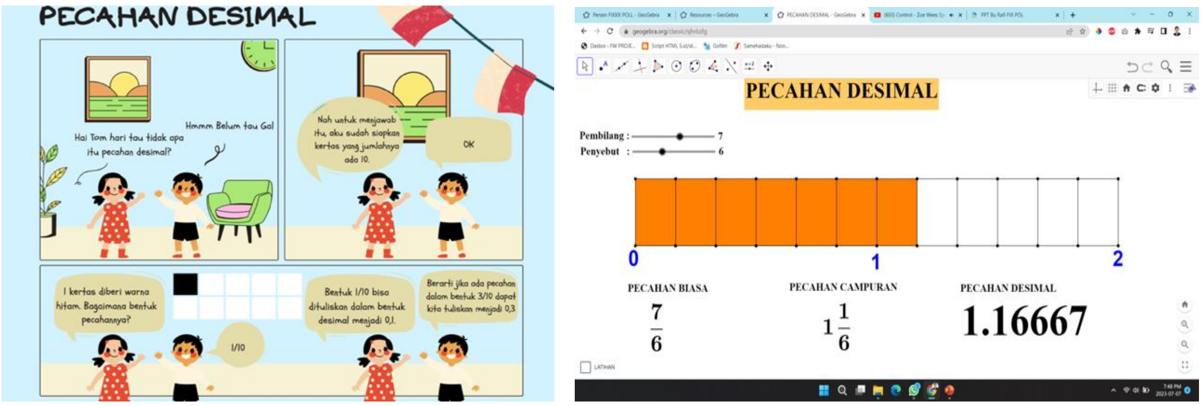
Picture 5. Media Design for the Algorithm Indicator

The algorithm indicator infused into the media required students to use algorithms to compare fractions and identify larger or smaller fractions. In this case, a number line was presented to pave students' understanding of fraction comparison.



Picture 6. Media Design for the Generalization Indicator

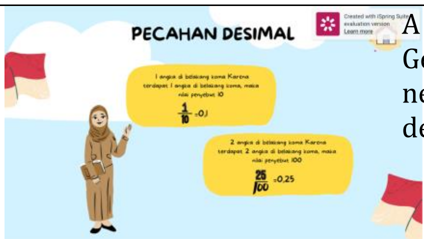
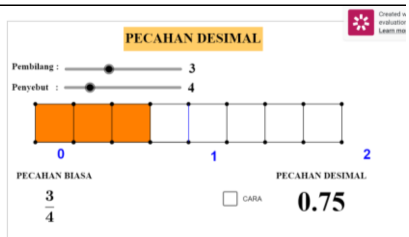
At this stage, the media encouraged the students to mention the general pattern of similarities in a given problem. They were guided to find out how to make sense of the fact that two fractions have the same value.



Picture 7. Media Design for The Debugging Indicator

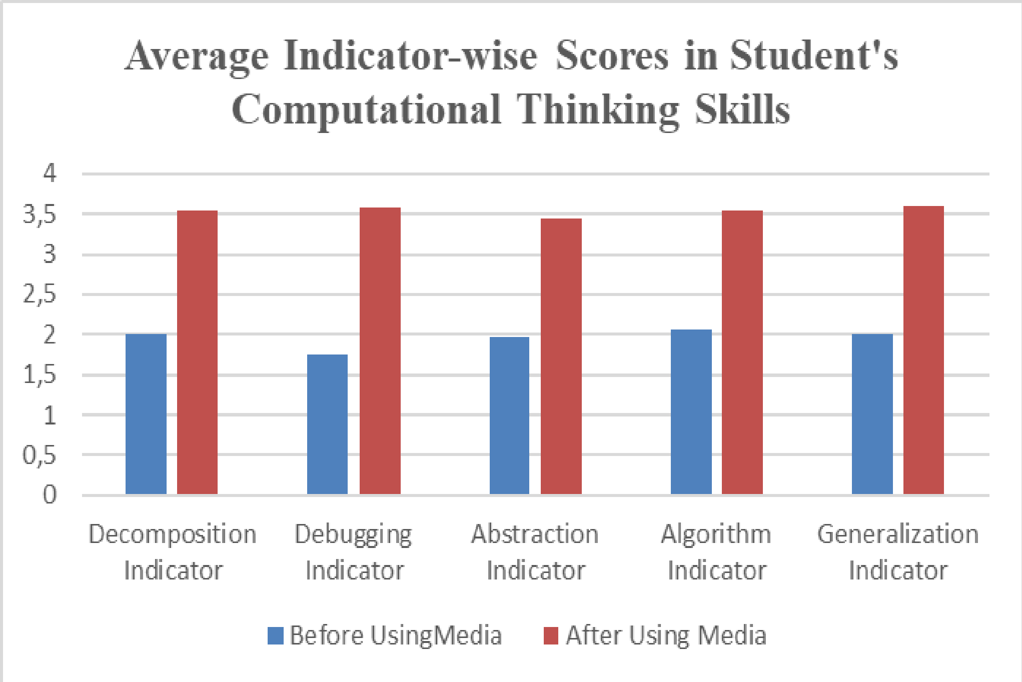
This indicator made it imperative to engage students in analyzing arithmetic operations and the results and reasons behind correct or incorrect answers. In this section, a comic related to decimal fractions was presented to reassess whether an ordinary fraction still has the same value when converted into decimal form. Following the experts' feedback, several revisions were made to the media. Table 7 presents the revisions.

Table 7. The Results of Media Revision

No.	Before Revision	Experts' Suggestions	After Revision
1		A simulation with Geogebra was necessary for the decimal fractions.	
2		A simulation with Geogebra was necessary for the fractional percentages.	
3		The questions should be arranged more neatly and attractively by diversifying the existing multiple-choice and open-ended questions by drag-and-drop	

The trial phase was carried out at the school by involving five random students in the fourth grade. The trial began with an introduction to learning media assisted by Ispring Suite 9 and GeoGebra Software (draft II). Then, the students are asked to learn fractions using the learning media, and then they must complete a questionnaire. The questionnaire results marked a practicality rate of 86.67, indicating that the media fell under the good category. In other words, these students did not find any issues when operating the media for learning fractions. It is largely coherent with a study on the development of Geogebra-based learning media with the ADDIE development model in Class XI at Public Senior High School 3 of Medan. The students in that study demonstrated decent mastery in using the media, as evidenced by an average response of 89% classified as "very strong" (Nababan, 2020). Subsequent to the test, the second draft is revised based on the users' feedback and suggestions. This second-round revision led to the third draft of the learning media. This newer version was also tested in a product effectiveness test involving five students of the same grade at the same research site.

The effectiveness Test also employs a questionnaire, from which N-Gain scores pertinent to students' test scores are retrieved before and after using the media. These scores are put into a t-test. This study's final product revision stage was not carried out because the students raised no feedback or suggestions during the test. The t-test aims to find out any significant difference in students' computational thinking between the pretest and posttest. The analysis results report an N-Gain score of 0.8, which thus acknowledges a significant increment in students' computational thinking skills. Based on Table 6, any N-Gain score > 0.7 falls under the high category. Figure 8 shows the students' scores in computational thinking skills.



Picture 8. Average Indicator-wise Scores in Students' Computational Thinking Skills

Picture 8 shows a consistent increase in the average score of each computational thinking skill indicator after using the media. The total average before using the media was 1.95, while that after using the media was 3.53. Based on Table 3, this final total average falls under the 'very effective' category. The next stage was the t-test with the aid of SPSS, the result of which is presented below.

Table 8. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-test	22	45	50	47.44	1.211
Post-test	22	86	90	88.00	1.195
Valid N (listwise)	22				

Table 8 shows that 22 people are involved in each of the tests. The minimum and maximum scores in the pretest are 45 and 50, respectively. Meanwhile, the minimum and maximum scores in the posttest are 86 and 90. The standard deviations in the pretest and posttest are 1.21 and 1.19, respectively.

Table 9. Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Pre-test	0.080	22	0.200*	0.983	22	0.956
Post-test	0.182	22	0.057	0.920	22	0.078

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Due to the small sample (<50), the Shapiro-Wilk test was performed, and it reported *p* above 0.05 in both pretest and posttest. It implied that the data was normally distributed.

Table 10. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	47.44	22	1.211	0.258
	Post-test	88.00	22	1.195	0.255

A paired-sample t-test involved two measurements on the same subject for a certain treatment. If a treatment has no effect, then the average difference is zero. The research findings document the standard error means of 0.258 and 0.255 for each pretest and posttest. Again, this acknowledged an increase from the pre-test to the post-test.

Table 11. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test & Post-test	22	0.969	0.000

Research hypotheses:
H_0: There is no significant difference in the average scores of students' computational thinking skills between the pretest and posttest

H_a: There is a significant difference in the average scores of students' computational thinking skills between the pretest and post-test

Table 12. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-test – Post-test	-40.557	0.302	0.064	-40.691	-40.423	-630.140	21	0.000

As appreciated in Table 12, the analysis results reported p = 0.000 (2-tailed), so H_a was approved. At this stage, it is confident to acknowledge the increased computational thinking skills after using the media. The mean shows the average difference in the two variables tested, namely the pretest and posttest scores. A mean score of 40.557 signifies the difference between both test scores. The standard deviation is 0.302, indicating the standard deviation of the difference scores. The standard error mean is 0.064, indicating the standard error of the difference in values used in calculating test statistics and confidence intervals (Lower and Upper bound). The t, which is -630.140, shows the test statistic for the paired test. Finally, df shows the degrees of freedom of the test in the data, marked by a figure of 21.

In the dissemination and implementation stage, the learning media that had met validity, practicality, and effectiveness criteria was implemented at the school. A file in .rar format containing the final version of learning media was shared and implemented as a regular learning media to improve students' computational thinking skills on fractions in the fourth grade. An instructional media user manual was also introduced to the students and teachers.

Conclusion and Suggestions

The interactive learning media Smart Fractions developed in this study have been assessed and proven valid, effective, and practical by media experts, learning experts, and students as target users. Based on the research results, the validity of the media is marked at an average of 3.53, implying a decent rate of validity. In the same vein, the practicality test also demonstrates satisfactory practicality, as indicated by a practicality score of 86.67%, which means very good. Finally, the effectiveness test, as performed by assessing student learning outcomes and analyzing the N-Gain score, documents a score of 0.8, corresponding to a noteworthy increase in computational thinking skills before and after the application of Smart Fractions. The t-test result (2-tailed) reports on p 0.000, which also acknowledges a significant difference between students' computational thinking skills before and after the use of Smart Fractions. The results have demonstrated that Ispring and GeoGebra are two very useful tools for developing students' computational thinking in Mathematics instruction. Both tools support an interactive and dynamic approach, allowing students better to understand mathematical concepts through visual and hands-on experiences.

Eventually, this study recommends teachers combine appropriate models, methods, strategies, and approaches when planning their lessons with the aid of Ispring and Geogebra in light of achieving learning objectives. Another recommendation concerns adapting the research model to develop another version of Smart Fractions that can support Mathematics learning at higher education levels, i.e., junior high school and senior high school.

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References

Aksa, M. (2017). Classification and characteristics of historical learning media. *International Conference on Teacher Training and Education 2017 (ICTTE 2017)*, 1–7. https://doi.org/10.2991/ictte-17.2017.1

Arikunto, S. (2013). *Prosedur penelitian suatu pendekatan praktik [Research procedures a practical approach]*. PT Rineka Cipta.

Aziz, A., & Amidi, A. (2021). Development of android-based interactive learning media on statistics. *Unnes Journal of Mathematics Education*, *10*(3), 244–250. https://doi.org/10.15294/ujme.v10i3.54145

Benluo, Y., & Shuguang, L. (2008). Preliminary thinking about the mathematic foundation of modern computational electromagnetism. *2008 4th International Conference on Ultrawideband and Ultrashort Impulse Signals*, 192–194. https://doi.org/10.1109/UWBUS.2008.4669406

Cahdriyana, R. A., & Richardo, R. (2020). Berpikir komputasi dalam pembelajaran matematika [Computational thinking in mathematics learning]. *LITERASI (Jurnal Ilmu Pendidikan)*, *11*(1), 50–56. https://doi.org/10.21927/literasi.2020.11(1).50-56

Chaeroni, Y., Hamdani, N. A., Margana, A., & Rahadian, D. (2020). Penerapan i-spring suite 8 pada model pembelajaran improve untuk meningkatkan kemampuan pemahaman dan pemecahan masalah matematis peserta didik pada pokok bahasan program linear di tingkat sekolah menengah [Application of i-spring suite 8 in the improve learning model to improve students' understanding and solving mathematical problems on the subject of linear programming at the middle school level]. *Gunahumas*, *2*(2), 357–386. https://doi.org/10.17509/ghm.v2i2.23026

Darmayanti, R., Sugianto, R., Baiduri, B., Choirudin, C., & Wawan, W. (2022). Digital comic learning media based on character values on students’ critical thinking in solving mathematical problems in terms of learning styles. *Al-Jabar: Jurnal Pendidikan Matematika*, *13*(1), 49–66. https://doi.org/10.24042/ajpm.v13i1.11680

Firdha, N., & Zulyusri, Z. (2022). Penggunaan ispring dalam pengembangan media pembelajaran interaktif [Using ispring in developing interactive learning media]. *Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi*, *6*(1), 101–106. https://doi.org/10.33369/diklabio.6.1.101-106

Hasibuan, Y. R., Khairani, N., & Surya, E. (2023). Pengaruh kemampuan awal matematis dan model learning cycle 5E berbantuan geogebra untuk meningkatkan kemampuan pemecahan masalah matematis siswa dan kemandirian belajar matematis siswa [The influence of initial mathematical abilities and the 5E learning cycle model assisted by geogebra to improve students' mathematical problem solving abilities and students' mathematical learning independence]. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *7*(1), 740–750. https://doi.org/10.31004/cendekia.v7i1.2168

Hia, Y., & Nainggolan, E. K. B. (2023). Development of geogebra interactive learning media in the spatial ability to build flat side spaces of cubes and beams at SMPN 1 Sunggal. *Jurnal Ilmiah Pendidikan Holistik (JIPH)*, *2*(1), 29–54. https://doi.org/10.55927/jiph.v2i1.2801

Hobri, H. (2020). *Metodologi penelitian pengembangan (aplikasi pada penelitian pendidikan matematika) [Development research methodology (application to mathematics education research)]*. Pena Salsabila.

Lamb, S., Maire, Q., & Doecke, E. (2017). *Key skills for the 21st-century: An evidence-based review*. http://hdl.voced.edu.au/10707/458899

Lapawi, N., & Husnin, H. (2020). The effect of computational thinking module on achievement in scienceonal thinking modules on achievement in science. *Science Education International*, *31*(2), 164–171. https://www.icaseonline.net/journal/index.php/sei/article/view/205

Lestari, A. C., & Annizar, A. M. (2020). Proses berpikir kritis siswa dalam menyelesaikan masalah PISA ditinjau dari kemampuan berpikir komputasi [Students' critical thinking processes in solving PISA problems are viewed from computational thinking skills]. *Jurnal Kiprah*, *8*(1), 46–55. https://doi.org/10.31629/kiprah.v8i1.2063

Martiningsih, R. R. (2018). Peningkatan hasil belajar himpunan dengan menggunakan aplikasi ispring suite 8 [Improving set learning outcomes by using the iSpring suite 8 application]. *Jurnal Teknodik*, *22*(1), 35. https://doi.org/10.32550/teknodik.v21i3.344

Nababan, N. (2020). Pengembangan media pembelajaran berbasis geogebra dengan model pengembangan addie di kelas XI SMAN 3 Medan [Development of geogebra-based learning media with the Addie development model in class XI SMAN 3 Medan]. *Inspiratif: Jurnal Pendidikan Matematika*, *6*(1), 37–50.

Nickerson, H., Brand, C., & Repenning, A. (2015). Grounding computational thinking skill acquisition through contextualized instruction. *Proceedings of the Eleventh Annual International Conference on International Computing Education Research*, 207–216. https://doi.org/10.1145/2787622.2787720

Nurhayati, L., Ernawati, M., & Zanthy, L. S. (2020). Pembelajaran menggunakan pendekatan kontekstual berbantuan aplikasi geogebra untuk meningkatkan kemampuan pemecahan masalah matematis siswa [Learning uses a contextual approach assisted by the geogebra application to improve students' mathematical problem solving abilities]. *Sigma*, *5*(2), 44–48. https://doi.org/10.53712/sigma.v5i2.713

Nurkanti, M., Utari, T. S. G., & Devi, C. (2018). *Improving student learning outcomes* *through the use of interactive visual learning media (MIVI)*. *1*(1), 64–68. https://doi.org/10.5220/0008679500640068

Putri, R. S., & Wardoyo, C. (2017). The development of financial accounting learning tools with the Gall and Borg Model. *Dinamika Pendidikan*, *12*(2), 86–97. https://doi.org/10.15294/dp.v12i2.13559

Ratnawati, D., Wijayanti, A., Widodo, W., & Setiadi, B. R. (2020). ICT-based learning media development. *Journal of Physics: Conference Series*, *1446*(1), 1–6. https://doi.org/10.1088/1742-6596/1446/1/012038

Safitri, W. Y., Retnawati, H., & Rofiki, I. (2020). Pengembangan film animasi aritmetika sosial berbasis ekonomi syariah untuk meningkatkan minat belajar siswa MTs. *Jurnal Riset Pendidikan Matematika*, *7*(2), 195–209. https://doi.org/10.21831/jrpm.v7i2.34581

Santi, L., & Guspatni, G. (2022). Development of powerpoint-ispring learning media on redox material for class X SMA. *Edukimia*, *4*(2), 76–83. https://doi.org/10.24036/ekj.v4.i2.a389

Saputra, R., & Alipia, M. (2022). Studi literatur: Peningkatan minat belajar peserta didik menggunakan pengembangan media powerpoint berbasis ispring suite [Literature study: Increasing students' interest in learning using the ispring suite-based powerpoint media development]. *J-Simbol: Jurnal Magister Pendidikan Bahasa Dan Sastra Indonesia*, *10*(2), 56–61. https://doi.org/10.23960/J-Simbol/v10i2.2022.01

Satria, E., Sa'ud, U. S., Sopandi, W., Tursinawati, T., Rahayu, A. H., & Anggraeni, P. (2022). Pengembangan media animasi interaktif dengan pemorgraman scratch untuk mengenalkan keterampilan berpikir komputasional [Development of interactive animation media with scratch programming to introduce computational thinking skills]. *Jurnal Cerdas Proklamator*, *10*(2), 217–228. https://doi.org/10.37301/cerdas.v10i2.169

Sentance, S., & Csizmadia, A. (2017). Computing in the curriculum: Challenges and strategies from a teacher's perspective. *Education and Information Technologies*, *22*, 469–495. https://doi.org/10.1007/s10639-016-9482-0

Silwana, A., & Qohar, A. (2022). Development of articulate storyline and geogebra-based interactive learning media on the topic of tube surface area. *AIP Conference Proceedings*, *2566*(1), 1–8. https://doi.org/10.1063/5.0114340

Supiarmo, M. G., Sholikin, N. W., Harmonika, S., & Gaffar, A. (2022). Implementasi pembelajaran matematika realistik untuk meningkatkan kemampuan berpikir komputasional siswa [Implementation of realistic mathematics learning to improve students' computational thinking skills]. *Numeracy*, *9*(1), 1–13. https://doi.org/10.46244/numeracy.v9i1.1750

Tabesh, Y. (2017). Computational thinking: A 21st-century skill. *Olympiads in Informatics*, *11*(2), 65–70. https://doi.org/10.15388/ioi.2017.special.10

Wati, I. F. (2020). Digital game-based learning as a solution to fun learning challenges during the Covid-19 Pandemic. *1st International Conference on Information Technology and Education (ICITE 2020)*, 202–210. https://doi.org/10.2991/assehr.k.201214.237

Yağcı, M. (2020). A study on computational thinking and high school students' computational-thinking skill levels. *International Online Journal of Educational Sciences*, *10*(2), 81–96. https://doi.org/10.15345/iojes.2018.02.006

Yohannes, A., & Chen, H.-L. (2021). Geogebra in mathematics education: A systematic review of journal articles published from 2010 to 2020. *Interactive Learning Environments*, 1–16. https://doi.org/10.1080/10494820.2021.2016861

Yusfa, H. A., & Guspatni, G. (2021). Pengembangan media pembelajaran powerpoint-spring terintegrasi pertanyaan prompting pada materi hydrocarbon kelas XI SMA [Development of integrated powerpoint-ispring learning media with prompting questions on hydrocarbon material for class XI SMA]. *Entalpi Pendidikan Kimia*, *2*(3), 39–48. https://doi.org/10.24036/epk.v2i3.182

Zakwandi, R., & Istiyono, E. (2023). A framework for assessing computational thinking skills in the physics classroom: Study on cognitive test development. *SN Social Sciences*, *3*(3), 46. https://doi.org/10.1007/s43545-023-00633-7

Zhang, J.-H., Meng, B., Zou, L.-C., Zhu, Y., & Hwang, G.-J. (2023). Progressive flowchart development scaffolding to improve university students' computational thinking and programming self-efficacy. *Interactive Learning Environments*, *31*(6), 3792–3809. https://doi.org/10.1080/10494820.2021.1943687