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Improving Mathematics Learning Outcomes Through Interactive Electronic Modules Based on Constructivism and Cone of Experience

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ABSTRACT

Indonesia is anticipated to attain its golden period by 2045, requiring substantial adaptation and change in the development of high-quality human resources via education. The ongoing problem of inadequate mathematics performance and the prevalence of Teacher-Centered Learning (TCL) methodologies at SMAN 14 Jakarta underscores the need for educational innovation. This project seeks to build and implement an interactive electronic module based on constructivist pedagogy, using Edgar Dale's Cone of Experience to improve students' understanding of counting concepts. Primary problems include insufficient conceptual understanding among students, poorly matched educational materials, and evaluation methods that do not accurately represent instructional goals. This research utilizes a Research and creation (RnD) approach, namely the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), for systematic module creation. The results indicate that the module has strong validity for content, medium, and language. The module has considerable efficacy, resulting in a dramatic enhancement in students' learning results. The practicality evaluation reveals a high level of practicality. This research finds that the proposed module significantly enhances mathematical proficiency, has practical applicability in instructional contexts, and contains strong validity for educational use.

Keywords: ADDIE model, constructivist pedagogy, counting principles, Edgar Dale's cone of experience, interactive electronic module

Meningkatkan Hasil Belajar Matematika Melalui Modul Elektronik Interaktif Berbasis Konstruktivisme dan Kerucut Pengalaman

ABSTRACT

Indonesia diperkirakan akan mencapai masa keemasannya pada tahun 2045, yang membutuhkan adaptasi dan perubahan substansial dalam pengembangan sumber daya manusia berkualitas tinggi melalui pendidikan. Masalah yang terus berlanjut berupa kinerja matematika yang tidak memadai dan maraknya metodologi Pembelajaran Berpusat pada Guru (TCL) di SMAN 14 Jakarta menggarisbawahi perlunya inovasi pendidikan. Proyek ini

berupaya membangun dan mengimplementasikan modul elektronik interaktif berbasis pedagogi konstruktivis, menggunakan Kerucut Pengalaman Edgar Dale untuk meningkatkan pemahaman siswa tentang konsep berhitung. Masalah utamanya meliputi pemahaman konseptual yang kurang di antara siswa, materi pendidikan yang tidak sesuai, dan metode evaluasi yang tidak secara akurat mewakili tujuan instruksional. Penelitian ini menggunakan pendekatan Penelitian dan Kreasi (RnD), yaitu model ADDIE (Analisis, Desain, Pengembangan, Implementasi, dan Evaluasi), untuk pembuatan modul yang sistematis. Hasilnya menunjukkan bahwa modul tersebut memiliki validitas yang kuat untuk konten, media, dan bahasa. Modul tersebut memiliki efikasi yang cukup besar, yang menghasilkan peningkatan dramatis dalam hasil belajar siswa. Evaluasi kepraktisan menunjukkan tingkat kepraktisan yang tinggi. Penelitian ini menemukan bahwa modul yang diusulkan secara signifikan meningkatkan kemampuan matematika, memiliki penerapan praktis dalam konteks pengajaran, dan mengandung validitas yang kuat untuk penggunaan pendidikan.

Keywords: Cone of experience, Edgar Dale, efektivitas pembelajaran, model ADDIE, modul elektronik interaktif

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1. Introduction

As Indonesia moves toward its Golden Indonesia 2045 vision, the nation needs to transform its education system to develop high-quality human resources (Direktorat Jenderal Pendidikan Tinggi., 2023). Quality, innovation, and relevant education to the challenges of the times is the key to building the younger generation with strong knowledge, skills, and character (Aini, 2024). In this context, the collaboration of all parties is needed to improve the quality of education, including at the high school level which has several compulsory subjects, one of which is mathematics. Mathematics is a core subject because of its fundamental role in various sciences, technology, as well as the development of logical thinking skills and their application in daily life (Fauzan & Anshari, 2024).

Although mathematics is a compulsory subject for 12 years, a significant number of students still face substantial challenges in understanding basic concepts and achieving learning objectives. This remains a global issue, as basic mathematical skills are essential for problem-solving and cognitive development (Barroso et al., 2021). A lot of pupils are scared and anxious when they have to do arithmetic. Educational psychology study delineates mathematics anxiety as a distinct emotional reaction that adversely affects attention, working memory, and performance (Dowker et al., 2016). Students often feel scared before tests, particularly in arithmetic. Tests pose a threat to the safety of certain pupils. Carey et al. (2019) found that students' lack of confidence and interest in math might be caused by their fear of failing or being humiliated. Also, if there isn't enough emotional support in the classroom or if the methods of instruction are boring and focused on the instructor, students could experience worse anxiety (Barroso et al., 2021). Students may develop a stronger dislike for mathematics activities if teachers do not actively connect with them or use innovative teaching strategies (Dowker et al., 2016).

Many students at other secondary schools, like SMA Negeri 14 in Jakarta, have shown signs of mental anguish and have stopped paying attention in arithmetic class. Research from across

the world has shown that classroom dynamics and pedagogical choices have a significant impact on students' levels of mathematical anxiety as well as their level of emotional and cognitive investment in the subject (Demedts et al., 2022).

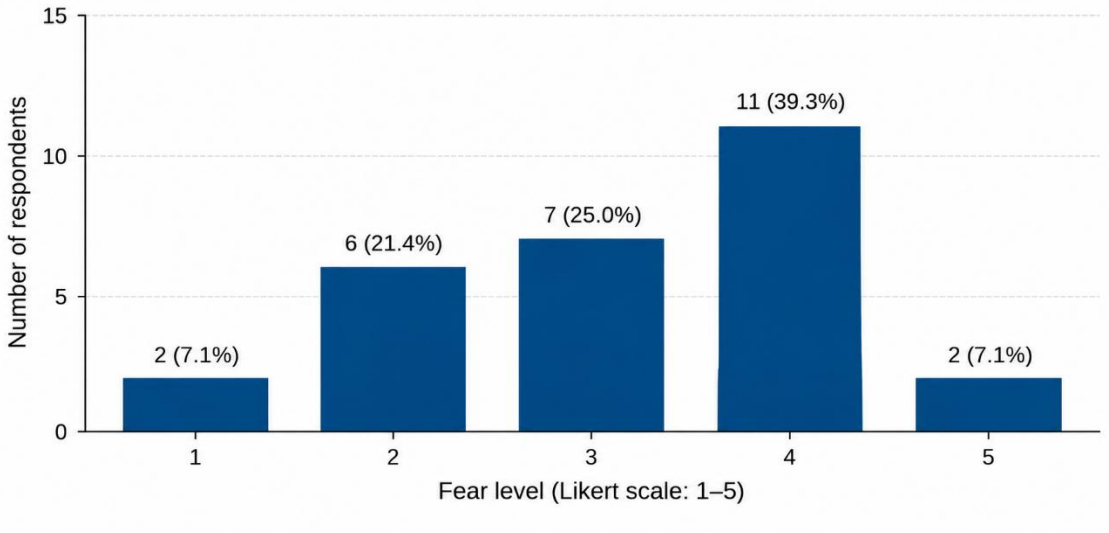


Figure 1. Students' Self-Reported Fear of Mathematics Learning (N = 28)

According to Ng et al. (2022), 13 of the 28 students reported feeling anxious and uneasy about mathematics. Mathematics anxiety may reduce students' engagement, hinder conceptual understanding, and negatively affect learning outcomes (Yaftian, 2022). Therefore, creating an emotionally supportive learning environment and incorporating engaging strategies, such as games, instructional tools, and group discussions, are important for motivating students and developing their critical thinking skills (Mamolo, 2024).

Similar challenges were identified among students at SMAN 14 Jakarta, where mathematics was perceived as difficult and uninteresting. Of the 28 students surveyed, 14 identified mathematics as their most difficult subject, attributing this difficulty to low interest, limited understanding of fundamental concepts, or difficulties performing mathematical calculations. These findings highlight the need for learning resources and instructional media that accommodate students' learning needs and support their understanding of mathematical concepts (Hilz, 2025; Akendita, 2024).

The students' summative assessment results further indicate challenges in achieving the Minimum Competency Criteria (Kriteria Ketuntasan Minimal, KKM). In Summative Test 1, only 6 of 36 students (16.7%) achieved the KKM when learning materials were provided in PDF format based on student worksheets (Lembar Kerja Peserta Didik, LKPD), although this represented an improvement over the previous assessment, in which no students achieved the criterion. In Summative Test 2, the use of PowerPoint presentations and calculators was associated with an increase in the number of students achieving the KKM to 13 (36.1%). Nevertheless, 23 students (63.9%) did not meet the criterion. In Summative Test 3, which employed a student-centered learning (SCL) approach, 13 students (36.1%) obtained scores between 90 and 100. However, the reported results indicate that a substantial proportion of students continued to experience learning difficulties. Challenges in accessing learning content through mobile devices may have further constrained the learning process. These findings suggest that the integration of accessible and interactive visual media warrants further consideration as a means of supporting students' mathematical understanding (Supriadi & Hanif et al., 2024; Chaiarwut, 2025).

Similar challenges have been reported in other schools. At MAN 3 Jakarta, only 29.4% of students achieved the KKM, while at SMA Negeri 1 Pasir Penyu, the average mathematics

score was 71.44, with 55.88% of students achieving the criterion. These findings suggest that difficulties in mathematics learning extend beyond a single school and underscore the importance of exploring more engaging and collaborative instructional approaches (Çibukçiu, 2025).

This approach requires teachers to have in-depth knowledge and extensive teaching experience (Do et al., 2023). In a recent study using Edgar Dale's Cone of Experience paradigm, researchers found that students were more engaged and able to understand abstract concepts, such as mathematics, after using multimedia and participating in experiential learning (Georgieva et al., 2023; Bicen & Beheshti, 2017). Mamolo (2024) stated that this approach can improve education by encouraging active student engagement using visual media and experiential learning. However, this approach also presents challenges, such as rigid media, teaching materials inconsistent with the lesson content, and formulaic and illogical resources. These problems were particularly evident in a recent study conducted at SMA Negeri 14 in Jakarta. Interactive modules based on the "cone of experience" model can facilitate student understanding but need to be improved to better meet competency standards while providing a more engaging and flexible learning experience. The "cone of experience" technique, based on constructivism, was used to create an interactive electronic mathematics module. This module aims to improve students' mathematical understanding, critical thinking skills, and study habits using simulations, interactive media, and hands-on activities. The goal of this research is to see how well this module helps students comprehend arithmetic better, become more involved, and meet curricular standards so that they do better in school.

2. Research Methods

2.1 Research Design

This study uses a quantitative approach with a quasi-experiment method. The design used is the pretest-posttest non-equivalent control group design. In this design, there are two groups, namely the experimental group that is treated using constructivism-based learning media, and the control group that uses conventional media. Both groups were given a pretest and a posttest to measure the improvement of students' mathematical understanding.

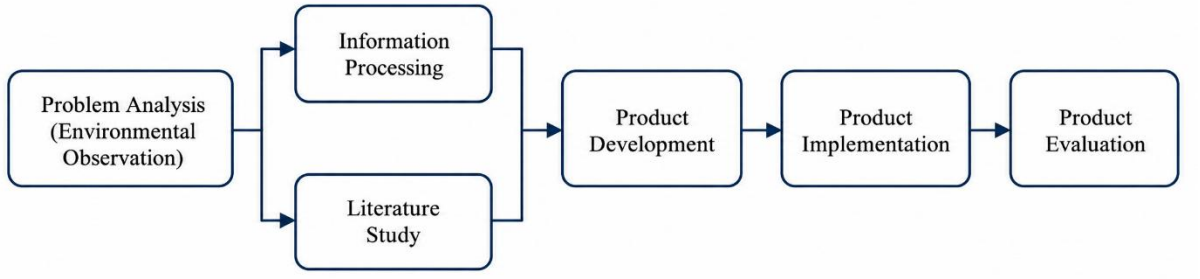


Figure 2. Research framework

2.2 Research Subject, Location, and Time

The research was carried out at SMA Negeri 14 Jakarta in the even semester of the 2023/2024 school year, with a total population of 36 students. The subjects of the study were class XII students consisting of two classes: class XII MIPA 1 as the experimental group and class XII MIPA 2 as the control group. The number of students in each class is 28 people. The selection of subjects used a purposive sampling technique with the consideration that both classes had relatively balanced academic abilities based on previous math scores

2.3 Research Instruments and Data Collection Techniques

The test instrument's quality in this research was evaluated according to its validity and reliability. The assessment, intended to evaluate students' comprehension of mathematical ideas, consisted of multiple-choice questions and descriptive items, linked with the indications of mastery in the enumeration rules content. Subject teachers and math education professors looked over the instrument to make sure it was content valid. The method confirmed that the assessment correctly measured the targeted learning outcomes. In addition, student activity observation sheets were employed to add to the quantitative data that had already been collected, which made the findings more reliable. The techniques used to collect data included giving students pretests and posttests and watching and recording what they did while they were studying.

2.4 Data Analysis Techniques

Quantitative data derived from the pretest and posttest outcomes were evaluated using normality tests, homogeneity tests, and t-tests, facilitated by the SPSS software. This analysis aims to determine the difference in learning outcomes between the experimental and control groups. The improvement in learning outcomes was also analyzed by calculating the *normalized gain* value. Meanwhile, observational data was analyzed descriptively to describe student involvement during the learning process.

3. Results and Discussion

This research uses an R&D approach with the ADDIE model to develop an interactive electronic module based on constructivism to improve students' abilities. In the analysis stage, the researcher conducted observations and interviews at SMAN 14 Jakarta to identify obstacles to mathematics learning, including students' low understanding due to the habit of seeking instant answers through technology and limited access to textbooks. The questionnaire results revealed students' enthusiasm for comprehensive and interactive learning modules incorporating comics introducing learning objectives, explanatory videos, GeoGebra-based virtual laboratories, and UTBK practice questions. The inclusion of comics is consistent with research highlighting students' perceptions of comics as a mode of mathematics instruction (Tay et al., 2024), while interactive GeoGebra activities have been associated with students' conceptual understanding and engagement (Hidayat et al., 2024). The teacher also said that the permutation and combination material is a challenge for students due to the complexity of the formula, while the teaching method used is still dominated by lectures and group discussions, with low student involvement. These findings form the basis for designing modules that are relevant to students' learning needs and characteristics.

Schools do not require the creation of interactive electronic modules, but teachers are given the freedom to compile teaching materials. The teacher stated that interactive e-modules are indispensable to support student learning, especially so that students do not just copy answers from the internet. Modules should also be designed according to the characteristics of Gen-Z students with interesting features such as game elements and accessibility without having to download. Teachers suggest modules be made per chapter with a comprehensive format, given the relatively short learning time of Grade 12.

3.1 Document Analysis and Interactive Module Development

The pre-test was attended by 36 students of SMAN 14 Jakarta, showing that only 13 students exceeded the KKM, indicating a low understanding of the enumeration rules material and the need for learning interventions. The school has adequate digital infrastructure, and students are used to using technology, so they are ready to implement constructivism-based electronic modules.

Modules are designed using a variety of platforms, such as Heyzine for interactive flipbooks, PowerPoint for design, Freepik, Pinterest, and ArtGuru for visual elements, as well as Oblik, Remove.bg, MiCanvas, and CapCut for animation and video. The modules are published via YouTube, and the interactive sections are created with GeoGebra (for math exploration) and *Wordwall* (educational quizzes & games). *Google Forms* are used for pre-testing and data collection. The module is compiled based on the official books of the Ministry of Education and Culture and Erlangga, and integrates *Edgar Dale's Cone of Experience* approach, to be more visual and in accordance with the characteristics of Generation Z. The design results show an attractive, educative, and encouraging active student involvement.

3.2 Summary of the Structure of Constructivism-Based Mathematics Interactive Modules

The constructivism-based interactive mathematics module was designed to facilitate students' active engagement in constructing mathematical knowledge through contextual problems, visual representations, interactive exploration, and symbolic formalization. The module consists of several interconnected components that support students throughout the learning process, from activating prior knowledge to evaluating their understanding. The structure and functions of these components are summarized in Table 1.

Table 1. Structure and Components of the Constructivism-Based Interactive Mathematics Module

Components	Description
Foreword	Convey the purpose, benefits, how to use the module, as well as the author's appreciation and expectations.
Instructions for Use	Self-paced and directed study guides for students to understand the flow and get the most out of the modules.
Table of Contents	Displays a complete material structure with navigation buttons for quick access to each section.
CP/ATP Introduction	Contains an introductory video that explains the learning objectives and competencies to be achieved.
Learning Level	Helps students gauge their level of mastery of the material and recognize areas that need improvement. Comprehension **(***Enactive*) Introduction to comic material that is relevant to students' lives, encouraging interest and initial understanding.
Introduction and Definition (*Iconic)*	Connecting the comic to the main material with a "How Can It Be" video and a misconception warning.
"Did You Know!"	Provide engaging additional insights and broaden students' perspectives.
Digital Laboratory (*Enactive*)	Use GeoGebra for concept exploration and interactive discovery of formulas.
Symbolic Stages	Help students draw conclusions in the form of symbols or formulas from previous learning experiences.
Sample Questions and Exercises + *Games*	Practice questions, discussion videos, as well as quizzes and two-level interactive games to reinforce concepts.
Material Summary	Key points and formulas are presented concisely with visualizations for easy understanding.
Competency Test	Questions with various levels of difficulty are accompanied by discussions to measure and improve student understanding.
UTBK/SNBT Training	Exam preparation questions complete with discussion videos to improve students' academic readiness.

3.3 Expert Validation

The e-module was evaluated by six experts: two subject-matter experts, two media experts, and two Indonesian-language experts. The assessments covered content suitability and accuracy, instructional and constructivist features, visual design and multimedia integration, and language quality. The quantitative results are summarized in Table 2.

Table 2. Summary of Expert Validation Results

Validation Aspect	Total Score	Mean Score	Category
Subject matter	146	3.65	Highly valid
Media	117	3.90	Highly valid
Language	44	3.67	Highly valid
Overall	**307**	**3.74**	**Highly valid**

The summary shows that media validation obtained the highest mean score (3.90), followed by language validation (3.67) and subject-matter validation (3.65). The overall mean score was 3.74. These findings suggest that the e-module was positively assessed by experts across the three validation components. However, the overall mean should be interpreted in accordance with the validity criteria established in the study, and the validation results alone do not demonstrate the module's effectiveness in improving student learning outcomes. The constructivism-based Mathematics Interactive Electronic Module was declared very good and valid by two subject matter experts, two media experts, and two linguists based on quantitative data. However, the researcher felt that it was necessary to deepen the validation, so the validation was carried out by a mixed method, combining quantitative and qualitative data to obtain more comprehensive results.

Subject matter experts stated that the content of the modules was relevant, interactive, and supported the principles of constructivism, although there were notes such as reliance on internet access, language inconsistencies, and some examples that were less appropriate to the student's context. The module should use Indonesian consistently and incorporate contexts familiar to students to enhance its relevance to their learning experiences. Its visual design, interactive features, and game-based exercises should also be evaluated in terms of usability and accessibility, as these are important considerations in mathematics educational technology (Molina et al., 2022). Furthermore, providing downloadable or offline versions may broaden access for learners with limited internet connectivity (Ferguson et al., 2024).

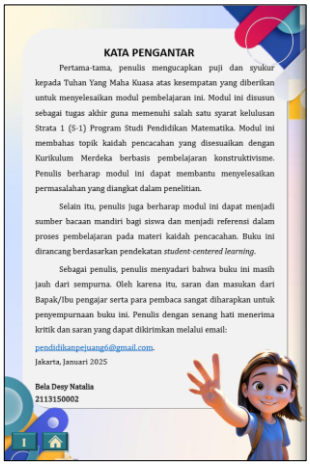
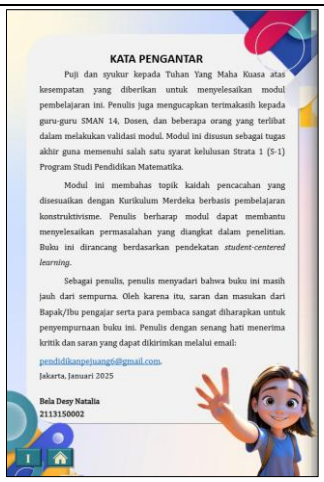
From the linguistic aspect, the modules are considered communicative and in accordance with the characteristics of high school students. However, there were some corrections to the use of punctuation, foreign terms, and the delivery of opening greetings.

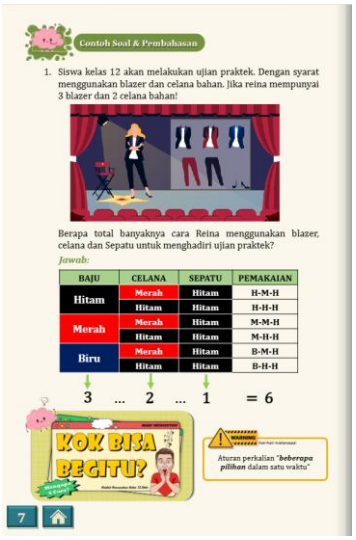
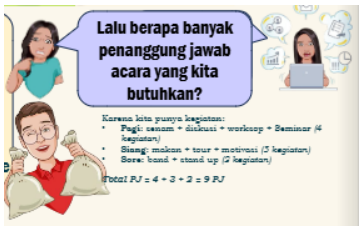
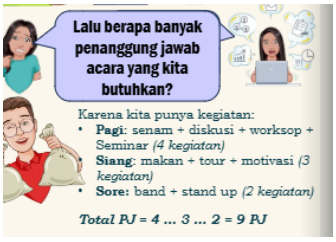
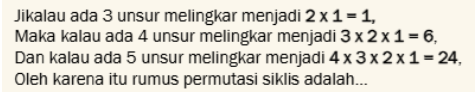
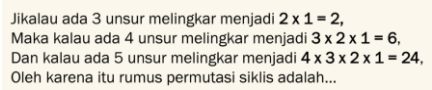
3.4 Product Revision

Based on the results of this validation, the module was declared suitable for use with revision. The researcher then continues *the development stage* by perfecting the product according to the input from the validators so that the module is more optimal in supporting learning.

- Link before *Development:* *https://heyzine.com/flip-book/7e855a3de6.html*
- Link after *Development:* *https://heyzine.com/flip-book/34f523de52.html*

Table 3. Product Development

<table>
<tr><th>Before Revision</th><th>After Revision</th></tr>
<tr><td>
KATA PENGANTAR
Pertama-tama, penulis mengucapkan puji dan syukur kepada Tuhan Yang Maha Kuasa atas kesempatan yang diberikan untuk menyelesaikan modul pembelajaran ini. Modul ini disusun sebagai tugas akhir guna memenuhi salah satu syarat kelulusan Strata 1 (S-1) Program Studi Pendidikan Matematika. Modul ini membahas topik kaidah pencacahan yang disesuaikan dengan Kurikulum Merdeka berbasis pembelajaran konstruktivisme. Penulis berharap modul ini dapat membantu menyelesaikan permasalahan yang diangkat dalam penelitian.
Selain itu, penulis juga berharap modul ini dapat menjadi sumber bacaan mandiri bagi siswa dan menjadi referensi dalam proses pembelajaran pada materi kaidah pencacahan. Buku ini dirancang berdasarkan pendekatan student-centered learning.
Sebagai penulis, penulis menyadari bahwa buku ini masih jauh dari sempurna. Oleh karena itu, saran dan masukan dari Bapak/Ibu pengajar serta para pembaca sangat diharapkan untuk penyempurnaan buku ini. Penulis dengan senang hati menerima kritik dan saran yang dapat dikirimkan melalui email:
pendidikanpejuang6@gmail.com.
Jakarta, Januari 2025
Bela Desy Natalia
2113150002</td><td>
KATA PENGANTAR
Puji dan syukur kepada Tuhan Yang Maha Kuasa atas kesempatan yang diberikan untuk menyelesaikan modul pembelajaran ini. Penulis juga mengucapkan terimakasih kepada guru-guru SMAN 14, Dosen, dan beberapa orang yang terlibat dalam melakukan validasi modul. Modul ini disusun sebagai tugas akhir guna memenuhi salah satu syarat kelulusan Strata 1 (S-1) Program Studi Pendidikan Matematika.
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pendidikanpejuang6@gmail.com.
Jakarta, Januari 2025
Bela Desy Natalia
2113150002</td></tr>
<tr><td colspan="2">Action:
The linguist validator gives suggestions for the preface should not be preceded by the word "first" then the preface should be arranged in the order Praise thanks, thank you, the purpose of the module, expectations, and the way the reader gives suggestions.</td></tr>
<tr><td>Unit 1: Rule Of the Sum.....1
Unit 2: Rule Of Product.....5</td><td>Unit 1: Penjumlahan (Rule Of the Sum).....1
Unit 2: Perkalian (Rule Of Product).....5</td></tr>
<tr><td colspan="2">Action:
Validators who are experts in materials and languages provide advice for the table of contents section is a good idea to use Indonesian, even if you use English, do it with italic text.</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Action:
Validators are experts in materials and languages providing advice for titles, materials, and content of the material, preferably in Indonesian, if you still use English, do it with italic text.</td></tr>
<tr><td>1. Jika kita punya 3 pilihan buku yang bisa dibaca serta 5 pilihan film yang bisa ditonton, maka banyak kemungkinannya adalah...
Diketahui:
• Buku = ...
• Film = ...</td><td>1. Hani mempunyai 3 pilihan buku yang bisa dibaca serta 5 pilihan film yang bisa ditonton, maka banyak kemungkinannya adalah...
Diketahui:
• Buku = ...
• Film = ...</td></tr>
<tr><td colspan="2">Action:
The linguist validator gave advice for the question section; it is better to use grammar with the beginning of a sentence instead of a subsentence (a sentence that begins with a conjunction).</td></tr>
</table>

	
Action: Material expert validators provide suggestions for units one and two made the structuralist section. Where the module does not straightforwardly provide a formula, but lets students learn the pattern. And in the example part of the sentence, it is changed to be related to students.	
	
Action: Material expert validators provide suggestions for units one and two made the structuralist section. Where the module does not straightforward provide a formula, but lets students learn the pattern.	
	
Action: Media expert validators provide suggestions for sections to provide space for dots to be able to fill in the blanks, more tidily. So that it is good for the reader to see.	
	
Action: Media expert validators advise that the cyclic permutation section should be noted in the comic comprehension section, because there are errors or typo.	

After the product development stage, the researcher continues with a test of questions to measure the feasibility and suitability of the questions with the student's competencies. The trial was carried out in class 12-1, followed by the main research in class 12-2. The results of the trial were analyzed using *Anates software* showed that the majority of questions were in the

"medium" difficulty category, both in the pretest (66.67%) and posttest (80%), with a balanced distribution for "difficult" and "very difficult" questions. The instrument has been expertly validated with an Aiken's V value of 0.93, indicating a very high validity. The modules developed were tested in limited trials and assessed for effectiveness through 15 standardized questions, with results presented in the form of tables, line diagrams, and circles to evaluate the improvement of students' understanding.

Table 4. Post-test results XII-2

Range	Midpoint	Frequency	Percent (%)	
			Relative	Cumulative
36 – 45	40,5	2	6%	6%
46 – 55	50,5	3	8%	14%
56 – 65	60,5	2	6%	19%
66 – 75	70,5	0	0%	19%
76 – 85	80,5	9	25%	44%
86 – 95	90,5	6	17%	61%
96 – 100	98	14	39%	100%

Most of the grades are in the high range, with the highest range being 96-100, which makes up 39% of the entire data. The 76-85 value range is particularly important since it includes 25% of the data. The 66-75 range, on the other hand, has no significance. This reflects a distribution that skews towards high grades (*positive skewness*), with most students achieving good to very good grades. Overall, student grades were dominated by the upper category, indicating strong performance.

Positive skewness is the distribution of data that has a longer tail on the right side (high value), so that the majority of the data is centralized in low to medium values, with some of the more frequent but significant high values. This distribution is characterized by the relationship of Mean > Median > Mode, where the average of the data is larger because it is influenced by high values. The chart is asymmetrical, with the peak closer to the left side.

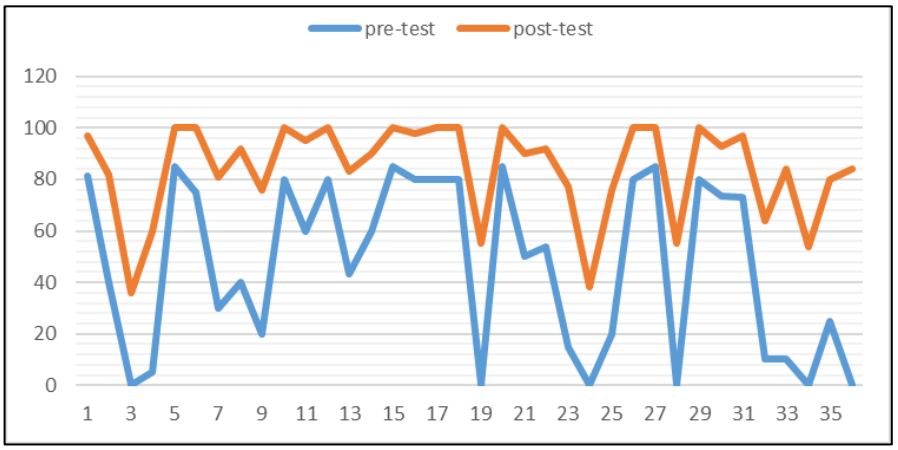


Figure 3. Value Comparison Chart

The line diagram shows the improvement experienced by almost all students. This reflects the effectiveness of the approach used in learning.

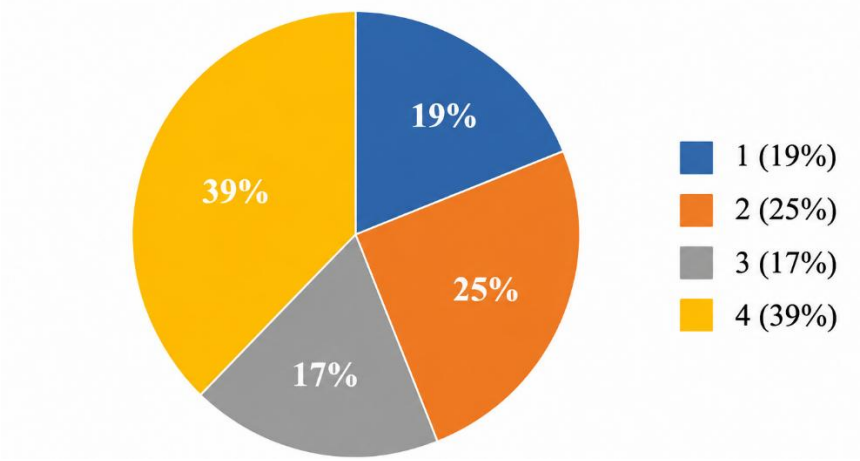


Figure 4. Percentage chart of value spread

Based on the pie chart in Figure 4, the distribution of students' grades shows that the majority are in the very good grade category (39%), which reflects the dominance of students with the highest academic achievements. As many as 17% of students were in the good grade category, showing a fairly solid performance but not dominating. The medium-grade category includes 25% of students, describing a group that is at an average level. Meanwhile, 19% of students are in the grade category below the KKM. Overall, this distribution showed positive results, although there were still students who needed intervention to improve their academic performance.

There are still 19% of students who score below KKM encouraging researchers to evaluate the feasibility of modules to improve students' abilities when used as independent learning tools for grade 12 high school students. This research was conducted through a questionnaire to all students to collect data on the practicality of modules in students' learning experiences, as well as in-depth interviews with students under the KKM to identify the obstacles they face in understanding the material with constructivism-based Interactive Module Electronics with the application of CoE to the enumeration rules material.

3.5 Results of the Evaluation Stage

After implementation, evaluation is carried out through tests and student questionnaires. The test results showed that out of 36 students, 75% experienced an increase in high learning outcomes with an average *N-Gain* of 0.70. The average score increased from 47 (pre-test) to 84 (post-test), reflecting a significant improvement in students' understanding after using constructivism-based interactive modules.

However, there are still 7 students with scores below the KKM. Interviews revealed that participants lacked the knowledge and skills necessary for independent learning and struggled to understand basic concepts, especially when exploring using GeoGebra. However, three students stated that their improved performance was due to the fact that the videos and interactive elements of the course enhanced their understanding of the material.

The questionnaire showed that the majority of students found the module practical and easy to use, with 27 students scoring highly. However, some students score lower due to usage constraints.

To reinforce the findings, comparative data from other schools were used to compare the effectiveness of the modules with other learning methods. This provides a broader perspective and reinforces the validity of the results that this interactive module is effective in improving the understanding of enumeration rules material.

Table 5. Students Score Data

Range	Midpoint	Frequency	Percent (%)	
			Relative	Cumulative
36 – 45	40,5	11	31%	31%
46 – 55	50,5	4	11%	42%
56 – 65	60,5	2	6%	47%
66 – 75	70,5	1	3%	50%
76 – 85	80,5	5	14%	64%
86 – 95	90,5	3	8%	72%
96 – 100	98	10	28%	100%

The results of the Two-Sample Assuming Unequal Variances *t-test* showed that there was a significant difference in students' understanding between SMAN 71 who did not use an interactive electronic module based on constructivism and SMAN 14 who used an interactive electronic module based on constructivism. In this study, SMAN 71 uses modules that can be accessed at: *https://pejuangpendidikan6.blogspot.com/2023/01/kaidah-pencacahan.html.*

The module is not designed based on the constructivism approach with the application of CoE, while SMAN 14 applies an electronic module designed with a constructivism approach with the application of CoE to improve student learning outcomes on enumeration principal material. These results indicate that the use of constructivism-based interactive electronic modules with the application of Edgar Dale's *cone of experience* can improve students' understanding more effectively when compared to digital learning approaches that are not supported by constructivism-based modules. The module used at SMAN 14 Jakarta, based on the constructivism approach with the application of Edgar Dale's Cone of Experience (CoE)**,** showed more effective improvement in students' understanding of enumeration principles compared to SMAN 71, which did not use this approach. The normality test (Kolmogorov-Smirnov) indicated that both groups' data were normally distributed ($p > 0.05$). The homogeneity test (Levene's Test) showed no significant differences between confirming that the data were comparable and the results reliable.

Table 6. Results of the Independent-Samples t-Test Comparing Students' Scores

Statistic	**SMAN 14 Jakarta**	**SMAN 71**
Number of students (n)	35	35
Mean score	65.43	83.77
Variance	884.08	346.06
Standard deviation	29.73	18.60
Statistical test	**Result**	
Mean difference (SMAN 14 Jakarta − SMAN 71)	−18.34	
t-statistic	−3.094	
Degrees of freedom	57	
Two-tailed (p-value)	.003	
Significance level	.05	
Decision	Reject (H0)	

The hypotheses tested were as follows:

(H0): There is no statistically significant difference in the mean scores for understanding counting principles between students at SMAN 14 Jakarta and SMAN 71.

(H1): There is a statistically significant difference in the mean scores for understanding counting principles between students at SMAN 14 Jakarta and SMAN 71.

This difference in understanding can be explained by the approach used in each module. The constructivism-based e-module at SMAN 14 is designed to facilitate students in actively building knowledge through learning experiences that connect concepts with real-world applications, making it easier for them to understand the material being taught. On the other hand, SMAN 71, which does not use constructivism-based interactive electronic modules, tends to rely on more traditional learning methods, which may not be enough to provide an in-depth learning experience and according to the needs of students. Therefore, the results of the t-test confirm that the use of constructivism-based electronic modules with the application of CoE plays a role in positively improving students' understanding of mathematical concepts.

The results of this study contribute to the solution of mathematics learning problems in general by providing an interactive module of mathematics based on constructivism with the application of Edgar Dale's cone of experience which is designed to improve students' understanding of the material on enumeration rules. The success of these modules can be measured through improved test scores before and after the use of the module, which reflects an improved understanding of students' concepts. The contribution of this research is in line with the vision of Golden Indonesia 2045, which aims to produce a superior generation of good learning outcomes and readiness to face global challenges.

3.6 Research Limitations

Research and development results indicate that constructivist-based electronic modules can improve student comprehension (Çibukçiu, 2025). However, these studies have limitations regarding module functionality and development time. The short implementation period (only two days) meant students didn't have enough time to fully absorb the material. The module also failed to address the lack of instructions on how to use interactive features, such as muting the sound (Demedts et al., 2022). As a result, some students struggled with the module due to the inability to mute the background music.

Interactive learning materials based on the Canva platform are a good strategy for learning social studies. Research by Santoso and Istiqomah (2022) found that these results support the view that visual learning aids help students understand abstract concepts. Expert evaluation of this platform demonstrated that its layout and content were appropriate for effective learning. Bicen and Beheshti (2017) noted that the use of interactive features and visual elements on the Canva platform can keep students engaged and make learning more relevant.

Especially in elementary schools, where learning must be engaging and hands-on, this platform can help students overcome boredom and lack of interest in their learning experiences. The use of Edgar Dale's Cone of Experience model can enhance the effectiveness of this module. Dale argued that children learn best through hands-on activities that engage multiple senses and cognitive processes (Sukarman et al., 2021). The Cone of Experience theoretical framework suggests that simulations, interactive videos, and other hands-on activities help students learn by doing. This not only helps students learn better but also allows them to apply what they learn in real-life situations.

4. Conclusion

This study demonstrates that the creation of a constructivist-based interactive electronic module and the application of Edgar Dale's Cone of Experience to the enumeration rule material is sound, practical, and effective. Good average relevance scores (3.6 for content, 3.9 for media, and 3.8 for language) were achieved in the online program. Significant improvements in student learning, with a 70% success rate demonstrated in the N-gain Test. User survey results also

showed a significant increase in module success, reaching 92%. In improving the quality of education, key concepts emphasize the need for preparatory aptitude tests and teachers to share learning materials before students interact with the module. A clever way to increase learning engagement is to test modules at different levels or with different materials, and to incorporate interactive elements such as digital simulations or augmented reality.

5. References

Aini, F. Q., Hasibuan, R. Y. A., & Gusmaneli, G. (2024). Pendidikan karakter sebagai landasan pembentukan generasi muda. *Dewantara: Jurnal Pendidikan Sosial Humaniora*, *3*(4), 54-69. https://doi.org/10.30640/dewantara.v3i4.3321

Akendita, P. A., Obeng, B. A., Abil, M., & Ahenkorah, M. (2024). Investigating the effect of socio-constructivist mathematics teaching on students' mathematics achievement: The mediating role of mathematics self-efficacy. *Educational Point, 1*(2), Article e110. https://doi.org/10.71176/edup/15662

Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin*, *147*(2), 134–168. https://doi.org/10.1037/bul0000307

Bicen, H., & Beheshti, M. (2017). The psychological impact of interactive multimedia in education. *Conference: BRAIN – Broad Research in Artificial Intelligence and Neuroscience*, *8*(4), 99–108. https://www.researchgate.net/publication/335137517

Carey, E., Devine, A., Hill, F., & Szűcs, D. (2019). Chicken or the egg? The direction of the relationship between mathematics anxiety and mathematics performance. *Frontiers in Psychology*, *10*, 1946. https://doi.org/10.3389/fpsyg.2015.01987

Chaiarwut, S., Srikoon, S., Siritaratiwat, A., & Kwangmuang, P. (2025). Enhancing executive mathematics problem-solving through a constructivist digital learning platform: Design, development and evaluation. Social Sciences & Humanities Open, *11*, Article 101338. https://doi.org/10.1016/j.ssaho.2025.101338

Çibukçiu, B. (2025). The impact of constructivist methods on students' mathematical problem-solving. *Discover Education, 4*(83). https://doi.org/10.1007/s44217-025-00475-w

Demedts, F., Reynvoet, B., Sasanguie, D., & Depaepe, F. (2022). Unraveling the role of math anxiety in students' math performance. *Frontiers in Psychology*, *13*, 979113. https://doi.org/10.3389/fpsyg.2022.979113

Direktorat Jenderal Pendidikan Tinggi. (2023). *Pendidikan Indonesia menuju Indonesia Emas 2045.* Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Do, H. N., Do, B. N., & Nguyen, M. H. (2023). How do constructivism learning environments generate motivation and learning strategy? The Design Science Approach. *Heliyon*, *9*(12), e22862. https://doi.org/10.1016/j.heliyon.2023.e22862

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology*, *7*, 508. https://doi.org/10.3389/fpsyg.2016.00508

Fauzan, H. & Anshari, K. (2024). Studi Literatur: Peran Pembelajaran Matematika Dalam Pembentukan Karakter Siswa. *Jurnal Riset Rumpun Ilmu Pendidikan*, *3*(1), 163–175. https://doi.org/10.55606/jurripen.v3i1.2802

Ferguson, R., Perryman, L.-A., & Ball, S. J. (2024). The importance of offline options for online learners. *Journal of Interactive Media in Education*, *2024*(1), Article 16. https://doi.org/10.5334/jime.898

Georgieva, D., Velikova, E., & Mazilu, I. M. (2017). Constructivism and multimedia learning. https://www.researchgate.net/publication/374422720

Hidayat, R., Noor, W. N. W. M., Nasir, N., & Ayub, A. F. M. (2024). The role of GeoGebra software in conceptual understanding and engagement among secondary school student. *Infinity Journal*, *13*(2), 317–332. https://doi.org/10.22460/infinity.v13i2.p317-332

Hilz, A., Hofman, A., Jansen, B., & Aldrup, K. (2025). Tracing students' practice behavior in an adaptive math learning program: Does it mediate the math anxiety–performance link?. *Learning and Instruction*, *98*, 102113. https://doi.org/10.1016/j.learninstruc.2025.102113

Mamolo, L. A., & Sugano, S. G. C. (2024). Digital interactive app and students' mathematics self-efficacy, anxiety, and achievement in the "new normal". *E-Learning and Digital Media*, *21*(5), 427-443. https:/doi.org/10.1177/20427530231167646

Molina, O., Fuentes-Cancell, D. R., & García-Hernández, A. (2022). Evaluating usability in educational technology: A systematic review from the teaching of mathematics. *LUMAT: International Journal on Math, Science and Technology Education*, *10*(1), 65–88. https://doi.org/10.31129/LUMAT.10.1.1686

Ng, C. T., Ho, A. K., & Gan, C. L. (2022). Evaluation of math anxiety and its remediation through a digital intervention. *Journal of Educational Psychology*, *114*(3), 601–616. https://doi.org/10.1002/brb3.2557

Santoso, H. A., & Istiqomah, N. R. (2022). Using canva to create visual materials in mathematics education. *Journal of Mathematical Pedagogy (JoMP)*, *3*(2), 114-120. https://doi.org/10.26740/jomp.v3n2.p114-120

Sukarman, S., Rahayu, W., & El Hakim, L. (2021). The Effectiveness of Mathematics E-Modules with a Contextual Approach on Geometry Matters to Improving Students' Learning Outcomes. *JPI: Jurnal Pendidikan Indonesia*, *10*(2), 362–369. https://ejournal.undiksha.ac.id/index.php/JPI/article/view/33530

Supriadi, S., & Hanif, M. (2024). Ethnomathematics mobile learning for pre-service elementary teachers: Creative thinking obstacles and didactic design analysis. *AsTEN Journal of Teacher Education*, *8*. https://doi.org/10.56278/asten.v8i.2776

Tay, X. W., Toh, T. L., & Cheng, L. P. (2024). Primary school students' perceptions of using comics as a mode of instruction in the mathematics classroom. International Journal of Mathematical Education in Science and Technology, 55(4), 997–1023. https://doi.org/10.1080/0020739X.2023.2170287

Yaftian, N. (2022). The effect of teaching using multimedia on mathematical anxiety and mathematical motivation. *Journal of Research and Advances in Mathematics Education*, *7*(1), 11–24. https://doi.org/10.23917/jramathedu.v7i2.16141