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# Development of Interactive E-Modules Based on SETS to Improve Students' Disaster Preparedness

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**ABSTRAK**

***Abstract:*** *This study aims to develop an interactive e-module based on the SETS (Science, Environment, Technology, and Society) approach incorporating disaster mitigation content to enhance students' disaster preparedness. The research employed a research and development (R&D) design using the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The participants consisted of 69 seventh-grade students from SMP Negeri 2 Ambulu and MTs Nahdlatul Arifin. Data were collected through expert validation sheets, teacher and student response questionnaires, pre-test and post-test results, and disaster preparedness observation sheets adapted from the National Disaster Management Agency (BNPB, 2020). The findings revealed that the developed e-module was categorized as highly valid, engaging, and effective, with an average N-Gain of 0.74 (high category). Students' preparedness levels reached 81.34% and 82.85% (ready category). Therefore, the SETS-based interactive e-module effectively enhances students' conceptual understanding and disaster response skills in the school context.*

**Abstrak**: Penelitian ini bertujuan untuk mengembangkan e-modul interaktif berbasis SETS (*Science, Environment, Technology, and Society*) yang memuat materi mitigasi bencana guna meningkatkan kesiapsiagaan siswa sekolah menengah. Jenis penelitian yang digunakan adalah penelitian dan pengembangan (R&D) dengan model ADDIE yang meliputi *tahap Analysis, Design, Development, Implementation, dan Evaluation*. Subjek penelitian melibatkan 69 siswa kelas VII dari dua sekolah, yaitu SMP Negeri 2 Ambulu dan MTs Nahdlatul Arifin. Data dikumpulkan melalui lembar validasi ahli, angket respon guru dan siswa, tes *pre-test* dan *post-test*, serta lembar observasi kesiapsiagaan berdasarkan indikator Badan Nasional Penanggulangan Bencana (BNPB, 2020). Hasil penelitian menunjukkan bahwa e-modul yang dikembangkan termasuk dalam kategori sangat valid, menarik, dan efektif dengan rata-rata peningkatan hasil belajar siswa sebesar N-Gain 0,74 (kategori tinggi). Tingkat kesiapsiagaan siswa mencapai 81,34% dan 82,85% (kategori siap). Dengan demikian, e-modul interaktif berbasis SETS ini efektif meningkatkan pemahaman konseptual dan keterampilan tanggap bencana siswa di sekolah.

## INTRODUCTION

Natural disasters constitute one of the most pressing global challenges in contemporary society. More than 300 million school-aged children worldwide reside in disaster-prone areas, with nearly 90% living in low- and middle-income countries (United Nations Office for Disaster Risk Reduction [UNDRR], 2023). Indonesia is particularly vulnerable due to its geographical position along the Ring of Fire, where more than 4,500 disaster events occur annually, predominantly floods, landslides,

earthquakes, and tsunamis (BNPB, 2024). These conditions highlight the critical need for systematic disaster preparedness education that equips students with adaptive knowledge and response capabilities from an early age.

The education sector plays a central role in cultivating disaster preparedness through structured learning experiences that foster awareness, skills, and responsible behavior. Schools serve not only as sites for knowledge transmission but also as environments for developing students' risk awareness and resilience. However, disaster education has not yet been fully institutionalized in Indonesian schools, as more than 60% lack disaster mitigation content integrated into learning activities (UNICEF Indonesia, 2023). This situation indicates that disaster-related learning remains fragmented and insufficiently oriented toward building students' practical preparedness.

The limited effectiveness of disaster education is further influenced by the dominance of conventional learning media, such as textbooks and student worksheets, which are generally static and less interactive (Nuvitalia et al., 2020). Learning approaches that emphasize rote memorization restrict students' ability to connect disaster concepts with real-world situations. In disaster contexts, students must understand the interrelationship between scientific principles, environmental conditions, technological interventions, and social dynamics to respond effectively during emergencies (Eren & Yağbasan, 2017). Accordingly, instructional materials that support contextual and integrative learning are essential to strengthen students' disaster preparedness.

Within this educational context, Social Studies (IPS) provides a strategic platform for integrating disaster literacy. As an interdisciplinary subject that synthesizes geography, history, economics, and sociology, social studies enables students to examine disasters from social, environmental, and spatial perspectives (Salwa & Firmantika, 2024). Despite this potential, the integration of disaster mitigation content in social studies learning remains limited, as teachers often face challenges in accessing curriculum-aligned and contextually relevant instructional materials (Ihsanudin et al., 2024). Consequently, innovative learning resources that explicitly embed disaster preparedness within social studies instruction are urgently required.

The Science, Environment, Technology, and Society (SETS) approach offers a coherent pedagogical framework to address these challenges. SETS emphasizes the interconnectedness of scientific knowledge, environmental contexts, technological developments, and social systems in understanding real-world problems. Empirical studies have demonstrated that the SETS approach enhances students' conceptual understanding, critical thinking, and problem-solving abilities in socio-environmental learning contexts (Maknun et al., 2018; Mahlianurrahman & Aprilia, 2024). From this perspective, integrating SETS into social studies learning provides a theoretical foundation for developing disaster preparedness as a critical educational outcome. In parallel with pedagogical innovation, the rapid advancement of digital technology necessitates the use of interactive learning media in schools. Interactive e-modules offer flexibility, multimedia integration, and learner-centered interactivity that support meaningful learning experiences. Research indicates that digital e-modules significantly improve students' motivation and learning outcomes (Muliana, 2021). In disaster education, e-modules enable the visualization of risk scenarios, emergency response procedures, and mitigation strategies, thereby facilitating deeper understanding and active student engagement.

Despite the recognized potential of SETS-based learning and digital e-modules, existing research reveals a notable gap. Prior studies have primarily examined SETS-oriented instruction in relation to critical thinking skills (Rohman & Adriyono, 2023) or focused on the development of geospatial learning media such as WebGIS (Pratiwi & Soekamto, 2023). However, research that systematically develops an interactive social studies e-module integrating the SETS approach with disaster mitigation content, while simultaneously evaluating its validity, effectiveness, and attractiveness, remains limited. This gap underscores the need for development-oriented research that positions disaster preparedness as a central learning objective. To address this gap, the present study develops an interactive SETS-based e-module incorporating disaster mitigation content using the ADDIE development model, which consists of analysis, design, development, implementation, and evaluation stages (Gularso, 2024). The

ADDIE model provides a systematic and flexible framework that supports continuous evaluation throughout the development process. Through the integration of SETS principles within the ADDIE framework, this study seeks to produce a pedagogically sound and empirically grounded learning resource that enhances students' disaster preparedness.

This study is aligned with the objectives of the Merdeka Curriculum, which emphasizes contextual, project-based learning and the strengthening of student profiles. The use of interactive e-modules encourages students to engage in reflective thinking, collaboration, and solution-oriented responses to disaster scenarios. Therefore, the developed e-module functions not only as an instructional medium but also as a strategic tool for strengthening disaster literacy and character education in social studies learning. Overall, the primary objective of this research is to develop a valid, engaging, and effective SETS-based interactive e-module to improve students' disaster preparedness. Theoretically, this study contributes to the advancement of social studies education by integrating the SETS approach with digital disaster education. Practically, the findings provide educators, schools, and policymakers with evidence-based guidance for implementing innovative digital learning media to support disaster-resilient education across diverse educational contexts.

## METODE

This study employed a Research and Development (R&D) approach with a descriptive quantitative orientation, aiming to develop a Science, Environment, Technology, and Society (SETS)-based interactive e-module integrating disaster mitigation content and to examine its validity, attractiveness, and effectiveness in improving students' disaster preparedness. The R&D approach was selected because it enables the systematic production of educational products while simultaneously evaluating their quality and feasibility through structured development stages. This approach ensures that the developed e-module is not only innovative but also empirically grounded for instructional use.

The development process was guided by the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. The ADDIE model was chosen due to its flexibility, iterative nature, and emphasis on continuous evaluation at each stage, allowing refinement of the learning product based on empirical feedback. Through this model, the development of the SETS-based e-module was aligned with both pedagogical objectives and disaster preparedness outcomes. The research was conducted during the first semester of the 2025/2026 academic year at two junior high schools located in disaster-prone areas, namely SMP Negeri 2 Ambulu and MTs Nahdlatul Arifin Sumberejo. These schools are situated in the southern coastal region of East Java, an area characterized by a high risk of earthquakes and tsunamis. The selection of these locations ensured that the developed e-module was tested in an authentic context relevant to disaster mitigation learning objectives.

The research subjects consisted of two groups of seventh-grade students, involving 34 students from SMP Negeri 2 Ambulu and 36 students from MTs Nahdlatul Arifin, resulting in a total of 69 students participating in the field trials. In addition, six expert validators were involved, comprising two social studies content experts, two learning media experts, and two language experts, along with two social studies teachers who participated in the product attractiveness assessment. Subject selection was conducted using purposive sampling based on location relevance, school readiness, and curriculum alignment, ensuring the suitability of participants for evaluating the developed e-module.

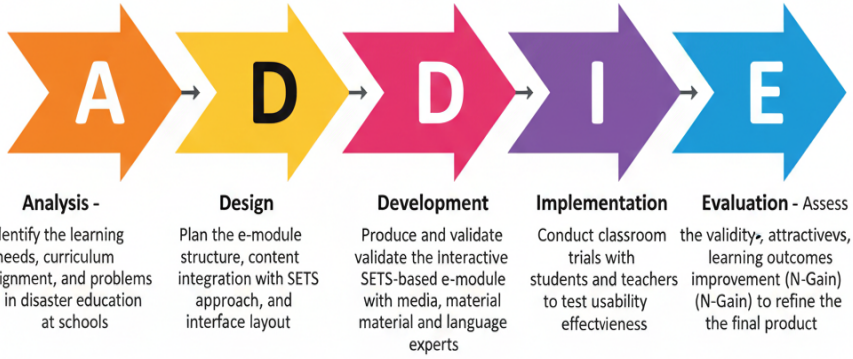


**Figure 1. Research Flow**

The ADDIE implementation began with the analysis stage, which focused on identifying students' learning needs, teachers' instructional challenges, and curriculum requirements. Data were collected through classroom observations and semi-structured interviews with social studies teachers to explore barriers to integrating disaster mitigation content and the need for digital instructional materials. This stage also included an analysis of Learning Outcomes and Learning Objectives Pathways within the Merdeka Curriculum Phase D, establishing a curricular foundation for the e-module development. The design stage involved structuring the e-module content, visual layout, and integration of SETS principles. The e-module was designed using the Canva Pro application and the Heyzine Flipbook platform, incorporating interactive elements such as instructional videos, reflective quizzes, and case-based disaster mitigation exercises. At this stage, the evaluation design was also prepared through pre-test and post-test instruments to measure changes in students' disaster preparedness following e-module implementation.

The development stage focused on producing the initial e-module prototype based on the approved design framework. Expert validation was conducted to assess content accuracy, media quality, and language clarity using a five-point Likert scale. Feedback from validators was systematically analyzed and used to revise the e-module before proceeding to classroom implementation, ensuring that the product met academic and pedagogical standards. The implementation stage consisted of small-group trials involving ten students at MTs Nahdlatul Arifin and large-group trials involving all seventh-grade students at both schools. During this stage, students used the SETS-based e-module independently within social studies lessons focused on disaster mitigation. Teachers acted as facilitators, while data collection included learning outcome tests, student and teacher response questionnaires, and disaster preparedness observations conducted during simulation activities. This implementation design enabled the evaluation of the e-module's practical effectiveness in authentic learning settings. The evaluation stage was conducted both formatively and summatively. Formative evaluation occurred throughout the development process based on expert validation and limited trials, while summative evaluation focused on assessing the effectiveness of the e-module in improving students' learning outcomes and disaster preparedness. The results of this evaluation informed final revisions, producing a refined learning product suitable for broader dissemination.

Multiple research instruments were employed to assess the feasibility and effectiveness of the developed e-module. Expert validation sheets were used to evaluate content, media, and language quality. Teacher and student response questionnaires assessed attractiveness, usability, and instructional relevance. Pre-tests and post-tests measured learning effectiveness, while disaster preparedness observation sheets assessed students' performance during mitigation simulations based on four indicators: knowledge, attitude, skills, and participation (Septiana et al., 2024). Collectively, these instruments provided comprehensive data on the quality and impact of the e-module.

$$V = \frac{Tse}{Tsh} \; x \; 100\%$$

Data analysis techniques included validity analysis, attractiveness analysis, learning effectiveness analysis, and disaster preparedness analysis. Product validity was calculated based on expert assessments and converted into percentage scores categorized according to predefined validity criteria.

**Table 1. Criteria for Product Validity Level**

| No | Percentage (%) | Criteria |
|---|---|---|
| 1 | 85% - 100% | Very valid, or can be used without revision |
| 2 | 70% - 84 % | Quite valid, usable but needs minor revisions |
| 3 | 50% - 69% | Less valid, not used because it needs major revisions |
| 4 | <50% | Invalid, or should not be used |

(Slamet, 2022)

The attractiveness of the SETS-based E-Module is measured using the following formula.

$$Attractiveness\ Score\ (\%) = \frac{Total\ Score\ Obtained}{Maximum\ Score}\ x\ 100\%$$

Product attractiveness was analyzed using percentage scores derived from teacher and student responses and interpreted based on established attractiveness criteria

**Table 2. Criteria for Product Attractiveness Level**

| No | Percentage (%) | Criteria |
|---|---|---|
| 1 | 85% – 100% | Very Interesting |
| 2 | 70% – 84% | Interesting |
| 3 | 50% – 69% | Quite Interesting |
| 4 | <50% | Not Interesting |

(Hanafi et al., 2020)

According to Hake (1998), effectiveness is obtained from the pre-test and post-test scores of students, which are analyzed using the N-gain formula.

$$N - Gain = \frac{Spost - Spre}{Smax - Spre}$$

Learning effectiveness was measured using the normalized gain (N-gain) derived from pre-test and post-test scores following established procedures

**Table 3. N-Gain Criteria**

| Values (g) | Criteria |
|---|---|
| < g > < 0,30 | Low |
| 0,70 > < g > ≥ 0,30 | Moderate |
| < g > ≥ 0,70 | High |

(Meltzer, 2002)

Student disaster preparedness was assessed using observation instruments based on national preparedness indicators, including knowledge, attitude, skills, and participation (BNPB, 2020). Preparedness scores were calculated using a weighted approach, with 70% allocated to group observation scores and 30% to individual assessment scores, in accordance with authentic assessment principles applied in the Merdeka Curriculum. Preparedness levels were interpreted descriptively using established national criteria.

$$Group\ Observation\ Score\ (SOK) = \frac{Total\ Group\ Score}{Maximum\ Score} x\ 100\%$$

$$Individual\ Assessment\ Score\ (SAI) = \frac{Total\ Group\ Score}{Maximum\ Score} x\ 100\%$$

$$Student\ Readiness\ Score(\%) = (0{,}70\ x\ SOK) + (0{,}30\ x\ SAI)$$

**Table 4. Preparedness Levels Criteria**

| No | Score (%) | Criteria |
|---|---|---|
| 1 | 85% – 100% | Very Ready |
| 2 | 70% – 84% | Ready |
| 3 | 50% – 69% | Somewhat Ready |
| 4 | <50% | Not Ready |

(BNPB, 2020)

Overall, the data analysis results were used to evaluate the success of the developed product based on three primary criteria: validity, effectiveness, and attractiveness. The SETS-based interactive e-module was considered suitable if it met the minimum standards of validity (⩾80%), effectiveness (N-gain ⩾0.3), and attractiveness (⩾75%). This methodological framework ensured that the research findings were empirically robust and directly relevant to the implementation of disaster mitigation-oriented social studies learning at the junior high school level.

## RESULTS AND DISCUSSION

This study resulted in the development of an interactive SETS-based e-module integrating disaster mitigation content through the ADDIE development model. The analysis stage revealed that seventh-grade students at SMP Negeri 2 Ambulu and MTs Nahdlatul Arifin are early adolescents who tend to be active, visually oriented, and responsive to contextual learning experiences. However, their initial understanding of natural disasters was still largely descriptive, indicating the need for instructional media that connects scientific explanations of disasters with Indonesia's geological conditions and social contexts. These findings justify the use of interactive digital media incorporating visuals, simulations, and contextual case studies to strengthen disaster-related conceptual understanding.

Questionnaire data further indicated that conventional social studies learning lacked interactivity and digital engagement, particularly in terms of visual presentation and learning activities. At the same time, students expressed strong interest in learning materials that enhance disaster preparedness. In this context, the development of a SETS-based interactive e-module becomes pedagogically relevant, as it integrates science, environment, technology, and society into a unified learning experience aligned with the Merdeka Curriculum and oriented toward disaster literacy. The design stage translated these needs into an e-module structure that emphasizes clear learning flow, conceptual mapping, contextual visuals, and interactive learning elements. The module integrates videos, simulations, and quizzes to facilitate students' engagement with disaster phenomena, mitigation strategies, and social implications.


**Figure 2. E-Module Cover**

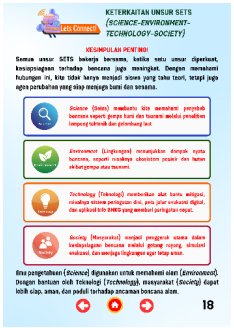


**Figure 3. SETS Aspects in E-Modules**

The learning design follows the four SETS learning phases: invitation, exploration, proposing opinions and solutions, and decision-making. These phases guide students from initial contextual exposure to reflective problem-solving and mitigation decision-making using real disaster cases, particularly the 2004 Aceh tsunami. This structure supports meaningful learning by linking scientific concepts with real-world disaster experiences and social responsibility.


**Figure 3. The Invitation Phase in E-Modules**


**Figure 4. The Exploration Phase in E-Modules**


**Figure 5. The Proposing Opinions and Solutions Phase in E-Modules**


**Figure 6. The Decision-Making Phase in E-Modules**

The visual and interactive design of the e-module emphasizes simplicity, intuitive navigation, and age-appropriate aesthetics. Illustrations of the Ring of Fire, animated disaster processes, and evacuation simulations are complemented by interactive features such as drag-and-drop activities, short reflections, and feedback-based quizzes. These features are intended to enhance engagement and support learning retention, consistent with principles of multimedia learning. The development stage included expert validation involving content experts, instructional media experts, and language experts. The validation results demonstrate that the e-module achieved a very high feasibility level, with an overall average score of 90.2%.

**Table 5. Results of the Validation of Interactive E-Modules Based on SETS**

| Assessment Aspect | Percentage (%) | Criteria |
|---|---|---|
| Material Expert | 93.0% | Very valid |
| Instructional Media Expert | 94.0% | Very valid |
| Linguist | 83.5% | Quite valid |
| **Average Total** | **90.2%** | **Very valid** |

These results indicate that the e-module meets instructional design standards in terms of content accuracy, media quality, and language clarity. This finding aligns with constructivist learning theory, which emphasizes the importance of contextual and interactive learning environments in supporting meaningful knowledge construction (Branch, 2010; Piaget & Vygotsky). The SETS framework further strengthens this approach by enabling students to understand disasters as multidimensional phenomena involving scientific processes, technological responses, environmental impacts, and social consequences.

The implementation stage involved field testing at SMP Negeri 2 Ambulu and MTs Nahdlatul Arifin with a total of 64 seventh-grade students. User response data from teachers and students indicate that the e-module was perceived as highly attractive and engaging.

**Table 6. Results of Teacher and Student Interest Test**

| Responden | Percentage (%) | Criteria |
|---|---|---|
| Two Social Studies Teachers | 87.8% | Very Interesting |
| 34 Students from SMP N 2 Ambulu | 79.7% | Interesting |
| 36 Students from MTs Nahdlatul Arifin | 84.2% | Very Interesting |
| **Average Total** | **84.9%** | **Very Interesting** |

High attractiveness ratings reflect strong user engagement and support Mayer's (2020) Multimedia Learning theory, which emphasizes the effectiveness of combining text, images, and interactive elements to enhance cognitive processing. The results suggest that the visual and interactive design of the SETS-based e-module successfully increases student motivation and learning interest. Effectiveness testing using the N-Gain formula (Hake, 1998) showed a substantial improvement in students' mastery of disaster mitigation concepts.

**Table 7. Effectiveness Test Results Based on N-Gain**

| School Location | Average Pre-test | Average Post-test | Values (g) | Criteria |
|---|---|---|---|---|
| SMP N 2 Ambulu | 58.4 | 91.3 | 0.83 | High |
| MTs Nahdlatul Arifin | 61.7 | 88.6 | 0.74 | High |
| **Average Total** | **60.0** | **89.9** | **0.79** | **High** |

An average N-Gain score of 0.79 indicates that the e-module is highly effective in improving students' conceptual understanding of disaster mitigation. This finding is consistent with Efendi and Insani (2024), who reported that contextual digital e-modules enhance learning outcomes through visualization and interactivity. The added value of this study lies in integrating disaster mitigation content within the SETS framework, thereby extending learning outcomes beyond cognitive achievement toward reflective and applied understanding. The evaluation stage assessed students' disaster preparedness through classroom-based simulations, including response to warning signals, Drop–Cover–Hold On procedures, and evacuation practices.

**Table 8. Student Readiness Test Results**

| School Location | Group Observation Score (SOK) | Individual Assessment Score (SAI) | Preparedness Score | Criteria |
|---|---|---|---|---|
| SMP N 2 Ambulu | 76.77% | 92.06% | 81.34% | Ready |
| MTs Nahdlatul Arifin | 80.63% | 88.06% | 82.85% | Ready |
| **Average Total** | **78.70%** | **90.06%** | **82.10%** | **Ready** |

The preparedness results indicate that the SETS-based interactive e-module contributes not only to improved conceptual understanding but also to enhanced disaster awareness and response behavior. This supports findings by Rohman and Adriyono (2023), who showed that SETS-based learning encourages critical thinking and social awareness. The present study extends this contribution by demonstrating measurable effects on affective and psychomotor domains through simulation-based learning. In terms of novelty, this study differs from previous research such as Pratiwi and Soekamto (2023), which focused primarily on media development without assessing preparedness outcomes. By integrating SETS-based digital learning with disaster preparedness assessment in social studies, this research offers a holistic approach to disaster literacy that bridges cognitive, affective, and behavioral dimensions.

Despite these positive findings, several limitations should be acknowledged. The study did not include a control group, and the measurement of learning outcomes focused on short-term gains rather than long-term retention. In addition, the research scope was limited to two schools, which may affect the generalizability of the findings. Future studies are recommended to employ experimental designs with comparison groups, examine long-term retention effects, and expand implementation across

diverse geographical contexts. The integration of emerging technologies such as augmented reality or virtual simulations may further enhance immersive disaster learning experiences.

## CONCLUSION

This study successfully developed and validated an interactive e-module based on the Science, Environment, Technology, and Society (SETS) approach for disaster mitigation in junior high school social studies learning. The findings confirm that the developed e-module is empirically valid, engaging, and effective in improving students' conceptual understanding of disaster-related issues as well as their preparedness behaviors. The integration of SETS within a digital learning format enables students to connect scientific concepts with environmental conditions, technological responses, and social realities, thereby strengthening disaster literacy in a contextual and meaningful manner. From a theoretical perspective, this research reinforces the relevance of SETS-based learning as an interdisciplinary framework that can be effectively applied beyond science subjects, particularly in social studies oriented toward character education and disaster awareness. Practically, the developed e-module offers an innovative digital learning alternative that aligns with the Merdeka Curriculum's emphasis on contextual, student-centered, and project-based learning. Socially, the implementation of this learning media has the potential to contribute to the development of disaster-resilient students from an early age and to support the Disaster Resilient School program promoted by national disaster management authorities.

Despite these contributions, several limitations should be acknowledged. The study was conducted in a limited number of schools within a specific disaster-prone region, which requires caution in generalizing the findings to broader educational contexts. In addition, the relatively short implementation period did not allow for the examination of long-term retention or sustained changes in students' disaster preparedness attitudes and behaviors. Constraints related to access to digital devices and internet connectivity also affected the optimal use of the interactive features of the e-module. Future research is therefore recommended to expand the scope of implementation across diverse geographical areas with varying disaster risk profiles and to employ experimental or mixed-methods designs to capture cognitive, affective, and social dimensions more comprehensively. Further studies may also explore the integration of advanced technologies such as augmented reality, virtual simulations, or learning analytics to enhance interactivity and long-term learning impact. Through these efforts, SETS-based digital learning innovations can be further refined and scaled to strengthen disaster education and resilience in broader educational settings.

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