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Effectiveness of Discovery Learning with Genially for Improving Students' HOTS Science Literacy on Chemical Bonding

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Abstract: Higher Order Thinking Skills (HOTS) and scientific literacy are important competencies for students in learning chemistry, especially on abstract topics such as chemical bonding. This study aims to determine the effect of the Discovery Learning model assisted by interactive Genially media on students' HOTS scientific literacy skills. The study was conducted on 10th grade students at SMA Negeri 2 Percut Sei Tuan on the topic of chemical bonding. This research employed a quantitative pre-experimental method using a one-group pretest-posttest design. The sample consisted of 30 students selected through random sampling techniques. Data were collected using pre-test and post-test instruments designed to measure students' HOTS scientific literacy skills before and after the implementation of the Discovery Learning model with Genially media. Data analysis included normality tests, paired sample t-tests (right-tail), and N-Gain analysis. The results showed that the average score increased from 34.4 in the pre-test to 59.8 in the post-test. The paired sample t-test produced a significance value of 0.002 ($p < 0.05$), indicating that the treatment had a significant effect on students' HOTS scientific literacy skills. In addition, the N-Gain score of 0.34 indicated a moderate level of improvement. In conclusion, the Discovery Learning model assisted by interactive Genially media is effective in improving students' HOTS scientific literacy skills on chemical bonding.

Keywords: HOTS science literacy; discovery learning model; interactive media genially; chemical bonding.

INTRODUCTION

Education in this era has shifted from conventional education to 21st century education based on the principle of developing competencies in knowledge, skills, and attitudes. The rapid development of technology and information has changed educational perspectives, requiring curriculum adjustments and innovative teaching methods to prepare students for

future challenges. Digital literacy has become an essential competency in 21st century education and remains a major challenge in the educational system (Yusuf, 2023). In the implementation of the Merdeka Curriculum, Higher Order Thinking Skills (HOTS) are considered one of the most important competencies that students must possess (Handayani, 2023). HOTS refers to cognitive abilities related to analyzing, evaluating, and creating, which are closely

related to Bloom's taxonomy at the C4–C6 levels (Pratama et al., 2021). However, students in Indonesia still face difficulties in analyzing and applying concepts to solve problems because most students tend to rely on memorization and have limited ability to apply their knowledge in real situations (Azwar & Jahro, 2023).

Science literacy is the ability to identify scientific questions, formulate conclusions based on evidence, and use scientific knowledge in decision-making related to natural phenomena and human activities. In chemistry learning, students are required to actively construct concepts and understand scientific processes, which are closely related to science literacy skills (Dayelma et al., 2019). Science literacy is also an essential competency in the 21st century because it enables individuals to respond to global issues scientifically (Budianti et al., 2024). Moreover, science literacy is not limited to theoretical understanding but also includes the ability to explain phenomena scientifically and use evidence in making decisions (Budianti et al., 2024). These competencies are strongly connected to critical thinking skills, including focus, reason, inference, situation, clarity, and overview (Djami & Kuswandono, 2020).

The importance of improving science literacy can also be seen from international assessment results. The Organisation for Economic Co-operation and Development (OECD) regularly conducts the Programme for International Student Assessment (PISA) to evaluate students' science literacy. Indonesia has consistently participated in this assessment; however, the results remain below the international average and tend to decline (Asyhari, 2015). During the period of 2000–2018, Indonesia's average science literacy score ranged from 393–396, while the average score of OECD member countries reached 489 (Fuadi, 2020). Several previous studies also reported low science literacy levels among Indonesian students. Sutrisna (2021) found that students' average

science literacy score was only 31.58 and categorized as low. Rahmadani et al. (2022) reported that 66% of students at SMAN 1 Kuripan were classified in the low science literacy category, with an average score of 23.89. Similarly, Zulanwari et al. (2023) found that 46.26% of students had low science literacy abilities. These findings indicate that science literacy remains a major educational problem in Indonesia. Students' skills in discovering chemical concepts must be aligned with their science process skills to achieve the desired learning objectives (Widyaningrum & Agustini, 2021).

One of the causes of low science literacy is the lack of learning activities oriented toward developing HOTS and scientific reasoning. Therefore, innovative learning models and interactive media are needed to support meaningful learning. Yustiqvar et al. (2019) explained that interactive media can become an effective learning resource for students. In addition, Husnah et al. (2019) stated that interactive teaching media supported by text, video, animation, and graphics can improve students' engagement and understanding because students can directly observe and interact with learning materials. The use of interactive media is particularly important in chemistry learning because many chemistry concepts are abstract and difficult for students to visualize.

Chemical bonding is considered one of the most abstract and conceptually challenging topics in chemistry. This material discusses ionic and covalent bonds that cannot be directly observed by students, although the concepts are closely related to daily life, such as ionic bonds in table salt (NaCl) and covalent bonds in sugar. Understanding chemical bonding requires students to connect concepts, analyze relationships between particles, and apply scientific reasoning in solving problems. According to Adytia and Dwiningsih (2018), selecting appropriate learning methods and media can help develop four domains of science literacy: context, knowledge,

competence, and attitudes. Therefore, chemistry learning requires learning approaches that actively involve students in constructing concepts and applying scientific thinking skills. Teachers are considered a major factor in determining learning outcomes and play a crucial role in encouraging students to think and solve problems through various teaching innovations. Teachers' knowledge of Higher Order Thinking Skills (HOTS) and their teaching strategies are key to achieving educational goals (Tambunan, S & Damanik, M., 2024).

Several previous studies have investigated efforts to improve HOTS and science literacy through innovative learning models. Imanda et al. (2024) reported that the discovery learning model with a HOTS orientation could improve students' literacy skills and critical thinking abilities in problem-solving. Similarly, Khairani et al. (2022) found that discovery learning significantly improved students' HOTS because the model encourages students to think critically, creatively, actively, and collaboratively. These studies demonstrate that discovery learning has strong potential to improve students' higher-order thinking skills. However, previous studies mainly focused on the implementation of discovery learning without integrating interactive digital media that can support visualization and engagement in chemistry learning.

The results of interviews with chemistry teachers at SMA Negeri 2 Percut Sei Tuan revealed that literacy activities had been implemented in learning, but they were still not specifically directed toward science literacy development. Teachers commonly used student-centered and teacher-centered learning models supported by PowerPoint presentations, teaching materials, and learning videos. However, these learning media were considered insufficient to improve students' HOTS scientific literacy skills optimally. This condition indicates the need for more innovative learning approaches that integrate interactive media

and student-centered learning models to improve students' scientific reasoning and problem-solving abilities.

Based on the analysis of previous studies and field conditions, there is still a research gap regarding the integration of discovery learning and interactive digital media to improve students' HOTS scientific literacy skills, especially in chemical bonding material. Previous studies generally focused separately on discovery learning, HOTS, science literacy, or interactive media. Few studies have specifically examined the integration of Discovery Learning and Genially interactive media in chemistry learning. Therefore, the novelty of this study lies in integrating the Discovery Learning model with Genially interactive media to improve students' HOTS scientific literacy skills on chemical bonding material.

This study aims to examine the effect of Discovery Learning assisted by Genially interactive media on students' HOTS scientific literacy skills in chemical bonding material among 10th grade students at SMA Negeri 2 Percut Sei Tuan.

LITERATURE REVIEW

Higher Order Thinking Skills (HOTS) are essential competencies that students must possess in 21st century education. HOTS refers to students' ability to analyze, evaluate, and create in solving problems and applying knowledge to various situations (Simaremare & Suyanti, 2024). HOTS science literacy is understood as the ability to use higher-order thinking skills in solving scientific problems and phenomena. In its implementation, HOTS-oriented questions are considered effective in improving students' science literacy skills because they encourage students to think critically and scientifically. HOTS literacy generally covers the cognitive levels of analyzing (C4), evaluating (C5), and creating (C6). These thinking skills are characterized by complex reasoning processes, interpretation, self-regulation, and the ability to construct new meanings. Science literacy itself refers to the understanding of

scientific concepts and processes, including explaining scientific phenomena, evaluating scientific investigations, and interpreting scientific data and evidence.

Science literacy has several indicators that measure students' ability to think scientifically. According to Harahap and Jahro (2025), science literacy includes the ability to identify information and data, utilize information, generate explanatory models, distinguish scientifically investigable questions, formulate hypotheses, make predictions, analyze data, interpret data, and draw conclusions. Based on the PISA 2018 framework, there are three categories of cognitive abilities that students must demonstrate as a measure of their literacy abilities, namely analyzing, evaluating, and interpreting. The analyzing category includes the abilities to use theories, ideas, information, and facts; use standard scientific search procedures; analyze the role and function of scientific assessment; identify and produce explanatory models; make and assess predictions; and formulate hypotheses (Jahro et al., 2024). These indicators show that science literacy is not only related to conceptual understanding but also to scientific reasoning and problem-solving abilities. Therefore, the development of HOTS and science literacy should be integrated into the learning process to prepare students to face scientific and real-world challenges.

One important factor influencing the development of HOTS and science literacy is the learning model used in the classroom. A learning model serves as a framework that guides learning activities, strategies, and techniques in achieving learning objectives (Sri Wahyuni et al., 2024). Learning models also provide opportunities for teachers to design suitable teaching materials and create effective classroom interactions. According to Sinaga (2023), variations in learning models allow teachers to develop learning materials, adapt instruction to students' needs, and conduct trials of innovative learning approaches. Therefore, selecting an appropriate learning model is essential to

support students' active participation and higher-order thinking development.

One learning model that is closely related to HOTS development is Discovery Learning. Discovery Learning is a pedagogical approach that encourages students to actively discover concepts through exploration and investigation. This model emphasizes student-centered learning, where students become active participants while teachers act as facilitators and supervisors (Santiani et al., 2024). The primary purpose of Discovery Learning is to develop students' higher-order thinking skills, learning motivation, and scientific attitudes. According to Syamsyidah et al. (2024), Discovery Learning involves several stages that encourage students to identify problems, formulate hypotheses, collect and analyze data, verify findings, and draw conclusions independently. These learning activities support the development of students' analytical and critical thinking skills.

The Discovery Learning model also provides several advantages in the learning process. Alfitry et al. (2020) explained that Discovery Learning empowers students in their learning process, encourages intuitive thinking, develops students' self-concept, increases confidence through collaboration, and promotes independent and objective thinking. These characteristics indicate that Discovery Learning has strong potential to improve students' HOTS and scientific reasoning skills. However, the effectiveness of this model can be enhanced when supported by appropriate learning media that help students visualize abstract concepts and increase learning engagement.

Learning media play an important role in improving the quality of teaching and learning activities, especially in the digital era. Technological developments have encouraged the use of interactive media to improve learning efficiency and effectiveness. Previous studies have demonstrated the potential of interactive learning models and digital media to improve student engagement

and learning outcomes. Tools that incorporate game elements, can improve students' attention, creativity, and problem-solving skills, transforming passive learning into active participation (Karmina, P & Dewi, R, 2025). Learning media are needed because many learning materials contain abstract and complex concepts that are difficult to understand through conventional explanations alone. Interactive media can simplify difficult concepts and present learning materials in more engaging ways. Therefore, integrating interactive media into learning activities can help students better understand concepts and participate more actively in the learning process.

One interactive platform that has recently gained attention in education is Genially. Genially is a web-based digital platform used to create interactive learning media and creative presentations without requiring advanced programming or design skills. This platform offers various interactive features, including visual elements, animations, audio, video, and interactive activities that can improve students' engagement during learning. Kurniawan et al. (2025) reported that the use of Genially succeeded in increasing students' scores with a percentage of 84.84%, indicating that the platform effectively supports active learning. Similarly, Tueno et al. (2024) found that Genially interactive media effectively improved students' learning outcomes and literacy skills because it presents learning materials in innovative, interesting, and easy-to-understand ways. These findings suggest that Genially has strong potential to support HOTS-oriented and literacy-based learning. Chemistry, as a branch of science, requires the presentation of facts obtained not only based on theory but also on application in the learning process so that students can construct new knowledge (Sitorus, D & Jahro, I, 2024).

In chemistry learning, the use of innovative learning models and interactive media is particularly important because many chemistry concepts are abstract. One of the most challenging topics in chemistry is

chemical bonding. Chemical bonding refers to the attractive forces between atoms that form stable compounds or molecules. The formation of chemical bonds involves interactions between electrons through electron transfer, acceptance, or sharing. Through chemical bonding, atoms combine to form substances with different physical and chemical properties from their constituent elements. In this study, the chemical bonding material focuses on three subtopics: atomic stability, ionic bonds, and covalent bonds. Because these concepts are microscopic and abstract, students often experience difficulties in understanding them. Therefore, chemistry learning requires innovative approaches that actively involve students in constructing concepts and visualizing scientific phenomena. The integration of Discovery Learning and Genially interactive media is expected to support students in understanding chemical bonding concepts while improving their HOTS scientific literacy skills.

METHODS

Research Design

This study used a pre-experimental method with a one-group pretest-posttest design. Pre-experimental research is conducted to determine the effect of a treatment on a single group without a comparison class. In this design, students were given a pretest before the treatment and a posttest after the treatment to determine the improvement in students' HOTS scientific literacy skills after the implementation of the Discovery Learning model assisted by Genially interactive media (William & Hita, 2019). The research design is presented in Table 1.

Table 1. Desain one group pretest-posttest

Pretest	Treatment (X)	Posttest
T ₁	X	T ₂

T₁ represents the pretest administered before treatment, X represents the implementation of the Discovery Learning model assisted by Genially interactive media,

and T_2 represents the posttest administered after treatment.

Population and Sample

This research was conducted at SMA Negeri 2 Percut Sei Tuan. The population of this study consisted of 10th grade students. The sample used in this study was one class consisting of 30 students. The sampling technique used was random sampling.

Research Instrument

The instrument used in this study was an objective test consisting of 15 multiple-choice questions with five answer options, including one correct answer and four distractors. The instrument was designed to measure students' HOTS scientific literacy skills on chemical bonding material. The material covered three subtopics: atomic stability, ionic bonds, and covalent bonds.

Before being used in the research, the instrument was validated by an expert validator from the Chemistry Education Department to assess the suitability of the content, indicators, and language used in the questions. After the expert validation process, the instrument was tested on 30 students of class X at SMA Negeri 2 Percut Sei Tuan who were not included in the research sample. The instrument analysis included validity, difficulty level, discriminating power, and reliability tests. Reliability testing was carried out using Cronbach's Alpha to determine the consistency of the instrument. Questions that met the criteria were selected and used as the research instrument.

Research Procedure

The research procedure consisted of three stages: pretest, treatment, and posttest. Students were first given a pretest to measure their initial HOTS scientific literacy skills, followed by the implementation of the Discovery Learning model assisted by Genially interactive media, and finally a posttest to measure the improvement in their HOTS scientific literacy skills on chemical bonding material.

Research Hypothesis

The research hypotheses are as follows:

H_0 : $X_{\text{posttest}} \leq X_{\text{pretest}}$,
There is no significant improvement in students' HOTS scientific literacy skills on chemical bonding material after the implementation of the Discovery Learning model assisted by Genially interactive media.

H_a : $X_{\text{posttest}} > X_{\text{pretest}}$,
There is a significant improvement in students' HOTS scientific literacy skills on chemical bonding material after the implementation of the Discovery Learning model assisted by Genially interactive media.

Data Analysis Technique

Then, the data obtained from students' answer sheets were analyzed using several statistical tests as follows:

- 1) Normality test
The normality test is used to find out whether the research data has been distributed normally or not. To determine whether the data is normally distributed, the Shapiro-Wilk test is used on a sample of less than 50 with a Significance (Sig.) value of > 0.05 , which states the data is normally distributed.
- 2) Paired t-test, right tail
After it was confirmed that the data used in the study was distributed normally, statistical analysis was carried out using the Paired sample T-test. The paired sample T-test is used to test the average difference between two paired data taken from the same subject, but at different times and conditions. This test is done to find out if there is a significant influence between the condition before and after treatment.
- 3) N-gain test
N-Gain was used to obtain data on the The N-Gain test was used to determine

the effectiveness of the Discovery Learning model assisted by Genially interactive media in improving students' HOTS scientific literacy skills.

RESULT AND DISCUSSION

Research Instrument Data Analysis

The result of the test instrument test were obtained as follows:

1) Validity Test

The validity test was conducted using SPSS version 26.0, where the question item is declared valid if the value r is calculated $> r$ table. The number of students (n) in this data is 30 people from class XII C, so it uses a significance level of 0.05 with r table = 0.349. From the test instrument validation table result, 18 out of 30 questions were declared valid, while the remaining questions were invalid. This validity test was conducted to determine the accuracy of each question item in measuring students' HOTS scientific literacy skills on chemical bonding material, thereby ensuring that the instrument produced accurate and relevant research data.

2) Difficulty Level Test

The difficulty level test was conducted on the 18 valid questions. The results showed that 16 questions had a difficulty index ranging from 0.31 to 0.70, indicating a moderate level of difficulty. These findings suggest that the test instrument was sufficiently appropriate for measuring students' abilities because the questions were neither too easy nor too difficult.

3) Differentiating Power Test

The discriminating power test was conducted on the valid questions using SPSS version 26.0. The results showed that 15 questions had discriminating power ranging from medium to very good, while one question was categorized as low. This

result indicates that most of the question items were able to distinguish students with high and low abilities effectively. Therefore, the instrument was considered suitable for use in the research.

4) Reliability Test

The 15 questions that passed the validity, difficulty level, and discriminating power tests were further tested for reliability using Cronbach's Alpha. The reliability test result showed a Cronbach's Alpha coefficient of 0.79, indicating that the instrument had a high level of reliability because the coefficient was within the range of 0.60–0.80. Thus, the 15 questions were considered reliable and suitable for use as pretest and posttest instruments.

Pretest and Posttest Result

The research data were obtained from the pretest conducted before the learning treatment and the posttest conducted after the implementation of the Discovery Learning model assisted by Genially interactive media. The pretest results showed that the highest score achieved by students was 53.3, the lowest score was 13.3, and the average score was 34.4. These results indicate that students' initial HOTS scientific literacy skills on chemical bonding material were still relatively low before the treatment was implemented.

This condition indicates that many students still experience difficulties in connecting scientific concepts with real-life contexts, interpreting data, and applying scientific knowledge in problem-solving activities (Tillah & Subekti, 2025).

After the learning treatment, the posttest results showed improvement in students' scores. The highest posttest score reached 80, the lowest score was 33.3, and the average score increased to 59.8. The increase in both the highest and lowest scores indicates that the learning process had a positive impact

on students' understanding of chemical bonding concepts and their HOTS scientific literacy skills. Although the average posttest score was still below the minimum mastery criterion (KKM), the improvement from the pretest score demonstrates that students experienced better conceptual understanding after participating in the learning process. This improvement indicates that the Discovery Learning model assisted by Genially interactive media was able to support students in analyzing scientific information, interpreting problems, and connecting chemical bonding concepts with real-life contexts.

Interactive media such as Genially help students visualize abstract concepts and support more meaningful learning processes, especially in chemistry learning that involves microscopic representations (Tampubolon et al., 2025).

Data Analysis Results

After obtaining the results of the pre-test and post-test, the data is then analyzed to determine the influence of the treatment and learning that has been carried out.

1) Normality Test

To determine whether the data is normally distributed, the Shapiro-Wilk test is used on a sample of less than 50 with a Significance (Sig.) value of > 0.05 , which states the data is normally distributed. The results of this research data test can be seen through the following table.

Table 2. Normality Test Result

Treatment	Shapiro-Wilk (Sig.)	Information
Pre-Test	0.07	Normal
Post-Test	0.19	Normal

Based on Table 2, the significance values of the pretest and posttest were 0.07 and 0.19, respectively. Since both values were greater than 0.05, the data were normally distributed and met the

requirements for further statistical analysis using the paired sample t-test.

2) Paired Sample T-Test, right tail

The paired sample t-test was conducted to determine whether there was a significant difference between students' pretest and posttest scores after the implementation of the Discovery Learning model assisted by Genially interactive media. The test was conducted at a significance level of 0.05. The results are presented in Table 3.

Table 3. Paired Sample T-test Result

Treatment	Sig. (2-tailed)	Information
Pre-Test & Post-Test	0.002	there is a significant difference

Based on the table above, the results obtained using SPSS version 26.0 with a significance level of 0.05, show that the sig. value for pre-test and post-test is 0.002. This states that in the paired sample T-test, there is a significant difference between pre-test and post-test, which means that there is an influence on the application of the discovery learning model with interactive media Genially to Student's HOTS Literacy Science Skills.

Based on Table 3, the significance value obtained was 0.002, which was lower than 0.05. Therefore, H_0 was rejected and H_a was accepted, indicating a significant difference between the pretest and posttest scores. These findings demonstrate that the implementation of the Discovery Learning model assisted by Genially interactive media significantly improved students' HOTS scientific literacy skills on chemical bonding material.

The average pretest score was 34.4, while the average posttest score increased to 59.8 with a total sample of 30 students. The average score difference between the pretest and

posttest was 25.4. In addition, the t-calculated value was 7.99, which was greater than the t-table value of 1.699 at a significance level of 0.05 with a degree of freedom of 29. These results further confirm that students' posttest scores were significantly higher than their pretest scores after the treatment. The improvement in students' HOTS scientific literacy skills is consistent with the characteristics of the Discovery Learning model, which encourages students to actively identify problems, analyze information, and draw conclusions independently. The use of Genially interactive media also contributed to students' engagement because the learning materials were presented through visual and interactive features that supported students in understanding abstract chemical bonding concepts. These findings are in line with the studies of Khairani et al. (2022), which reported that Discovery Learning can improve students' HOTS, and Tueno et al. (2024), which found that Genially interactive media effectively improves literacy skills and learning engagement.

3) N-Gain Test

This test uses a comparison between the pre-test and post-test gain scores of the class with the maximum achievable gain. The results of the N-Gain test can be seen in the following table 5.

Table 4. N-Gain Test Result

Average		
Pre-Test	Post-Test	N-Gain Score
34.4	59.8	0.34
34.4	59.8	0.34

Based on Table 4, the N-Gain score obtained was 0.34, which falls into the medium category. This result indicates that the implementation of the Discovery Learning model assisted by Genially interactive media had a moderate effect on improving students' HOTS scientific literacy skills. Similar findings were reported by Maulana et al. (2024), who found that Discovery Learning effectively improves students' scientific literacy skills through active problem-solving and concept exploration.

The improvement achieved by students was not fully optimal because several limitations were encountered during the learning process. One of the main factors was the limited learning time, which reduced students' opportunities to explore problems and discuss concepts more deeply. In addition, some students tended to answer questions without carefully analyzing the stimulus and context provided, which affected their posttest performance. Furthermore, chemical bonding is considered an abstract topic that requires strong conceptual understanding and visualization skills, making it challenging for some students to fully master the material within a limited instructional period.

Despite these limitations, the learning process showed positive outcomes in terms of students' participation and scientific reasoning abilities. Students became more actively involved in identifying problems, interpreting scientific information, and discussing solutions during the learning activities. The average N-Gain result indicates that the Discovery Learning model assisted by Genially interactive media was able to gradually improve students' HOTS scientific literacy skills, particularly in analyzing and interpreting chemical bonding concepts. These findings support previous studies showing that student-centered learning models combined with interactive digital media can enhance higher-order thinking skills and scientific literacy development.

However, the improvement in students' HOTS scientific literacy skills was still not fully optimal, as indicated by the medium category of the N-Gain score. Several factors may have influenced these results, including limited instructional time, differences in students' initial abilities, and students' unfamiliarity with HOTS-based scientific literacy questions. In addition, chemical bonding is considered an abstract chemistry topic that requires strong conceptual understanding and visualization skills. As a result, some students still experienced difficulties in analyzing scientific information and applying concepts to problem-solving situations. These findings indicate that the development of HOTS scientific literacy skills requires continuous practice, consistent learning habituation, and longer instructional duration to achieve more optimal learning outcomes.

CONCLUSION

The results of this study showed that the implementation of the Discovery Learning model assisted by Genially interactive media significantly improved students' HOTS scientific literacy skills on chemical bonding material. This was indicated by the increase in the average pretest score from 34.4 to 59.8 in the posttest, supported by a significance value of 0.002 (< 0.05) and an N-Gain score of 0.34 in the moderate category. These findings indicate that Discovery Learning assisted by interactive digital media can support students' higher-order thinking skills and scientific literacy, especially in understanding abstract chemistry concepts.

However, the improvement achieved was still not fully optimal due to limited instructional time and students' unfamiliarity with HOTS-based scientific literacy questions. Therefore, further research is recommended to apply this learning model over a longer learning duration and in broader chemistry materials to obtain more optimal results.

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