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# The development of PISA-like mathematics problem using Lombok Island contexts

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**Abstract**
The results of the PISA test for mathematical literacy in 2000–2018 and several previous studies show that students' critical thinking abilities in Indonesia are still relatively low. One of the reasons why students' critical thinking skills in Indonesia are low is because PISA-like problems have not been integrated evenly into mathematics learning. The aim of this research is to obtain a prototype of PISA-like mathematics problems in the context of Lombok Island that are oriented towards critical thinking skills that are valid, according to experts. This research is design research, which consists of 3 stages, namely analysis, design, and evaluation. The PISA-like problem that has been developed consists of twelve questions about space and shape, uncertainty, and data. Each set of questions consists of levels 1 to 6. Lombok Island contexts contained in the questions are Mount Rinjani, woven cloth with Subahnale and Alang motifs, the game of Dengkleng (Engklek), Gendang Beleq, and the Limbungan traditional house. At the evaluation stage, the validity of the development product is assessed by experts. The instrument used is a PISA-like problem validation sheet. The results of this research obtained a prototype of a PISA-like mathematics problem with a valid category, according to experts.

**Keywords:** PISA; mathematics problem; Lombok islands context; critical thinking

**Abstrak**
Hasil tes PISA untuk literasi matematika pada tahun 2000-2018 dan beberapa penelitian terdahulu menunjukkan bahwa kemampuan berpikir kritis siswa di Indonesia masih tergolong rendah. Rendahnya kemampuan berpikir kritis siswa di Indonesia salah satunya disebabkan karena soal-soal sejenis PISA belum terintegrasi secara merata dalam pembelajaran matematika. Salah satu aspek penting dalam mengembangkan soal-soal matematika sejenis PISA adalah mempertimbangkan pemecahan masalah dalam berbagai konteks nyata disekitar siswa. Tujuan dari penelitian ini adalah untuk mendapatkan prototype instrumen tes matematika sejenis PISA dengan konteks Pulau Lombok berorientasi pada kemampuan berpikir kritis yang valid menurut ahli. Penelitian ini merupakan penelitian desain (design research) yang terdiri dari 3 tahap, yaitu analisis, desain, dan evaluasi. Pada tahap evaluasi, salah satunya adalah menilai kevalidan produk pengembangan oleh ahli. Instrumen yang digunakan yakni lembar validasi tes matematika sejenis PISA. Hasil penelitian ini diperoleh prototype instrumen tes matematika sejenis PISA dengan konteks Pulau Lombok berorientasi pada kemampuan berpikir kritis yang berkategori valid.

**Kata Kunci:** PISA; masalah matematika; konteks Pulau Lombok; berpikir kritis

## 1. INTRODUCTION

PISA (Programme for International Student Assessment) is an international program organized by the OECD (Organization of Economic Co-operation and Development). One of the skills required to work on these PISA tests is critical thinking (Effendi et al., 2019; Feriyanto & Putri, 2020; Hasan, 2019; Hobri et al., 2018; Lestari & Putri, 2020). PISA problem-solving calls for a high level of reasoning, thinking, and innovative planning. Since critical and fundamental thinking comes before high-level thinking, understanding and planning demand sufficient thinking abilities from students. A thorough examination of how students think through PISA problems is necessary to reduce errors and encourage critical thinking in the students (Hasan, 2019).

Being a critical thinker is one of the talents needed in the twenty-first century, which is why Indonesia's educational system currently aims to develop critical thinkers (As'ari, 2014; As'ari et al., 2017; Basri et al., 2019; Daso, 2013; Widana et al., 2018). The application of cognitive abilities or techniques that raise the possibility of desired results is known as critical thinking (Halpern, 2003). The term "critical thinking" refers to the kind of purposeful, reasoned, and goal-directed thinking that goes into problem-solving, conclusion-making, consideration-making, and decision-making (Rudd et al., 1999). Critical thinking is oriented to result, rational, logical (Simon & Kaplan, 1993; Stahl & Stahl, 1991), and reflective thinking in order to determine what is believed and acceptable, followed by decision-making and accountability for the decision (Zoller, 1997). Facione describes the ability to think critically into six stages: interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione, 1990).

According to PISA results for mathematical literacy, in 2012, Indonesia ranked 64 out of 65 countries, with an average score of 375 from the OECD country average of 494 (OECD, 2013). In 2015, Indonesia ranked 63rd out of 70 countries, with an average score of 386 out of the OECD country average of 490 (Andari & Ekawati, 2021; Jannah et al., 2019). In 2018, Indonesia ranked 73rd out of 79 countries, with an average score of 379 from the OECD country average of 487 (OECD, 2019). The results of the PISA test show that critical thinking ability of students in Indonesia is still low. In addition to the PISA results, some studies also show that students' ability to think critically in solving mathematical problems is still low (Adharini & Herman, 2020; Afriansyah et al., 2021; As'ari et al., 2017; Basri et al., 2019; Widana et al., 2018).

One of the reasons for the poor critical thinking ability of Indonesian students is because PISA-like mathematics problems have not been integrated evenly into mathematics learning (Andari & Ekawati, 2021; Dasaprawira et al., 2019; Effendi et al., 2019; Jannah et al., 2019; Lestari & Putri, 2020; Nizar et al., 2018; Permatasari et al., 2018; Pratiwi et al., 2019; Yansen et al., 2019). Most students are accustomed to solving mathematical

questions whose level of thinking is limited to knowledge and application (Nusantara et al., 2021; Zulkardi et al., 2020), such as memorizing formulas, calculating, or simply applying simple concepts (Widana et al., 2018). The development of evaluation tests using mathematical questions like PISA that are oriented towards critical thinking skills is also needed.

The research by Wulandari et al. (Wulandari et al., 2023) indicates that teaching mathematical literacy to students is difficult for 78% of teachers. Math literacy is one of the topics examined by the PISA. In addition, the teachers report that the mathematical disciplines that students struggle with the most are geometry, measurement, data, uncertainty, and algebra. Among the mathematics topics assessed by PISA are geometry, data, and uncertainty. Furthermore, the lack of learning materials for related courses has been pointed out by 55% of educators as the reason why students don't master the subject. One important aspect in developing PISA-like mathematics problems is considering problem solving in different contexts (Nusantara et al., 2021; Sáenz, 2009; Stacey, 2011). The local context of Lombok Island has a lot of potential that can be used as a source of reference in creating content about PISA-like mathematics problems. One of them is the local culture of Sasak tribal communities, such as traditional food, customary ceremonies, traditions, traditional musical instruments, traditional customary houses, traditional games, and so on. In previous studies, researchers created a textbook focused on higher-order thinking skills with substantial content on Sasak culture. (Subarinah et al., 2022). Studies have shown that textbooks with local contexts can improve students' high-level thinking skills (Subarinah et al., 2023). Therefore, further, the objective of this research is to develop PISA-like mathematics tests with the Lombok Island context oriented on the ability to think critically.

## 2. METHODS

This research is developmental research consisting of three stages: analysis, design, and evaluation (Akker et al., 2006). The analysis phase consists of materials, curricula used by schools, indicators of critical thinking skills, analysis of the PISA framework through PISA details consisting of content, mathematical content categories, and cognitive competence as well as the context of Lombok Island. From Figure 1, in the final phase, the researchers used formative evaluation designs that included self-evaluation, one-to-one, expert review, small groups, and field trials (Ahyan et al., 2014; Tessmer, 1993).

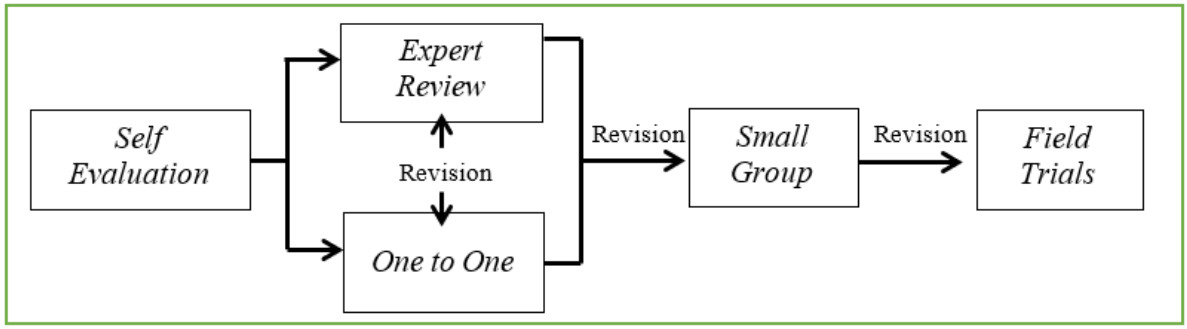



**Figure 1.** Process of Evaluation Designs

In the first year, this research has been carried out to the phases of self-evaluation and expert review. Researchers have developed of PISA-like mathematics test according to the design and validated the test product. The validation process is carried out by providing research instruments in the form of a product validation questionnaire sheet which is equipped with an assessment rubric. The results of the assessment of all these validators serve as a reference for complete information regarding the feasibility of a developed of PISA-like mathematics test. The validation was done by three lecturers of mathematics education. The data of feedback, input, and suggestions for improvement by the expert is analyzed descriptively, while the score obtained from the validator is calculated by its Aiken index to determine the validity of the contents of the instrument with the formula:

$$V = \frac{\sum s}{[n(c-1)]}$$

Description:
$V$ = Aiken validity index
$s$ = $r - l_0$
$r$ = Score given by the validator
$l_0$ = Lowest validity assessment score
$c$ = Highest validity score
$n$ = Number of Validators

After obtaining Aiken validity index scores, the scores will be divided into 5 categories namely highly valid, valid, sufficiently valid, less valid and invalid, which will be determined on the basis of validity indexes in Table 1 below.

**Table 1.** Instruments Validity Category

| Validity Index | Category |
|---|---|
| $0{,}80 \leq V \leq 1$ | Highly valid |
| $0{,}60 \leq V < 0{,}80$ | Valid |
| $0{,}40 \leq V < 0{,}60$ | Sufficiently valid |
| $0{,}20 \leq V < 0{,}40$ | Less valid |
| $0{,}0 \leq V < 0{,}20$ | Invalid |

Source: (Arikunto, 2010)

## 3. RESULTS AND DISCUSSION

### 3.1 Results

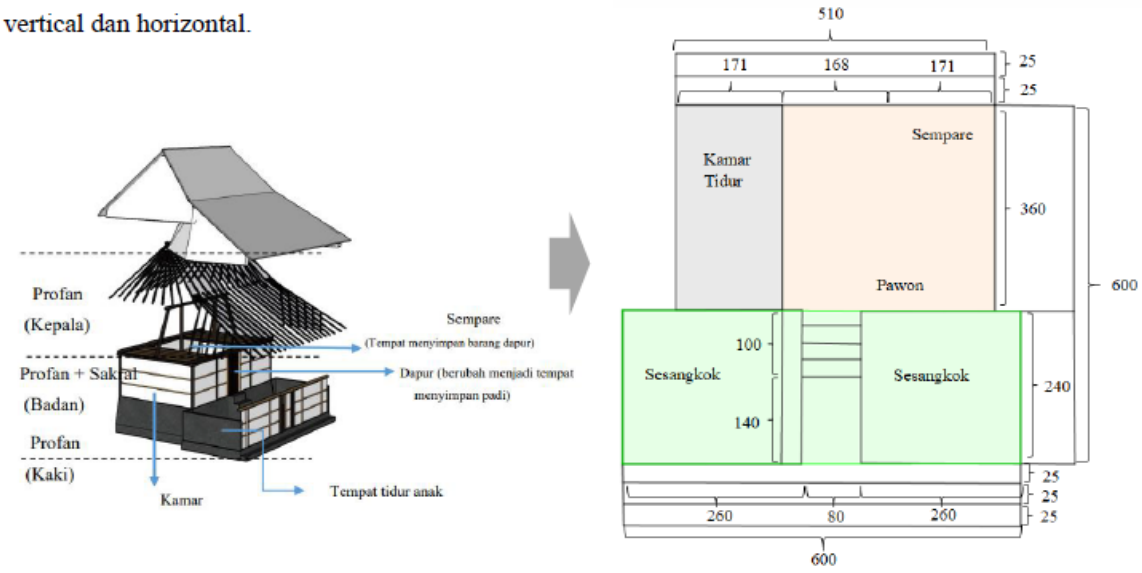
The analysis phase consists of the analysis of development needs regarding PISA tests, the characteristic analysis of the problems used by PISA from 2000 to 2018 (level of mathematical competence, mathematics contents, mathematician context, level of literacy 1 to 6, and the form of the PISA test), the learning access of the Merdeka curriculum level SMP/MTs/Package B, indicators of the process of critical thinking skills, and the context of Lombok Island that will be integrated into the development of PISA tests. In the design phase, two test instruments have been developed, namely, a test instrument with shape and space content and uncertainty and data content. Each test consists of six questions ranging from literacy level 1 to level 6. Each problem on the test developed in this study uses the local context of Lombok Island which is a real-life situation where students live, for example climbing the Rinjani mountain, buying woven cloth with Subahnale and Alang motifs, making clothes designs with pictures of tribal dresses of Sasak, playing Dengkleng (Engklek), craftsmen of traditional musical instruments of Gendang Beleq, buying traditional cuisine of the Lombok island, and acquainted with building sketches of customary houses of Limbungan or Bale Sasak Limbungan.

Limbungan or Bale Sasak Limbungan is a traditional customary house found in the settlements of Sasak tribes in Dusun Limbongan, Perigi Village, Suela Prefecture, East Lombok District, West Nusa Tenggara. These indigenous houses are characterized by the use of materials that come from nature. The construction used wood on the pillar part, walls with bamboo embroidery, and roofing for the roof (Wahyudi et al., 2022). Figure 2 below is a PISA-like mathematics problem about shape and space with Bale Sasak Limbungan context that has been developed.

**Bale Adat Limbungan**

Sumber: https://lombok.tribunnews.com/2022/09/17/wisata-lombok-uniknya-rumah-adat-limbungan-di-lombok-timur?page=all

Rumah adat Limbungan atau Bale Sasak Limbungan adalah rumah adat tradisional yang terdapat pada permukiman Suku Sasak di Dusun Limbungan, Desa Perigi, Kecamatan Suela, Kabupaten Lombok Timur, Nusa Tenggara Barat. Rumah adat ini dicirikan dengan penggunaan bahan-bahan yang bersumber dari alam. Konstruksinya menggunakan kayu pada bagian tiang, dinding dengan anyaman bambu, dan alang-alang sebagai atap. Gambar berikut ini menunjukkan sketsa rumah dari tampak vertical dan horizontal.




Tampak Vertikal Tampak Horizontal

Tentukan luas area dari Bale Adat Limbungan tersebut. Tuliskan jawabanmu di lembar jawaban!

**Figure 2.** PISA-like mathematics problem about shape and space with Bale Sasak Limbungan context

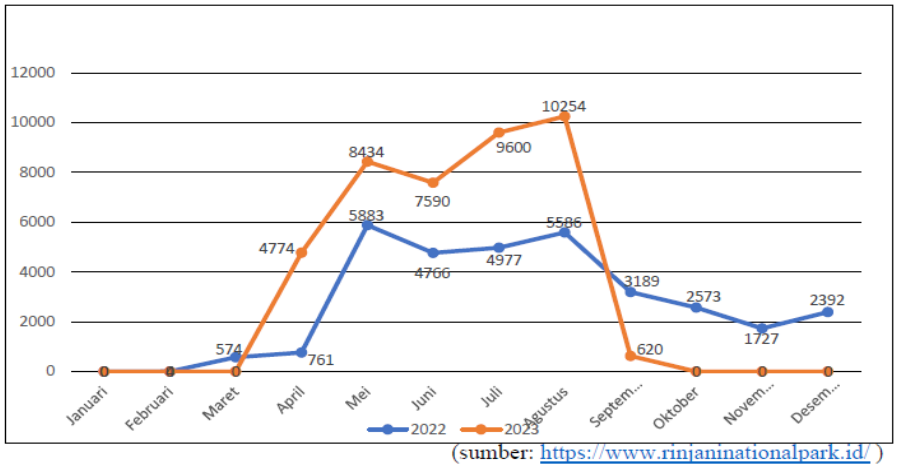
Mount Rinjani is a mountain located on Lombok Island, West Nusa Tenggara. It is the second highest volcano in Indonesia with an altitude of 3726 above sea level and is located at latitudes 8°25' LS and 116°28' BT. It is part of Mount Rinjani National Park which covers an area of about 41330 ha. Figure 3 below is PISA-like mathematics problem about content uncertainty and data with the context of Mount Rinjani that has been developed.

**Pendaki Gunung Rinjani**

Gunung Rinjani adalah gunung yang berlokasi di Pulau Lombok, Nusa Tenggara Barat. Gunung ini merupakan gunung berapi kedua tertinggi di Indonesia dengan ketinggian 3.726 mdpl serta terletak pada lintang 8°25' LS dan 116°28' BT. Gunung ini merupakan bagian dari Taman Nasional Gunung Rinjani yang memiliki luas sekitar 41.330 ha. (sumber: https://id.wikipedia.org/wiki/Gunung_Rinjani )

(sumber: https://id.wikipedia.org/wiki/Gunung_Rinjani )

Selama tahun 2022-2023, pendakian gunung Rinjani dibuka untuk umum mulai Januari sampai dengan Desember. Berikut adalah grafik dari jumlah pendaki gunung Rinjani selama tahun 2022-2023.




(sumber: https://www.rinjaninationalpark.id/ )

1. Berdasarkan grafik diatas, jumlah pendaki terbanyak pada tahun 2022-2023 berada pada bulan?

**Figure 2.** PISA-like mathematics problem about uncertainty and data with Mount Rinjani context

At the evaluation stage, the action taken is to perform self-evaluation and expert validation. As for the quantitative data of expert validations of PISA-like mathematical instruments test are presented in Table 2 below.

**Table 2.** Quantitative Data from Validation Results of PISA-like Mathematical Instruments Test

| Le-vel | Content | Lombok Island Context | Average Validation of Content Components | Average Validation of Construct Components | Average Validation of Language Components | Average | Descrpition |
|---|---|---|---|---|---|---|---|
| **Instrument Test 1** | | | | | | | |
| 1 | *Shape and Space* | Designs of Sasak clothes | 0,875 | 0,867 | 0,771 | 0,838 | Highly valid |
| 2 | *Shape and Space* | The game of Dengkleng (Engklek) | 0,854 | 0,867 | 0,771 | 0,831 | Highly valid |
| 3 | *Shape and Space* | Craftsmen of Gendang Beleq | 0,813 | 0,813 | 0,771 | 0,799 | Valid |
| 4 | *Shape and Space* | Jajanan Tradisional Lombok | 0,771 | 0,813 | 0,729 | 0,771 | Valid |
| 5 | *Shape and Space* | Traditional cuisine of the Lombok island | 0,833 | 0,771 | 0,729 | 0,778 | Valid |
| 6 | *Shape and Space* | Bale Adat Limbungan | 0,813 | 0,771 | 0,750 | 0,778 | Valid |
| **Instrument Test 2** | | | | | | | |
| 1 | *Uncertainty and Data* | Mount Rinjani | 0,792 | 0,792 | 0,750 | 0,778 | Valid |
| 2 | *Uncertainty and Data* | Mount Rinjani | 0,833 | 0,833 | 0,750 | 0,806 | Highly valid |
| 3 | *Uncertainty and Data* | Mount Rinjani | 0,833 | 0,833 | 0,750 | 0,806 | Highly valid |
| 4 | *Uncertainty and Data* | Mount Rinjani | 0,792 | 0,833 | 0,667 | 0,764 | Valid |
| 5 | *Uncertainty and Data* | Woven cloth of Sukarara Village (Subahnale | 0,813 | 0,783 | 0,667 | 0,754 | Valid |

| Le-vel | Content | Lombok Island Context | Average Validation of Content Componen ts | Average Validation of Construct Componen ts | Average Validation of Language Componen ts | Average | Descrpitio n |
|---|---|---|---|---|---|---|---|
| | | and Alang motifs) | | | | | |
| 6 | *Uncertaint y and Data* | Mount Rinjani | 0,813 | 0,800 | 0,813 | 0,808 | Valid |

From Table 2, it can be seen that each problem developed is declared valid based on expert validation. However, there are some suggestions and improvement notes submitted by the validator related to the problem that has been developed. The results can be seen in Table 3 below.

**Table 3.** Qualitative Data from Validation Results of PISA-like Mathematical Instruments

| Validator 1 | Validator 2 | Validator 3 |
|---|---|---|
| **Instrument Test 1** | | |
| 1. There's some typing that needs to be fixed.<br>2. The answer keys to number three and five need to be reviewed.<br>3. Question number four needs to be fixed from the point of view of the object used. The option used to adjust to the volume suspension is liquid objects such as honey and sweet thistle. | 1. There's some typing that needs to be fixed.<br>2. Question number four, "keciput" can be replaced with another cake.<br>3. Question number 5, the term "Buy 1 Get 1 Free" can only be used in Indonesian, in order to be better known. | 1. There's some typing that needs to be fixed.<br>2. Question number four, "keciput" can be replaced with another cake. |
| **Instrument Test 2** | | |
| 1. The answer keys to number one need to be reviewed.<br>2. The choice of answers on number 2 can be made with different ranges to make it easier for students to make estimates.<br>3. Add index to the circle diagram because there are some similar colors. | 1. Question number one to four, the readings given are worth using the previous year compared to the current year.<br>2. The editorial on question number 5 can be corrected to refer to alternative solutions.<br>3. There's some typing that needs to be fixed. | 1. There's some typing that needs to be fixed.<br>2. The editorial on question number 5 can be corrected to refer to alternative solutions. |

| Validator 1 | Validator 2 | Validator 3 |
|---|---|---|
| 4. The editorial on question number 4 can be corrected to refer to alternative solutions.<br>5. On question number 6, the pictures of the numbers on the Torean village line need to be clarified. | | |

Based on the suggestions and input of the validator in Table 3, the instrument was further improved and a prototype 1 was produced. Next, prototypes 1 will be tested in the field on a small and large scale in the second year of the study.

3.2 Discussion

Each test consists of six questions ranging from literacy level 1 to level 6. Each problem on the test developed in this study uses the local context of Lombok Island which is a real-life situation where students live, for example climbing the Rinjani mountain, buying woven cloth with Subahnale and Alang motifs, making clothes designs with pictures of tribal dresses of Sasak, playing Dengkleng (Engklek), craftsmen of traditional musical instruments of Gendang Beleq, buying traditional cuisine of the Lombok island, and acquainted with building sketches of customary houses of Limbungan or Bale Sasak Limbungan. According to Assadi and Hilbi's research, making mathematical concepts relatable to students' surroundings through events, situations, and real-world experiences will give them more credibility and flexibility and aid in their understanding of certain abstract ideas (Assadi & Hibi, 2022). Additionally, since studying will be more enjoyable, engaging, and interactive (Choirudin et al., 2020; Rohmaini et al., 2020), students will be more driven to learn (Zaenuri et al., 2019).

On the problem construction component on the instrument validation sheet, there is an evaluation indicator that contains the statement "the problem developed is capable of giving the student a stimulus to think critically". Based on the evaluation of expert validators, the result was that the average validation score for that indicator in test 1 was 0.764 and for test 2 was 0.736 with each having a valid category. This means that the instrument that has been developed is capable of stimulating students to think critically. Critical thinking is one of the high-level thinking skills, which is consistent with some previous studies that have stated that taking a PISA-like test in a local context has a potential effect on stimulating students' high-level thinking abilities, such as communication (Dasaprawira et al., 2019; Efriani et al., 2019; Nizar et al., 2018; Permatasari et al., 2018; Riya et al., 2019), representation (Dasaprawira et al., 2019; Efriani et al., 2019; Nizar et al., 2018; Permatasari et al., 2018; Pratiwi et al, 2019; Riya

et al., 2019), reasoning (Dasaprawira et al., 2019; Efriani et al., 2019; Pratiwi et al, 2019), and critical thinking (Lestari & Putri, 2020; Usnul et al., 2019). Accordingly, the use of ethnomathematics in developing mathematical teaching materials, including test instruments, can improve students' high-level thinking skills.

## 4. CONCLUSION

The product that has been developed meets valid criteria based on the assessment of three experts. Several aspects such as aspects of language, content, and construct were declared valid. So, it can be said that this PISA-like mathematics tests with the Lombok Island context is appropriate to be used as an alternative assessment to know students' ability to think critically. Based on the findings, discussions, and conclusions that have been announced, further research needs to be done to determine the level of practicality and effectiveness of the product that has been developed.

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