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Research Paper

Understanding the Nature of Science for Elementary School Students in Rural, Suburban, and Urban Areas

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Abstract

Understanding science is an important component of scientific literacy, which is the main goal of science learning. This understanding can improve students' scientific literacy and enable them to achieve quality science learning outcomes. This research examines elementary school students' understandings of the nature of science in three areas: rural, suburban, and urban. This research aims to analyze and describe elementary school students' understanding of the nature of science in three different areas, which have an impact on students' understanding of science processing, and using it in everyday life. The data were collected using quantitative methods with a type of survey research, where data were obtained using a questionnaire distributed to students in the form of Google Forms and analyzed using descriptive analysis. The participants in this research were 5th-grade elementary school students in rural, suburban, and urban areas, totaling 78 students with 26 students in each region. The results of data analysis show that students' understanding of the nature of science in rural, suburban, and urban areas achieved satisfactory results. Students responded quite well to each statement in the questionnaire. Based on these results, it can be concluded that students in these three areas are good at processing knowledge and using it in everyday life. This research occurred in various geographic environments, namely rural, suburban, and urban. This research has a wider scope compared to previous research, which only focused on one area. The sample size in this research is limited, which affects the representativeness of the findings. In addition, the accuracy of a questionnaire depends on the wording, clarity, and reliability of the questions. Measurement errors can affect the quality of the data.

Keywords: *Elementary School Education, Nature of Science, Rural, Suburban, and Urban Areas.*

INTRODUCTION

The nature of science (NoS) refers to an understanding of the nature and characteristics of science. It covers various aspects that form the basis for understanding how science works, how scientific knowledge is obtained, and how scientists operate in society (Lorsbach et al., 2019; Widodo et al., 2019). In addition, NoS includes the values, beliefs, and principles inherent in scientific practice and scientific development. The values, beliefs, and principles inherent in scientific practice and scientific development constitute important elements of the NoS. One of the central values in science is objectivity (Galarosa et al., 2024), which requires scientists to approach research with an attitude free from personal influence or particular interests (Sert Çibik et al., 2024; Sutinah & Widodo, 2020). Honesty and transparency are also key values, and scientists are expected to report research results accurately, without hiding or manipulating data.

Scientists' attention to NoS continues to grow. This is because NoS is the process of how someone acquires knowledge so that they can understand scientific concepts correctly through various systematic stages to produce the desired findings (Lorsbach et al., 2019). NoS refers to the principles and ideas that provide a valid description of science as a way of knowing, as well as the characteristics of the development of scientific knowledge (Ju et al., 2023; Mercado et al., 2015). An understanding of NoS is considered necessary for graduation standards in science education before entering college, so that students can have scientific literacy (Amador-Rodríguez et al., 2021; Oh et al., 2023; Satria & Widodo, 2020). NoS can detail how science and scientists work and how scientific knowledge is created, validated, and influenced (McComas, 2015).

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Learning about NoS is very important because it offers benefits for both teachers and students. Teachers and students will have a good background in science, detailing how science and scientists work and how scientific knowledge is created, validated, and influenced (McComas, 2015); have an accurate view of what science is, including the types of questions science can answer, how science differs from other scientific disciplines, and the strengths and limitations of scientific knowledge (Adi & Widodo, 2018). Based on these opinions, understanding science impacts the ability to work with science and use it in everyday life.

Understanding NoS currently receives less attention and seriousness in the field of education. So far, NoS has not been taught as a material in schools, although NoS is a part of the knowledge that must be taught by teachers, but is often neglected or receives little attention (Adi & Widodo, 2018). Students do not have a proper understanding of NoS. One of the problems is that almost all science textbooks focus on scientific knowledge, while scientific inquiry, scientific thinking, and the social aspects of science are often ignored (Jiang & McComas, 2014). Considering the importance of understanding NoS, it is necessary to conduct research that reveals students' understanding of science in elementary schools through measurement instruments. Through this research, students' understanding of NoS can be revealed because this is an important topic before studying their learning more deeply (Yanuar & Widodo, 2020), especially in rural, suburban, and urban areas, which may differ in learning (Mudavanhu & Zezekwa, 2017).

By conducting such research, educators and policymakers can gain valuable insights into the current state of NoS comprehension among students. This information can highlight specific areas where educational interventions are needed, guiding curriculum development and teaching strategies (Yanuar & Widodo, 2020; Jiang & McComas, 2014). For example, identifying gaps in understanding can lead to the integration of NoS concepts into science curricula more effectively, ensuring that students are not only learning scientific facts but also how science operates as a method of inquiry and its role in society.

Moreover, addressing the disparity in NoS education across geographic areas is crucial. Students in rural areas may have different educational resources and opportunities than those in urban areas (Yanuar & Widodo, 2020). By understanding these differences, tailored educational programs can be developed to support students from various backgrounds, ensuring equitable access to quality science education while fostering a positive and supportive learning environment for children in their growing and learning years (Hermawan et al., 2024).

Ultimately, fostering a deep understanding of NoS among students can contribute to their overall scientific literacy (Lorsbach et al., 2019; Widodo et al., 2019) . This, in turn, empowers students to think critically, make informed decisions, and engage with scientific issues in their daily lives. Additionally, it prepares students for their future academic pursuits and careers in science, technology, engineering, and mathematics (STEM) fields. Therefore, enhancing NoS education is not only an academic goal but also a societal imperative, promoting a scientifically literate populace capable of tackling the challenges of the 21st century.

LITERATURE REVIEW

Nature of Science (NoS) is a science that is used to develop scientific knowledge and is an option for developing science (Annisa & Listiani, 2017). NoS will provide knowledge that science will develop as time and technology develop. Therefore, knowledge is not fixed but can change and be improved over time (Sert Çibik et al., 2024). NoS is knowledge about how science works; thus, it can be concluded that NoS is a science that is used to prove natural phenomena and to understand the process of science as well as how to solve and deal with problems wisely (McComas, 2015; Mccomas et al., 1998).

NoS is a complex concept that includes philosophy, sociology, and the history of knowledge (Lestari & Widodo, 2021). NoS involves a thorough understanding of the nature of scientific science, not only regarding the concepts presented, but also includes all aspects of NoS, such as the empirical nature of science, the creative and imaginative nature, social and cultural influences, and the tentative nature (Tursinawati & Widodo, 2019).

An understanding of NoS is critical in science education because it helps students develop a better understanding of how scientific knowledge is generated and validated (Mccomas, 2017). It also helps them understand the dynamic nature of scientific knowledge and how it is influenced by social and cultural factors (Atakan & Akçay, 2024). Thus, teaching NoS can help improve students' scientific literacy and prepare them to think critically about scientific issues in society (Dani, 2009; Mccomas, 2017). Furthermore, NoS helps in developing positive scientific attitudes, such as openness to new evidence, intellectual humility, and perseverance (Mccomas, 2017; Widodo, 2021). An understanding of NoS also allows students to appreciate the beauty and wonder of nature as well as the contribution of science to improving the quality of human life. Thus, NoS is not just knowledge about science, but also a way to understand and appreciate the world around us (Widodo, 2021; Yanuar & Widodo, 2020).

Many experts divide NoS into several components. However, in essence, science contains several components, such as knowledge, processes, and attitudes, that have certain characteristics (Hacieminoglu, 2014; Widodo, 2021). The relationship between the components and science can be seen in the following Table 1.

Table 1. The relationship between the nature of science from a component point of view and its nature of science

Science Component	Characteristic					
	Tentative	**Subjective**	**Empirical**	**Scientific Method**	**Limitations**	**Social Culture**
Knowledge	√	√	√			√
Process				√	√	
Attitude				√		

Based on this table, science not only contains scientific knowledge but also involves methods to obtain knowledge, or what is called the scientific process. Apart from scientific knowledge and scientific processes, science also contains a third component, namely, scientific attitude, which contains good attitudes that must be present to obtain scientific knowledge. The science component, which contains scientific knowledge, is the product of the work of scientists, which is often referred to as science as a product. The science component, which contains the method of obtaining knowledge, is called science as a process, and the science component, which contains attitudes to obtain knowledge, is called scientific attitude (Kapsala et al., 2022). Product, process, and attitude are one unit, so if you want to study science, you have to study the product, process, and attitude (Widodo et al., 2019).

Based on the table, it can be seen that scientific knowledge has four characteristics: tentative, subjective, empirical, and sociocultural. Meanwhile, the scientific process has the characteristics of the scientific method, and scientific limitations and attitudes have the characteristics of the scientific method. It can be concluded that these six characteristics are at the core of the nature of science (Jumanto & Widodo, 2018; McComas & Nouri, 2016; Rahayu & Widodo, 2019; Tursinawati & Widodo, 2019). Each characteristic of the nature of science has indicators, which in this research were then developed into instruments for collecting data for elementary school students.

These six characteristics form the core of the NoS and serve as a foundation for developing educational instruments that measure students' understanding of the NoS. By incorporating indicators for each characteristic into these instruments, researchers can effectively assess how well elementary school students understand the fundamental aspects of NoS.

The development of these instruments involves creating questions and tasks that reflect each characteristic. For example, questions might ask students to evaluate the tentativeness of scientific claims, recognize the role of empirical evidence, or understand the influence of sociocultural factors on scientific practices. Through these assessments, educators can identify areas where students excel and need additional support, ultimately leading to more targeted and effective science education.

In conclusion, understanding and teaching the core characteristics of NoS are essential for fostering scientific literacy among students (Lorsbach et al., 2019; Widodo et al., 2019). By highlighting the tentative, subjective, empirical, sociocultural, methodological, and attitudinal aspects of science (May et al., 2013). Educators can help students develop a nuanced and robust understanding of how science works, preparing them to engage thoughtfully with scientific issues in their everyday lives and future careers (Songsee & Nuangchalerm, 2022).

RESEARCH METHOD

This research uses quantitative methods with a type of survey research in which data are obtained using a questionnaire distributed to students in the form of Google Forms and analyzed using descriptive statistics. The population in this study was elementary school students from West Java, Indonesia. The sample in this study was 5th-grade elementary school students in rural areas, small towns, and large cities, with 78 students and 26 students in each region. The sample was determined using a purposive sampling technique that was chosen based on certain considerations and objectives (Widodo et al., 2019).

The data collection technique used in this research was a closed questionnaire. The development of this instrument includes three stages. In the first stage, the components constituting the study of the nature of science are selected based on a comprehensive review of the literature from experts. The nature of science literature generally states that science contains components of scientific products (scientific knowledge), scientific processes (scientific methods), and scientific attitudes (Widodo, 2021). Based on the theoretical studies, an instrument was developed with the following aspects and indicators. The instrument is in the form of a closed questionnaire with 47 items in the form of statements with 4 Likert scales.

In the second stage, a trial of the instrument for understanding science was conducted with elementary school students. In this trial, input was obtained by reviewing the content and format of the instrument questionnaire. With content, input on improving the use of language in relation to elementary school students. Regarding instrument format, the input was a closed questionnaire type, which is considered quite easy for respondents to complete.

In the third stage, items are developed and tested. The experts reviewed the question items for content validity and checked their meaning. The development of the question items is tested again so that the score results are obtained, which are then measured, tabulated, and described by the researcher.

Validation of the content of the statement is determined on the basis of expert judgment from experts and colleagues who are conducting similar surveys. In addition, discussions were held with teachers and students regarding minimizing bias when interpreting statements in closed questionnaires. The NoS understanding questionnaire grid can be seen in the following Table 2.

Table 2. NoS comprehension questionnaire

No	Component	Characteristic	Item no	Amount
1	Scientific knowledge	Tentative	1, 2, 3, 4, 5, 6	6
		Subjective	7, 8, 9, 10, 11, 12	6
		Empirical	13, 14, 15, 16, 17, 18, 19	7
		Influenced by social culture	20, 21, 22, 23, 24, 25	6
2	Scientific process	Scientific method	26, 27, 28, 29, 30, 31, 32	7
		Limitations	33, 34, 35, 36, 37, 38, 39	7
3	Scientific attitude	Scientific method	40, 41, 42, 43, 44, 45, 46, 47	8
Amount				47

The data analysis technique in this research goes through three stages: (a) Editing; The researcher ensures that the respondent has filled in all the statements in the questionnaire; (b) Scoring; Data measurement and collection is carried out by giving a score to the respondent's answer to each item, then adding up all the items; (c) Tabulation; Data that has been classified according to its groups is then tabulated into a table. Next, the questionnaire results are calculated by weighting the values according to the criteria. The percentage of criteria for understanding science can be seen in Table 3.

Table 3. Percentage of criteria for understanding science

Percentage	Criteria
84-100	Very good
68-83	Good
52-67	Enough
36-51	Bad
<36	Very good

Source: (Jumanto & Widodo, 2018)

FINDINGS AND DISCUSSION

This type of survey research was conducted using a data collection instrument in the form of a closed questionnaire. The proposed instrument is a result of a literature review on the nature of science. The nature of science among elementary school students in each region has different percentages. Rural areas received a percentage of 64.85 in the “enough” category; suburban areas received a percentage of 67.30 in the “enough” category; and urban areas received a percentage of 66.94 in the “enough” category. Data on the percentage of students’ understanding of the nature of science in rural, suburban, and urban areas can be seen in the following Table 4.

Table 4. Percentage of the nature of understanding science in the three regions

Areas	Percentage (in %)	Category
Rural	64,84	Enough
Suburban	67,30	Enough
Urban	66,94	Enough
Average	**66,36**	**Enough**

Based on the obtained data, even though it is in the same range, there are differences in the percentage of students’ understanding of the nature of science among the three regions. It is

possible that the different characteristics of students from each area could be a factor in gaining the percentage of understanding, although the differences are not significant. Student differences as stated by (Acar et al., 2015): "Besides, high SES students performed better than low SES students on scientific reasoning and NoS test". Besides that, Hacieminoglu (2014) also mentioned several influencing factors: "The possible creation of misconceptions, classroom discipline, lack of teacher experience, and lack of students' prior knowledge might be a problem". Factors such as misconceptions, classroom discipline, lack of teacher experience, and lack of knowledge of students from each school can influence this percentage.

The understanding of the nature of science among students in rural, suburban, and urban areas is similar. This can be seen from the not-too-big percentage difference, which is still in the category. The nature of science helps students understand what science is and how it works. However, it is difficult to incorporate it into teaching materials. This is not only related to curriculum policies, but also teachers' lack of understanding of the nature of science (Jiang & McComas, 2014; Kızkapan et al., 2023). This research also shows that the lack of understanding of the nature of science is caused by the area where students live, which includes economic, social, and cultural factors that influence learning (Kampourakis, 2016; Nandi et al., 2024; Satria & Widodo, 2020).

Students' understanding is influenced by the nature of the essential components of science. Each of the students' overall nature of science was in the category. The percentage of students' understanding of the nature of science in terms of characteristics is presented in Table 5.

Table 5. Percentage of students' understanding of the nature of science in terms of nature

Component	Characteristic	Percentage (in %)			Average	Category
		Rural	Suburban	Urban		
Scientific knowledge	Tentative	62,92	64,47	60,58	**62.66**	**Enough**
	Subjective	61,25	62,62	60,90	**61.59**	**Enough**
	Empirical	68,21	70,14	68,96	**69.10**	**Good**
	Influenced by Social Culture	63,75	65,86	65,71	**65.11**	**Enough**
Scientific process	Scientific Method	66,19	70,63	72,25	**69.69**	**Good**
	Limitations	61,67	61,61	63,74	**62.34**	**Enough**
Scientific attitude	Scientific Method	69,90	75,78	76,44	**74.04**	**Good**

Based on this table, it can be concluded that students who live in rural areas have the highest percentage of scientific method traits in the scientific trait component, with a percentage of 69.90, and the lowest percentage of subjective traits in the scientific knowledge component, with a percentage of 61.25. Meanwhile, students who live in suburban areas have the highest percentage of the nature of the scientific method in the scientific attitude component (75.78) and the lowest like limitations in the scientific process component (61.61). For students who live in urban areas, the highest percentage is found in the scientific method trait in the scientific attitude component, with a percentage of 76.44, and the lowest is in the subjective trait in the scientific knowledge component, with a percentage of 60.90. The abilities of students from the three regions had the highest percentage, namely, the scientific method in the scientific attitude component. The percentage of students' scientific attitudes is greater than the percentage of students' scientific

knowledge and scientific processes. This is possible because the lessons were provided by different teachers. Teachers' understanding of the nature of science has implications for the percentage of students' understanding of the nature of science (Adi & Widodo, 2018; Kinskey, 2023).

Based on the percentage obtained using each region, understanding the nature of science in terms of characteristics can be divided into two categories: enough and good. The characteristics included in the Enough category are: 1) Tentative, with a percentage of 62.66; 2) Subjective, with a percentage of 61.59; 3) Influenced by social culture, with a percentage of 65.11; and 4) Limitations, with a percentage of 62.34. Meanwhile, the characteristics that fall into the Good category are: 1) Empirical, with a percentage of 69.10; 2) Scientific method (in the scientific process), with a percentage of 69.69; and 3) Scientific method (in scientific attitude), with a percentage of 74.04.

A comparison of the percentage of students' understanding of the nature of science in terms of the nature of the scientific component in rural, suburban, and urban areas can be seen in Figure 1.

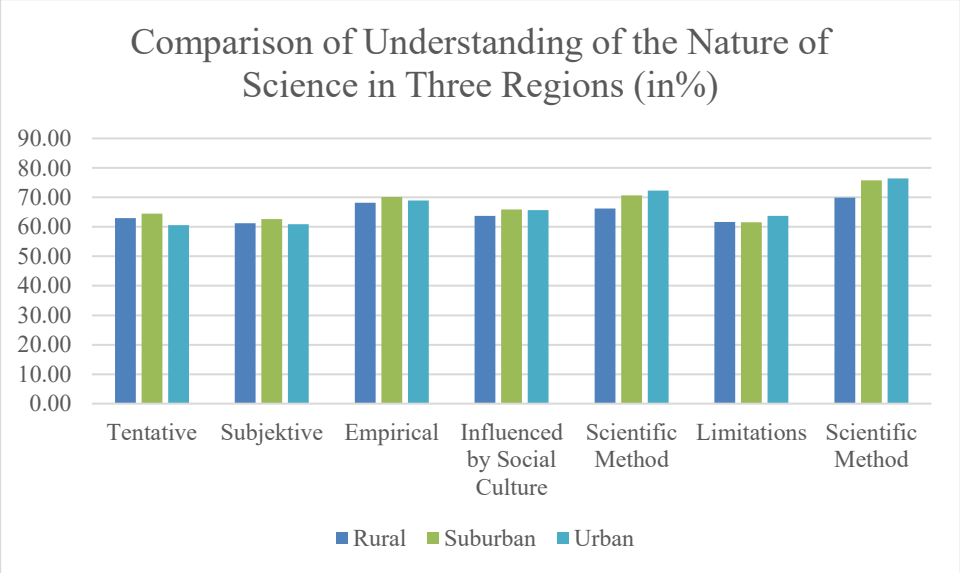

Figure 1. Comparison of the understanding of the essence of science in the three regions

Based on this graph, it can be concluded that the highest percentage of tentative characteristics is owned by the suburban area and the lowest is by the urban area. The highest percentage of subjective characteristics is occupied by the suburban area, and the lowest is the urban area. In terms of empirical characteristics, the highest percentage is occupied by suburban areas and the lowest by rural areas. Then the highest percentage of sociocultural influences was occupied by suburban areas, and the lowest by rural areas. The highest percentage of the scientific method component of the scientific process was in urban areas, and the lowest was in rural areas. In terms of limitations, the highest percentage was occupied by urban areas, and the lowest by suburban areas. Then, the highest percentage of the nature of the scientific method in the scientific attitude component was in urban areas, and the lowest was in rural areas.

Thus, it can be concluded that suburban areas have the highest percentage of scientific knowledge components compared to rural and urban areas. This means that students in suburban areas understand science better than those in rural and urban areas in terms of scientific knowledge. This is because scientific knowledge is a component that is easily understood and taught by teachers (Adi & Widodo, 2018; Mudavanhu & Zezekwa, 2017). Meanwhile, concerning the components of scientific processes and scientific attitudes, urban areas have the highest

percentage compared to rural and suburban areas. This means that students' understanding of the nature of science in terms of the components of scientific processes and attitudes is much better in urban areas than in rural and suburban areas. This is because access to the facilities and infrastructure used for learning in urban areas is easier and more complete.

Learning science in schools, especially elementary schools, certainly requires a certain learning approach that is presented explicitly and contextually. This is as suggested by (Mccomas, 2017) that "Conceptions of NoS are best learned through explicit, reflective instruction as opposed to implicitly through experiences with simply 'doing' science". Correspondingly, (Chaiyabang & Thathong, 2014) stated, "Through interventions it has proven possible for elementary school teachers to develop informed conceptions of the NoS through an explicit reflective approach". The reflective approach suggests that to improve teachers' understanding of the nature of science, the nature of science must be considered as a cognitive learning outcome and must be taught explicitly and not naturally formed during learning activities.

Learning should not only use lectures, but the development can be in the form of historical stories of the acquisition of scientific knowledge by famous scientists, and laboratories can also be a good place to help students see how science works (Anane & Lomotey, 2023; McComas, 2015). Discussions and reflections, experiments, investigations, socio-scientific issues, and the history of science can all be used effectively as contexts to introduce and reinforce the nature of science concepts (Adi & Widodo, 2018). Thus, it is recommended that every school completes facilities and infrastructure to support science learning in both rural, suburban, and urban areas so that students' understanding of the nature of science increases.

Previous studies have shown that contextual and experience-based learning can enhance students' understanding of the nature of science. For example, Abd-El-Khalick and Lederman (2000) emphasized the importance of explicitly incorporating the nature of science in learning so that students can understand how science develops and functions in real life. Additionally, Akerson, Abd-El-Khalick, and Lederman (2000) found that a history-of-science-based approach can help students comprehend the process of scientific discovery and how scientific theories evolve. Furthermore, Clough (2006) demonstrated that using historical scientific stories can make learning more engaging and meaningful for students while also improving their understanding of the epistemological aspects of science. In addition, Duschl and Grandy (2013) highlighted the importance of investigations and experiments in developing students' scientific thinking skills and enhancing their understanding of scientific processes. Therefore, supporting science learning through adequate facilities in rural, suburban, and urban areas is crucial for improving students' comprehension of the nature of science.

CONCLUSION

The nature of science plays an important role in science learning and students' daily lives. The nature of science is an important element in scientific literacy, which is the main goal of science learning. However, so far, this content has never been taught to students because it is not included in the teaching material at schools. The nature of science is very important for students to understand as an aspect that forms the basis for understanding how science works, how scientific knowledge is obtained, and how scientists operate in society.

Based on the results of the research and discussions that have been conducted, it can be concluded that the understanding of the nature of science among students in rural, suburban, and urban areas is almost the same. This can be seen from the not-too-big difference in percentage, which is still in the "Good" category. Increasing and perfecting knowledge is crucial. Even though the nature of science is not explicitly included in the curriculum, students must gain a

comprehensive understanding of the nature of science to be integrated into their learning so that the learning objectives of science learning can be achieved well.

LIMITATION & FURTHER RESEARCH

The study findings are subject to several limitations that could affect their robustness and generalizability. First, the relatively small sample size of 78 students (26 from each geographic area) limits the representativeness of the results. Additionally, the accuracy of the data is contingent on the clarity and reliability of the questionnaire design; any ambiguities or misunderstandings in the questions could lead to measurement errors. Furthermore, although the research spans rural, suburban, and urban areas, it may not capture variations within these regions that could influence outcomes. The reliance on Google Forms for data collection also presents a methodological constraint because it may exclude students without reliable internet access or familiarity with digital tools. Finally, the use of self-reported data introduces potential biases, such as social desirability bias, in which students may provide responses they believe are expected rather than their true thoughts and experiences.

Future research should involve a larger and more diverse sample size to enhance the representativeness and reliability of the findings. Longitudinal studies could offer valuable insights into how elementary school students' understanding of the nature of science evolves in different geographic areas. Complementing the quantitative survey with qualitative methods, such as interviews or focus groups, would provide a deeper understanding of the factors influencing student comprehension. Additionally, exploring regional variations within rural, suburban, and urban areas could reveal more nuanced differences in students' scientific literacy. Evaluating the impact of specific educational interventions aimed at improving students' understanding of the nature of science across different regions is also essential. Furthermore, investigating the role of technological accessibility, particularly in rural areas with limited internet access, could shed light on its influence on scientific literacy. Finally, expanding the research to include cross-cultural comparisons would provide a broader perspective on how different educational systems and cultural contexts affect students' understanding of the nature of science.

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