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INDONESIAN STUDENTS' MATHEMATICAL REPRESENTATION ABILITY ACCORDING TO LEARNING STYLES: SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

The purpose of this research is to explain the outcomes of Indonesian students' mathematical representation ability according to learning styles. The learning styles are visual, auditory, and kinesthetic. A systematic literature review (SLR) is the research methodology employed in this study. This study used data from 18 papers about mathematical representation ability according to learning styles. Publications published in Indonesia between 2015 and 2023 that are indexed by Google Scholar, SINTA, or Scopus form the publishing data. According to the publication year, the media in which it was published, the research methods employed, the subject's educational background, the research location, and the research findings, the description of this study was reviewed. The most research on mathematical representation ability according to learning styles was found to have been published in 2023, according to SLR. The most prominent research media that published the most research were SINTA and Google Scholar. Qualitative methods dominated this study, with junior high school students serving as the majority of research subjects and the island of Java serving as the most prominent research location in Indonesia. Furthermore, it could be stated that one of the elements influencing mathematical representation ability is learning styles.
Keywords: Mathematical Representation Ability, Learning Styles, Systematic Literature Review

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PRELIMINARY

Mathematics is a very important science and has a key role in various aspects of life (Manik et al., 2022). One of the important roles of mathematics is as a problem-solving tool. This is in line with the statement Warsitasari & Rofiki, (2022) that mathematics is a tool or instrument in the problem-solving process to support the progress of science. Difficulties in solving mathematical problems often arise because mathematical concepts tend to be abstract and difficult to relate to real-world situations directly (Islamiati, 2022). Therefore, to make it easier for students to solve abstract mathematical problems, the solution can be a mathematical model to represent the problem. Mathematical models that

are ideas from students in finding solutions to these problems are called representations (Ristiani & Maryati, 2022).

According to Yudhanegara & Lestari, (2015), representation ability is the ability to restate notations, symbols, tables, images, diagrams, equations, or mathematical expressions to other forms. Then, according to Novitasari et al., (2021), mathematical representation ability is a method used by students to express their thoughts on mathematical problems. Thus, mathematical representation ability is an individual's ability to illustrate or communicate mathematical concepts in various visual, symbolic, or verbal forms which include graphs, tables, formulas, diagrams, or mathematical language in expressing ideas to solve mathematical problems.

Based on NCTM (2000) to, mathematical representation ability is among essential aspects of the five standards of the mathematics learning process that must be mastered by students. Mastery of mathematical representation skills is very important because this ability allows students to find and develop ways of thinking in conveying mathematical ideas that are abstract to concrete, with the aim of being easier to understand (Lette & Manoy, 2019). This is in line with the statement that mathematical representation skills are closely related to communication and problem-solving skills (Suningsih & Istiani, 2021). Thus, mathematical representation ability is important for students to assist in expressing mathematical ideas to solve mathematical problems.

One of the factors that can affect students' mathematical representation ability is learning style (Nurhayati & Subekti, 2017). According to Porter et al., (2015), learning style is a combination of how a person absorbs organizes, and processes information which is divided into three types, namely visual learning style (accessing visual images that are created and remembered), auditory learning style (accessing types of music and words), and kinesthetic learning style (receiving motion and emotions). Therefore, not all students have the same learning style. So, it is important for teachers to pay more attention to their students' learning styles in order to find and adjust their teaching methods.

The results of research on representation ability according to learning styles are divided into two different groups. The findings of studies carried out by Silitonga (2020) stated that there was no significant difference in mathematical representation ability between students who had auditory, visual, and kinesthetic learning styles. However, there is a difference with the results of research conducted by Natonis et al., (2022) which states that students' representation abilities vary based on learning styles. The results of this study are in line with the results of research conducted by Wasqita & Sukoriyanto, (2023) which

also states that there are differences in students' representation abilities according to learning styles. Thus, it is known that there is a gap in the results of these studies. Therefore, it needs to be a concern and further research to fill the gap.

Based on the gaps identified from the results of these studies, according to Verina & Juandi, (2022), there are clearly several other gaps that should be of concern and further research, although many studies have been conducted on students' mathematical representation abilities according to learning styles in various schools, subjects, and different locations. Therefore, The author intends to analyze students' mathematical representation ability according to their learning styles using the Systematic Literature Review (SLR) method. Researchers utilize the systematic literature review process to find, analyze, assess, and interpret all of the literature that is accessible on a certain phenomenon of interest, with unquestionably pertinent research questions (Triandini et al., 2019). We can determine areas of the gap that require further investigation and get an idea of the scope and depth of the current body of work by studying the pertinent literature.

This study aims to convey the findings of research on mathematical representation ability according to learning style. The publication year, journal index, research methodology, level of education, research location, and search results all play a role in describing this study. Data on students' mathematical representation ability according to learning styles were gathered in the form of research findings. Using the study data that has been acquired, researchers ask questions that are relevant in the following contain: How is the relationship between the description of research findings and students' mathematical representation ability according to learning styles in terms of several categories, namely: publication year, publication media, research methods used, level of education, research location, and research.

METHODS

This research uses the Systematic Literature Review (SLR) method with a qualitative approach. SLR is a method used to combine scientific evidence with the aim of providing comprehensive answers to specific research questions (Lame, 2019). The study's data are secondary data derived from primary research on mathematical representation ability according to learning style.

The SLR research processes are used in this study by Juandi (2021), namely data collection, data analysis, and conclusion. Data were collected from the Google Scholar

database using the Publish or Perish software to find publications related to the topics discussed in this study.

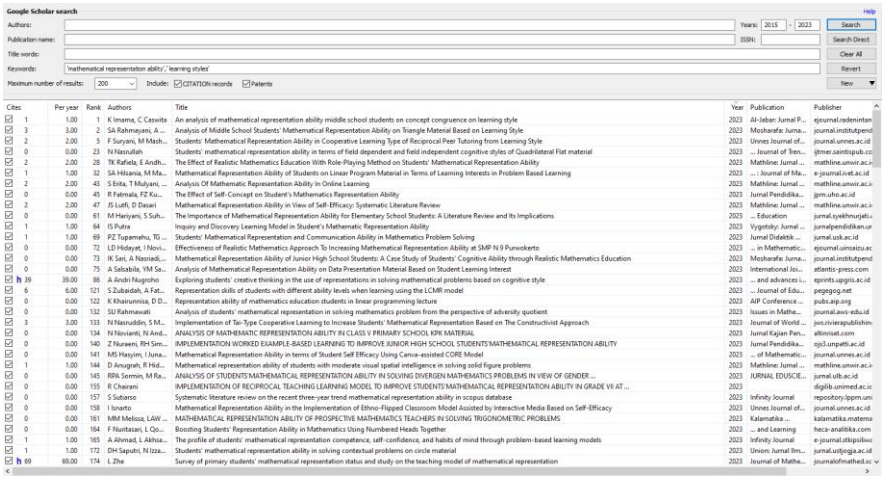

Figure 1. Search Results for Publications With Publish or Perish Software

After collecting the data, the sorting was applied to obtain relevant articles to be analyzed in this research. Based on the search results, 51 papers associated with mathematical representation ability according to learning style were obtained.

After data collection, every article has been extracted, and only those that satisfied the inclusion criteria were chosen for further analysis. The study's criteria were:

1. Mathematics education research.
2. Scopus or SINTA or Google Scholar-indexed journals.
3. Published in 2015-2023.
4. Research location in Indonesia.

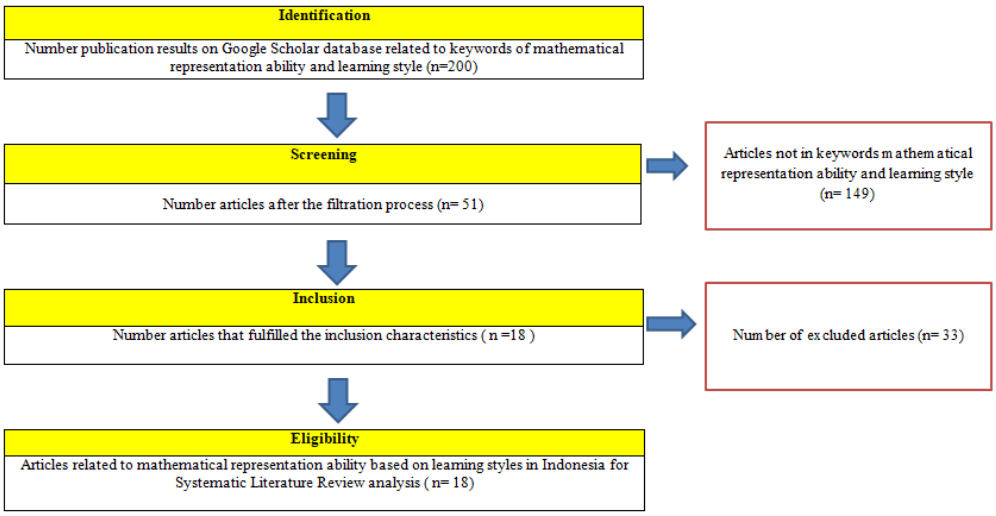

Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Diagram

Eighteen published articles were chosen as samples according to the predefined inclusion criteria. This study included an analysis of these articles. Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

RESULT AND DISCUSSION

The present study presents the findings from an analysis of studies pertaining to the ability of mathematical representation according to learning style. By applying the inclusion criteria for all relevant studies found, the studies were categorized based of year of publication, publication media, research method, education level of research subjects, research location, and research results presented in Table 1 below.

Table 1. Data Analysis Results

Category	Variations	Quantity
Publication Year	2015	1
	2016	0
	2017	0
	2018	0
	2019	1
	2020	3
	2021	1
	2022	5
	2023	7
Publication Media	Scopus	1
	Sinta 1	0
	Sinta 2	2
	Sinta 3	3
	Sinta 4	6
	Sinta 5	0
	Sinta 6	0

Category	Variations	Quantity
Research Method	Google Scholar	6
	Kualitatif	16
	Kuantitatif	0
	Campuran	2
Education Level of Research Subjects	Elementary School	0
	Junior High School	11
	Senior High School	4
	Vocational High School	2
	University	1
Research Location	Sumatera	2
	Java	10
	Kalimantan	1
	NTT	1
	NTB	4

Review by Publication Year

Based on the inclusion criteria, 18 publications were obtained that have been filtered and considered relevant for analysis. From the data, it is known that the number of publications each year has increased and decreased, as shown in Figure 3 below.

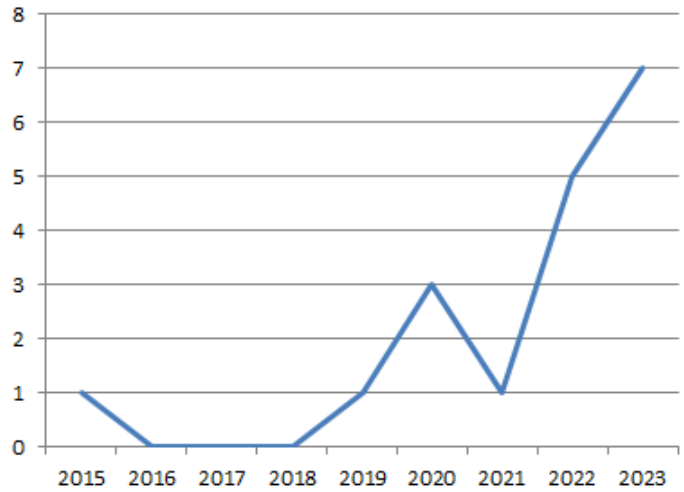

Figure 3. Review by Publication Year

It is evident from Figure 3 that studies on mathematical representation ability according to learning styles began in 2015. The year 2015 became the year limit in this study because publications before 2015 were publications in university repositories while the articles analyzed in this study were articles published in Scopus SINTA or Google Scholar indexed journals according to the inclusion criteria. Study on mathematical representation ability according to learning styles conducted in 2015 was research conducted by Sinaga and Hartoyo (2015). The study provides an explanation of mathematical representation ability in terms of visual, auditory, and kinesthetic learning styles on quadratic function material in one of the high schools in Pontianak. There were

no studies on mathematical representation ability based on learning styles before 2014 based on searches on Google Scholar and Publish or Perish that fulfilled the inclusion characteristics, so these studies were not included in this analysis.

Additionally, Figure 3 indicates that the highest number of publications occurred in 2023 as many as 7 publications in the period January to October 2023. Research on mathematical representation ability according to learning styles is done a lot in 2023 due to the ability of mathematical representation being one of the objectives of mathematics learning in the merdeka curriculum as stated in the decree of the head of BSKAP 2022 No. 33 of 2022. Then, to find out the right techniques and strategies for learning mathematics to achieve good students' mathematical representation skills, teachers need to know students' learning styles. This is because the tendency of learning styles is different for each student, depending on the internal and external aspects of each student and the appropriate learning style can improve student learning outcomes (Natonis et al., 2022).

Review by Publication Media

Considering the inclusion criteria, the study obtained articles published in journals indexed by SINTA or Google Scholar. For articles published on SINTA and Google Scholar simultaneously, they are categorized into SINTA-indexed journals. Thus, 18 publications were obtained that have been filtered and considered relevant for analysis. as presented in Figure 4 below.

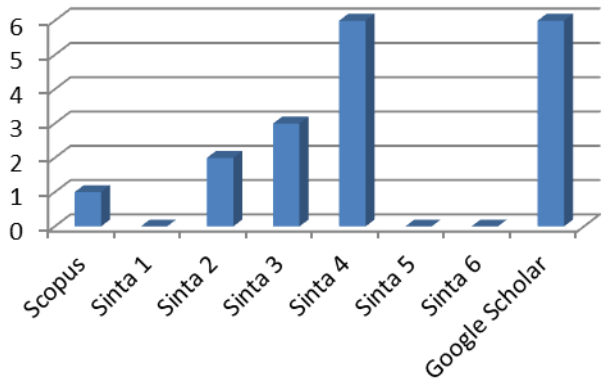

Figure 4. Review by Publication Media

Based on Figure 4, It seems that research on mathematical representation ability according to learning styles is published in SINTA 4 and Google Scholar-indexed journals as many as 6 articles each. Research on mathematical representation ability based on learning styles published in SINTA 4 indexed journals was published in 2020, 2022, and 2023. Meanwhile, research on mathematical representation ability based on learning styles

published in Google Scholar indexed journals was published in 2015, 2020, 2022, and 2023. Then, no research has been published in journals indexed by SINTA 1. However, there is 1 research published in Scopus-indexed journals. The absence of publications on mathematical representation ability according to learning styles in SINTA 1 indexed journals and the lack of publications in SINTA 2 and SINTA 3 can be a chance for upcoming scholars to publish their work in journals with SINTA 1 index (Rum & Juandi, 2022).

Review by Research Method

The articles analyzed in this research were restricted to articles with qualitative, quantitative, and mixed research methods. The following decryption of research studies based on the research methods used is shown in Figure 5.

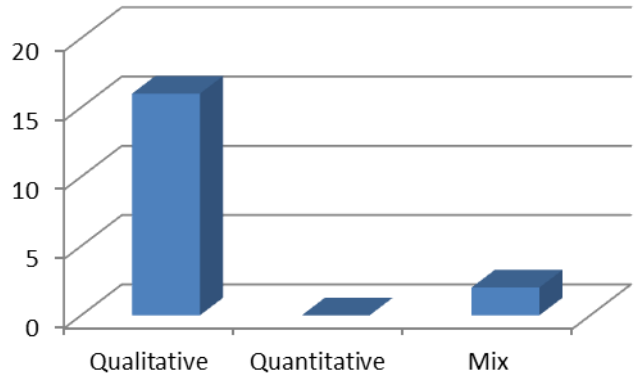

Figure 5. Review by Research Methods

Considering Figure 5, It is recognized that the qualitative research method is the most widely used research method for studies on mathematical representation ability according to learning style with a total of 16 studies. Qualitative methods lead to more holistic phenomenon research (Fraenkel & Wallen, 2012). Thus, through this method can understand the relationship and investigate the complexity between mathematical representation ability and learning style. Then, researchers frequently employ qualitative approaches because they allow them to examine pupils in their natural states. (Sugiyono, 2015). This can help researchers find out the factors that cause the learning style tendencies of a student and how the learning style affects mathematical representation ability. This is in line with Fadli's statement (2021) that research with qualitative methods is carried out in accordance with the natural conditions of students without any treatment.

The use of quantitative methods in the articles analyzed in this study was not found. This is because research on mathematical representation ability according to learning styles

has a complexity that is difficult to measure with quantitative precision. This is in line with the statement that quantitative problems more generally have a large area, and a complex level of variation but are located on the surface (Bungin, 2001). In addition, in the study of mathematical representation ability according to learning style, there are variables that cannot be controlled such as social interaction between peers. These variables that are difficult to control are not suitable when using quantitative methods because quantitative methods have difficulty in controlling other variables that can affect the research process (Rukminingsih et al., 2020).

Review by The Education Level of Research Subjects

The education level of the subjects in the articles associated with mathematical representation ability according to learning styles analyzed in this study is shown in Figure 6, below.

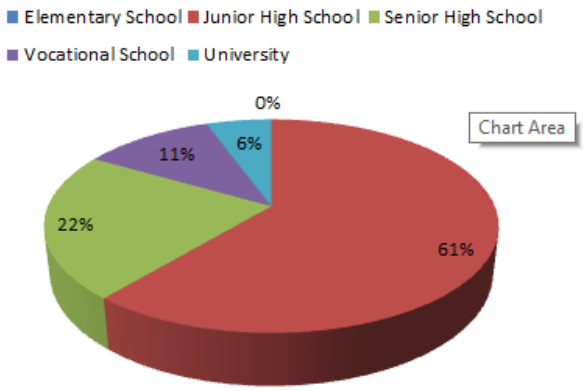

Figure 6. Review by Education Level of Research Subjects

Figure 6 illustrates that many studies on representation ability according to learning styles were conducted on subjects with a junior high school education level of 61%. This is possible because junior high school students need to master mathematical representation skills to use these skills in mathematical material that is starting to be abstract. This is reinforced by the NCTM (2000) statement which states that middle-grade students begin to create and use mathematical representations for more abstract objects as the main medium for expressing and understanding more abstract mathematical concepts. Based on this statement, it can also be seen that high school students need to master mathematical representation skills so that after junior high school students, high school students are the second most research subjects at 22%. Thus, many studies were conducted at the junior and senior high school levels to find out the description of the relationship between mathematical representation skills and the tendency of different learning styles of students. In addition, many studies on mathematical representation ability according to learning

styles were conducted at the junior and senior high school levels because many studies were conducted by mathematics education graduate students so the subjects in the study were junior and senior high school students.

Considering Figure 6, it is also known that studies pertaining to mathematical representation ability according to learning style has not been conducted on subjects with elementary school education levels. Hamilton & Ghatala (1994), stated that children aged 7 years to 12 years who are at the concrete operational stage of development based on Piaget's developmental stages use concrete thinking in solving problems. Thus, mathematical representation ability has an important role for elementary school students in solving mathematical problems. Therefore, future researchers can explore the relationship between mathematical representation ability and learning style with the subject's education level being elementary school.

Review by Research Location

The articles analyzed in this study are limited by inclusion criteria, namely studies on mathematical representation ability according to learning styles conducted in Indonesia. The following Figure 6 describes the research locations of the articles analyzed in this study.

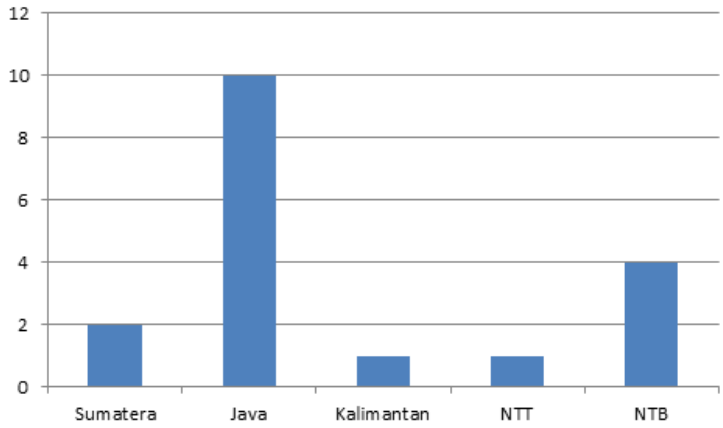

Figure 7. Review by Research Location

Considering Figure 7, it is known that Java is the location of the most studies pertaining to articles on mathematical representation ability according to learning styles analyzed in this study. The number of these articles is 10 articles. This may be due to the high population density and great social diversity in Java. This is in accordance with the statement that Java is the most dominant research location because half of Indonesia's total population is in Java (Khairunnisa et al., 2022). Then, some mathematical ability research using the Systematic Literature Review (SLR) method conducted by (Septian & Juandi,

2023; Verina & Juandi, 2022) also found Java as the most research location. In addition, the factor that allows Java to be the dominant research location is that there are academic and research centers in several cities, namely Jakarta, Bandung, Yogyakarta, and Surabaya.

Review by Research Results

Based on the 18 publications analyzed in this study, it is known that there are 2 groups of research results on mathematical representation ability according to different learning styles. The first group states that there are differences in mathematical representation ability between students who have auditorial, visual, and kin ematical representation skills in each learning style tendency. This is in line with the statement that in an effort to optimally improve mathematical representation skills with different student learning styles, it is necessary to use an appropriate learning model (Ristiani & Maryati, 2022) esthetic learning styles. On the other hand, the results of research conducted by Silitonga (2020) showed no significant difference in mathematical representation ability between students who have auditory, visual, and kinesthetic learning styles. This is because one of the junior high schools in Bandung City chosen by Silitonga as the research location is a school whose teachers when teaching mathematics tend to be the same in facilitating students according to their learning styles. Thus, if teachers are able to facilitate different learning styles of students, it can have an impact on improving math.

The first group that states that variations exist in mathematical representation abilities between students who have auditorial, visual, and kinesthetic learning styles is 17 publications other than Silitonga (2020). These publications are in accordance with the statement that one of the factors that can affect students' mathematical representation ability is learning style (Nurhayati & Subekti, 2017). The difference in publications can be caused by the selection of research subjects, research locations, and research methods. The first group's research focused on describing the relationship between different mathematical representation abilities in each learning style and also describing the different learning style tendencies of each student. The second group chose the description method but the focus of their research was to compare students' mathematical representation abilities according to learning styles. thus, there was no further description of the relationship between mathematical representation according to learning styles.

Based on the results of the analysis conducted on 18 publications in this study, it is known that students' mathematical representation skills according to learning styles can improve if they use the Achieved instruction assisted by the Problem Card learning model (Lastriani & Safa’atullah, 2019). The research was conducted by Lastriani and Safa'atullah

at one of the junior high schools on the island of Java. This can be a recommendation for teachers in determining learning models to improve mathematical representation ability based on appropriate learning styles. In addition, based on research conducted by Fauzan et al., (2018) it is known that the RME approach has a positive effect on students' mathematical representation ability according to learning styles. This is because the RME approach can accommodate different learning styles when students are involved in mathematical activities (Fauzan, 2002).

CONCLUSION

The analysis's findings utilizing the Systematic Literature Review (SLR) technique demonstrate that publications on mathematical representation ability according to learning styles get considerable attention, as evidenced by the existence of publications in each year starting in 2015. This also explains that mathematical representation ability according to learning style is an important topic to be researched. The research was conducted with the aim of describing the connection between mathematical representation ability and learning style and how the relationship between the two improves students' ability to represent mathematical concepts to solve a problem. In the span of 2015-2023, the year 2023 saw the greatest number of publications on mathematical representation ability according to learning styles. SINTA and Google Scholar emerged as the publication media with the highest volume of research publications. Qualitative methods dominated this study, with junior high school students serving as the most common research subjects. The island of Java emerged as the most popular research location in Indonesia for this study. Furthermore, it may be said that every learner has a leaning toward a different learning style.

Based on the results of this study, the recommendation for future researchers is to be able to examine the ability of mathematical representation in solving mathematical problems based on learning styles (visual, audiotory, and kinesthetic) using other student-centered learning models such as discovery, problem-based learning, and others to analyze the improvement of students' mathematical refractive thinking ability. In addition, future researchers can examine the ability of mathematical representation in solving mathematical problems based on learning styles (visual, audiotory, and kinesthetic) in terms of other aspects such as field independent and field dependent cognitive styles, habits of mind, and others.

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