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Implementation Levels of Inquiry with Blended Learning to Improve Creative Thinking Skills in the Pandemic Era

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Abstract: Current learning aims to improve students' skills to face 21st-century life. Creative thinking skills include 21st-century skills in innovation and technological development. This study aims to determine the improvement of students' creative thinking skills in the pandemic era using inquiry-based learning. This study uses a mixed method with an embedded design. The creative thinking skills test instrument is in the form of 14 open-ended questions developed based on the Scientific Creativity Structure Model compiled by Weiping Hu and Philip Adey. The analysis data using paired t-test. The results of statistical tests using paired t-tests showed a significant value of 0.000. Based on the decision-making criteria, if the significance value is less than 0.005, then H_o is rejected. The result can be interpreted as a significant difference between the pre-and post-test results. In addition, the increase in pretest-posttest scores was tested using n-gain and obtained a score of 0.55 in the medium category. Therefore, implementing levels of inquiry with blended learning on the light wave concept can improve the creative thinking skills in the medium category.

Keywords: Blended learning; Creative thinking; Level of inquiry; Physics

Introduction

Current learning aims to improve students' skills to face 21st-century life. Skills of the 21st century consist of three sets: learning and innovation, digital literacy, and life and career skills (Bai et al., 2018). Learning and innovation comprise four main components: creativity and innovation, critical thinking and problem-solving, communication, and collaboration, more popularly known as 4C (Handajani et al., 2018). Proper physics learning can develop the four main components (Saregar et al., 2020).

Creativity is a 21st-century skill that encourages human life to be more advanced through useful discoveries that have a wide impact. The development of human civilization depends on discoveries that stimulate other new and creative discoveries (Shabrina et al., 2018). Creativity can encourage someone to think more flexibly, solve problems creatively, and explore science concepts. However, the importance of creativity is not balanced with optimizing the development of creative process learning in the classroom, which is more oriented toward intelligence development than creativity skills. Teachers lack understanding of developing creative learning in the school (Rahmat et al., 2023).

Several studies state that students' creative thinking ability in some areas is still low (Asriadi et al., 2020; Batlolona et al., 2019; Meiarti et al., 2019). Besides that, observations in one of the high schools in Bekasi Regency showed that students were passive and tended to only listen to what the teacher explained. Students are

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less involved in learning, and communication tends to be one-way. The teacher explains the physics material and then gives practice questions to the students. Most physics learning only focuses on how students solve physics problems using mathematical equations (Rahmat et al., 2023).

According to PISA 2021, creative thinking is a competency to generate, evaluate, and improve ideas productively so that students can produce original and effective solutions, develop knowledge, and have an impactful imagination in creating something new (OECD, 2019). Creative thinking is a thought that makes a variety of ideas related to several topics in a limited time (Guilford, 1967). Creativity tends to be thinking habits rather than intellectual abilities, so students should be able to develop their creativity through learning at school. Creative thinking skills are part of high-level skills specifically focused on finding ideas, the emergence of various abilities, and divergent solutions to a problem (Darussyamsu et al., 2020).

The previous research about creative thinking skills is improved through learning involving students' active roles, such as the 5E learning model, STEM approach, project-based learning, and inquiry learning. Model inquiry learning can be integrated with other models or methods, for example STEM (Chen et al., 2021), mind mapping (Zubaidah et al., 2017), STAD (Prayitno et al., 2017), and so on. Integration between learning models expected to encourage the achievement of learning objectives more effectively.

Based on the development of research on levels of inquiry that has been carried out, the implementation of the levels of inquiry learning model is proven to improve 21st century skills. Wenning (2005) introduced a spectrum of levels of inquiry in learning. Levels of inquiry learning requires students to participate actively during the learning process, so that the controller in the class shifts from the teacher to the students. The levels of inquiry are carried out in stages from the lowest spectrum (discovery learning) to the highest spectrum (hypothetical inquiry). The higher the spectrum of inquiry, the higher the students' intellectual abilities. These spectrums have their characteristics which are their implementation will be adapted to students.

During the Covid-19 pandemic, learning shifted from face-to-face to distance learning. This condition encourages teachers and students to use technology devices in the distance learning process synchronously and asynchronously (Surahman et al., 2022). This encourages teachers to apply blended learning to achieve learning objectives. Most researchers have confirmed that blended learning is a contemporary and modern approach combining traditional and online or distance learning models by utilizing various technological media (Rahmat et al., 2022). Teachers' conceptions of blended learning that focus on using technology to achieve learning achievement and support critical investigations can encourage students to develop new ideas and understandings (Mulyanto et al., 2020). However, implementing blended learning during the pandemic has several obstacles: teachers not accustomed to using technology, unstable internet connections, and learning materials that have not been appropriately prepared in digital form (Rahmat et al., 2023).

Creative thinking skills are important but have not been optimally implemented in schools. In addition, the pandemic conditions changed moda learning into blended learning and became a challenge for teachers. This study aims to implement the level of inquiry (LoI) in blended learning, which is expected to improve students' scientific creative thinking skills.

Method

This research uses mixed-method, quantitative and qualitative data to gain a deeper understanding (Creswell et al., 2018). Meanwhile, the research design aims to collect quantitative and qualitative data simultaneously or sequentially (Creswell, 2012). The research design is shown in Figure 1.

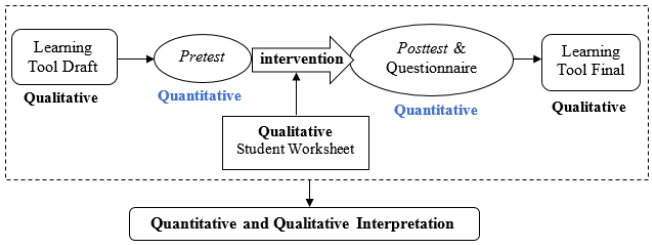

Figure 1. Research design

The participants of this research are 11th-grade senior high school students located in Cikarang, Bekasi Regency, Indonesia. The participants were 35 students (27 female and 8 male) with an average age is 16-17. The research instrument in this study are worksheets and open-ended questions. The worksheets are arranged based on the spectrum of levels of inquiry. The test instrument used is open-ended questions validated by five experts.

The results of pre-and post-test creative thinking skills were processed so that the total score of each student was obtained. Furthermore, the pretest-posttest results were tested for normality using the Saphiro Wilk test. The normality test results showed that the data were normally distributed, so the researcher used a parametric test (paired t-test) to determine whether there was a difference in the results of the pretest and post-test. This study also calculates n-gain to determine the increase in creative thinking skills. Statistical tests

were carried out with the help of SPSS. Meanwhile, students' answers on the worksheets were analyzed qualitatively.

Result and Discussion

Result

The students learn the light interference concept using an inquiry-based learning model during the pandemic. Blended learning is divided into face-to-face learning (live events) and distance learning (self-paced learning). The LoI learning process in accommodating creative thinking skills is shown in Table 1.

Table 1. Characteristics Levels of Inquiry with Blended Learning in Accommodating Creative Thinking Skills

Spectrum of LoI	Learning Mode	Indicator of creative thinking skills
1st meeting (Light interference)		
Discovery Learning	Live event	Fluency
Interactive Demonstration	Self-paced Learning	Flexibility
Inquiry Lesson	Live event Self-paced Learning	Fluency
Inquiry Laboratory	Live event	Fluency Flexibility
Real World Application	Self-paced Learning	Originality
2nd meeting (Light Diffraction)		
Discovery Learning	Live event	Fluency
Interactive Demonstration	Self-paced Learning	Fluency
Inquiry Lesson	Live event Self-paced Learning	Fluency
Inquiry Laboratory	Live event	Fluency Flexibility
Real World Application	Self-paced Learning	Originality
3rd meeting(Light Polarization)		
Discovery Learning	Live event	Fluency
Interactive Demonstration	Self-paced Learning	Flexibility
Inquiry Lesson	Live event Self-paced Learning	Flexibility
Inquiry Laboratory	Live event	Fluency Flexibility
Real World Application	Self-paced Learning	Flexibility Originality

In this research, implementing the levels of inquiry learning model is limited to the real-world application stage. Design learning integrates learning models of levels of inquiry with blended learning. Blended learning divides learning into face-to-face (live event) and distance learning (self-paced learning). Learning is carried out live event on the spectrum of discovery learning and inquiry laboratory and distance learning (self-paced learning) on the spectrum of real-world application. Meanwhile, on the spectrum of interactive demonstration and inquiry lessons, it can be done live event or self-paced learning. Learning is designed to train creative thinking skills in fluency, flexibility, and originality on each spectrum.

The statistical test results to determine the difference in the average pretest and post-test scores of creative thinking skills using the paired t-test can be seen in Table 2.

Table 2. Result of Paired t-Test

Data Source	Significance Level	*Sig. (2-tailed)*	Information
Pretest-Posttest	0.05	0.000	H_0 rejected

Based on Table 2, the results of the paired t-test obtained a significance value of 0.000. Suppose the significance value is less than 0.005. In that case, there is a significant difference between students' creative thinking skills after participating in levels of inquiry with blended learning on the concept of light waves. The pretest-posttest scores increased after participating in inquiry-blended learning on the concept of light waves, with an n-gain of 0.55 in the medium category. The n-gain score for each aspect is shown in Figure 2.

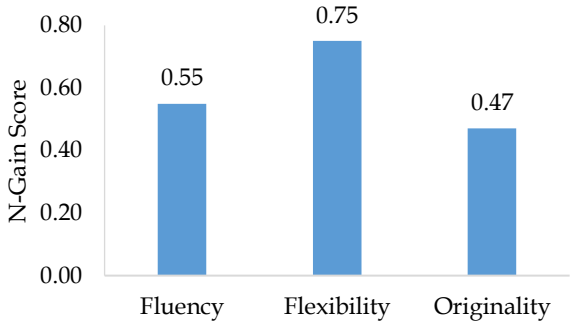

Figure 2. Graph of n-gain score on each aspect

Figure 2 shows that the flexibility aspect obtained the highest n-gain score of 0.75 in the high category, followed by the fluency aspect of 0.55 and the originality aspect of 0.47 in the medium category. The creative thinking skills test instrument consisted of 14 open-ended questions. Each question is structured based on product, trait, and process dimensions. Each dimension consists of several aspects. The aspects of each dimension are shown in Figure 3.

The procedure for assessing creative thinking skills is based on trait dimensions of fluency, flexibility, and originality (Hu et al., 2010). The scores obtained by

students are the sum of the fluency, flexibility, and originality scores. Fluency scores are obtained based on the number of answers given by students regardless of the quality of the answers. Flexibility scores are based on the number of approaches or alternative solutions to the problem (Eristya et al., 2019). Originality score based on the frequency tabulation of all student answers. An example of frequency tabulation of students' answers to the question '*what natural phenomena might occur if sunlight does not reach the earth?*' (Table 3).

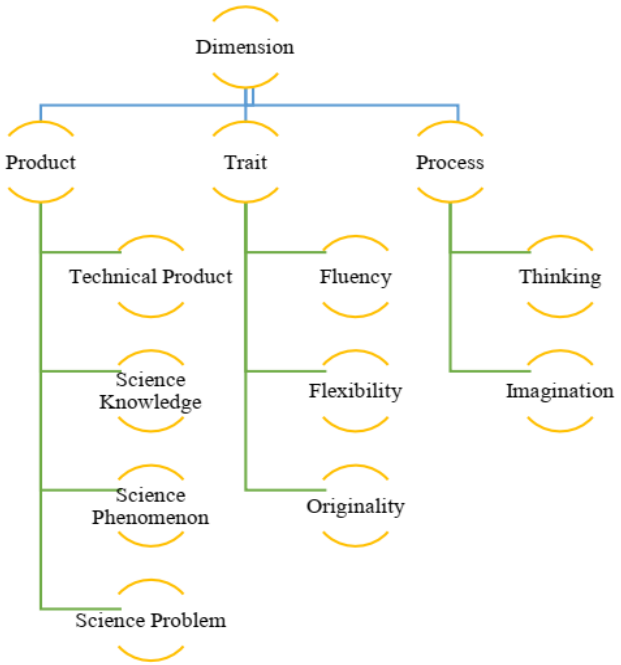

Figure 3. Dimension of creative thinking skills question

Table 3. Tabulation of the Answer Frequency

Student Answers	Frequency
No rain	
Plants do not photosynthesize	
Cold/falling temperature	
Extinct plants	
No evaporation	
No Oxygen	
Extinct animals	
Climate change	
Human dead	
Dark	
No rainbow	
Vitamin D deficiency	

= a student

= five students

The pretest and post-test results of creative thinking skills are assessed based on a rubric with a score range of 0-3. The students' pretest and post-test scores from numbers 1 to 2 are shown in Figure 4.

Figure 4 shows the scores obtained by students in the pretest and post-test. Number of 1a measures creative thinking skills in the scientific aspects of phenomena, fluency, and imagination and number of 1b measures scientific phenomena, originality, and imagination, only differing on the trait dimension. Number of 1a measures fluency and number of 1b measures originality. Meanwhile, number of 2 measures aspects of phenomenon science, fluency (2a) & originality (2b), and thinking.

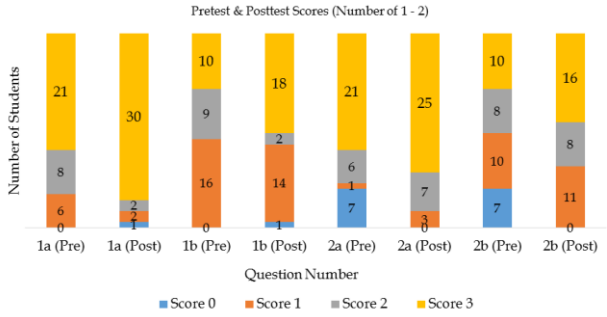

Figure 4. Obtaining students' creative thinking skills scores (numbers 1 – 2)

Based on Figure 4, the number of students who got a score of 3 was more in the post-test than the pretest. The number of score 3 has increased almost the same in number of 1a and number of 1b. This shows an increase in the scientific creativity of students in the fluency aspect as well as in the originality aspect. Furthermore, the acquisition of students' creative thinking skills scores at number of 3 - 5 is shown in Figure 5.

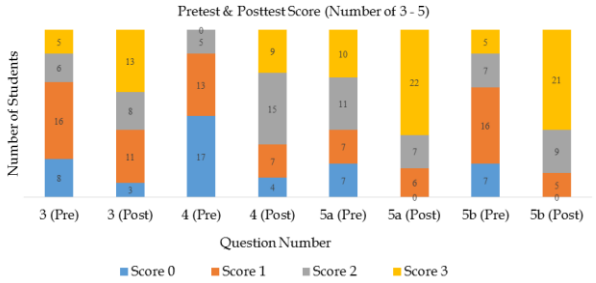

Figure 5. Obtaining students' creative thinking skills Scores (numbers 3 – 5)

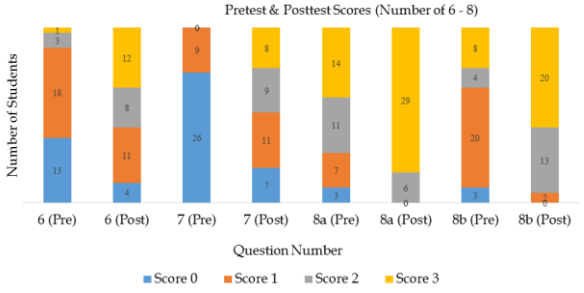

Figure 6. Obtaining students' creative thinking skills scores (numbers 6 – 8)

Figure 5 shows the score obtained at number of 3-5. Number 3 measures creative thinking skills in science knowledge, fluency, and thinking, number 4 measures aspects of science phenomenon, fluency, and thinking. Meanwhile, 5a and 5b measure aspects of product technical, flexibility × originality, and thinking. The acquisition of students' creative thinking skills scores at number of 6 to 8 is shown in Figure 6.

The acquisition of students' creative thinking skills scores at number of 6 to 8 is shown in Figure 6. Number of 6 measures creative scientific thinking skills on aspects of science phenomenon, fluency, and thinking, number of 7 measures aspects of technical product, originality, and thinking × imagination, and for number of 8a and 8b measures aspect of technical product, flexibility × originality, and thinking.

Based on Figure 6, the score of 3 increases for each number. On the other hand, the score of 0 has decreased. The most decrease in the score of 0 occurs in number 7 which measures originality. In the pretest, most of the students could not answer the diffraction experiment design using a compact disc. After participating in the lesson, students can provide answers even though only 8 students score 3. The difference in the answers number 7 on the pretest and post-test is shown in Figure 7.

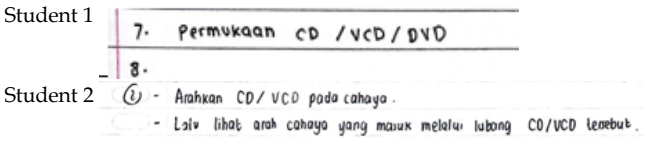

Figure 7. Students' answers on the pre-test

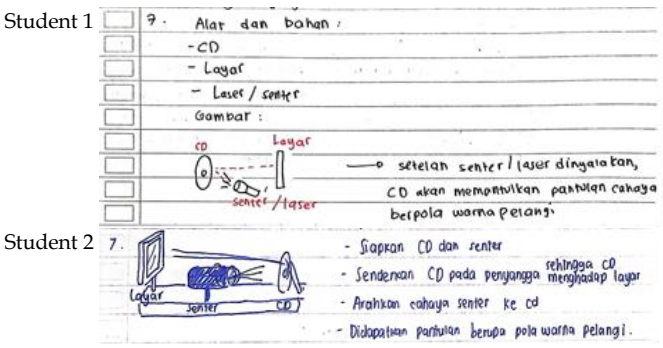

Figure 8. Students' answers on the post-test

Furthermore, the acquisition of students' creative thinking skills scores at number of 9 to 11 is shown in Figure 9. Numbers 9a and 9b measure creative thinking skills in science problems, flexibility×originality, and thinking. Meanwhile, 10 measures aspects of science knowledge, fluency, and thinking and 11a and 11b measure aspects of science problems, flexibility × originality, and thinking.

Based on Figure 9, the number of scores of 3 increased significantly and the number of scores of 0 decreased significantly at number 11a. However, the increase of scores 3 at number 11b is not as much as number 11a. Number 11a measures the aspect of flexibility while number 11b measures the aspect of originality. This shows that students can provide answers with various approaches after participating in learning, but their originality is still lacking. This can be seen from the number of students who gave similar answers. Figure 10 shows the score obtained at number of 12 - 14.

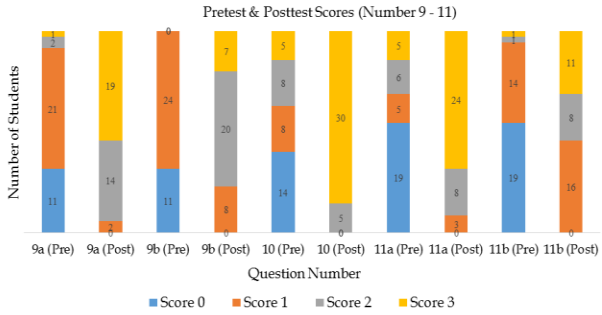

Figure 9. Obtaining students' creative thinking skills scores (numbers 9 – 11)

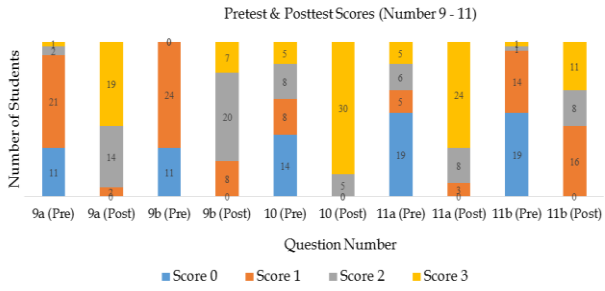

Figure 10. Obtaining students' creative thinking skills scores (numbers 12 – 14)

Number of 12 measures the aspects of technical product, originality, and thinking × imagination. Number of 13 measures the aspects of science knowledge, fluency, and thinking. Number of 14a and 14b have aspects of science knowledge, fluency × originality, and thinking.

Based on Figure 10, the number of students who received a score of 3 has increased and the number of students who have scored 0 has decreased. A significant change can be seen in number 12, the number of students getting a score of 0 which was initially 32 was reduced to 7 students. This shows that many cannot provide answers to the pretest so that they get a score of 0, but after participating in the learning students can provide answers and some even get the maximum score.

Discussions

The implementation of levels of inquiry was carried out starting from the spectrum of discovery learning, interactive demonstration, inquiry lesson, laboratory inquiry, and real world application. On the spectrum of discovery learning, learning focuses on the construction of students' knowledge and experiences through direct observation (Wenning, 2005). Observing phenomena makes students more motivated to learn a concept (Eristya & Aznam, 2019). In the interactive demonstration spectrum, the teacher demonstrates the concepts learned through interactive simulation (PhET) then asks probing questions about the relationship between variables, predicts a condition or explains something that might happen (Putranta et al., 2019). On this spectrum, the teacher describes the basic scientific procedures related to the concepts being studied, thereby helping students learn implicitly about the inquiry process that will be carried out (Wenning, 2005).

On the spectrum of inquiry lesson, students explore the material then the teacher guides by asking questions that lead to the right concept (Eristya & Aznam, 2019). Thus, students are expected to gain complete initial knowledge to design a scientific activity on the next spectrum. In the inquiry laboratory spectrum, students are guided independently to plan and carry out experiments and collect appropriate data. However, the conclusions given are often not focused on answering the objectives of the experiment so the role of the teacher is needed to direct students to give the right conclusions (Eristya & Aznam, 2019). In the real world application spectrum, students provide various possible solutions to the problems given at the beginning of learning. Students must understand that problems can be viewed from different aspects, so there is always more than one approach or solution for each problem (Winarto et al., 2021). Thus, students are expected to develop their scientific creative thinking skills, especially in aspect of flexibility and originality. Based on the analysis of the findings, the results of hypothesis testing indicate a significant difference between the results of the pretest and post-test of students' creative thinking skills (Ho is rejected). In addition, the increase in creative thinking skills can be seen from the n-gain score obtained, which is 0.55 in the medium category. The flexibility aspect gets the highest n-gain score, while the originality aspect gets the lowest n-gain score. This is in line with the research conducted by Malik et al. (2017) which obtained the lowest n-gain on the aspect of originality. This is in line with research conducted by Aboukinane (2007) showing that the implementation of inquiry-based laboratory activities has a positive impact on the ability of educational students to review problems from various aspects. Inquiry-based learning allows students to generate unusual ideas, brainchild, and solutions. This activity can train scientific thinking skills in the aspect of originality (Meiarti et al., 2019; Saregar et al., 2020).

The results of the study align with the research of Panjaitan et al. (2020) which states that there is a significant difference between students' creative thinking skills before and after students participate in inquiry-based learning on the concept of Temperature and Heat. Furthermore, research by Zubaidah et al. (2017) stated that implementing the inquiry learning model was proven to contribute significantly to creative thinking skills. Through inquiry, students have many opportunities to generate and discuss ideas, designs, find solutions, provide arguments, develop curiosity, and creativity. In addition, inquiry learning encourages students to express their ideas and feelings in various fun ways. Opportunities for expression and pleasant learning conditions become the basis for developing creative thinking skills including fluency, flexibility, and originality.

Conclusion

Levels of inquiry was successfully implemented in blended learning mode. Spectrums carried out face-to-face (live events) include discovery learning and inquiry laboratory. The spectrum carried out by distance learning (self-paced learning) includes real-world applications. Meanwhile, interactive demonstration and inquiry lessons can be conducted face-to-face or remotely. Implementing levels of inquiry-blended learning on the concept of light waves also improved students' creative thinking skills based on the significant value of the pretest-posttest mean difference test of 0.000 (Ho rejected) and the acquisition of an n-gain score of 0.55 in the medium category. This study can be a reference for researchers to test students' level of inquiry using appropriate learning methods. The limitation of the study is a small sample size and limited coverage area (Cikarang, Bekasi only). Future research can analyze the level of inquiry in other variables like critical thinking, problem solving.

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Author Contributions

SF is supervisor in this research have reviewed and monitored the research progress. RA discovered problems in school and compiled research instruments, analyzed data, and built manuscripts. ADR review and finalize the manuscript. DM and NSS gave an alternative method to analyze the data. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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