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Science Teaching Materials Based Jayapura Ethnoscience and Their Impact on Students' Science Process Skills

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Abstract: Students living in a dominant culture need science teaching materials that are able to mediate the transition of life from traditional science to scientific science. The solution offered is the application of ethnoscience in science learning. The purpose of the study was to develop ethnoscience-based science teaching materials and see its impact on students' science process skills. The type of research is research and development (Borg & Gall, 2003). The population of the study was grade VII students from four junior high schools in Jayapura City. The research sample consisted of eight classes, namely four classes as experimental classes that learned with Jayapura ethnoscience-based teaching materials and four classes as control classes with conventional teaching materials. Furthermore, a quasi-experiment was used using a randomized pretest-posttest control group design. The results of the study showed that with the reconstruction carried out, many traditional sciences were found that could be used to teach modern science. The developed Jayapura ethnoscience-based science teaching materials had a positive impact, and there was a significant difference in science process skills between students in the experimental and control classes. The developed Jayapura ethnoscience teaching materials were able to mediate students' learning transitions and support students' science process skills in learning science.

Keywords: Ethnoscience; Science process skills; Science teaching materials

Introduction

Minister of Education and Culture Regulation No. 68 of 2013 which produces the 2013 Curriculum states that education is rooted in national culture. Local culture has its own place as a learning resource. The government views culture as important as national identity, so it fosters it from an early age through various aspects, including through educational levels. Many people's original knowledge actually contains scientific values. Original science is built in a traditional society environment which contains various scientific concepts that are still not formalized, the form of development is inherited from generation to generation, is not structured and systemic in a curriculum, only applies in certain areas, is not standard, and is usually knowledge from the perception of a particular society towards a particular natural phenomenon (Adomah Bempah & Olav Øyhus, 2017; Duit & Treagust, 2003).

The original knowledge of society or indigenous science is often called traditional knowledge or local genius (Sumarwati, 2022). Indigenous science is the original knowledge of a tribe or local community that contains scientific values that are embedded in that community, originating from the values of belief that are passed down from generation to generation. Oriented to physical, emotional and cognitive activities, for example knowledge inherited from ancestors and transferred from generation to generation (Leitón & Kintana, 2023). Original science is built in traditional society which contains a number of scientific concepts that have not been formalized (Osborne & Allchin, 2024). The form of

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original science development is that it is passed down continuously from generation to generation, is not structured and systemic in a curriculum, is local, non-formal, and is generally knowledge in the form of people's perceptions of a natural phenomenon that occurs (Mikulecký et al., 2023).

Taylor et al. in Abd-El-Khalick et al. (2000), states that there are two conceptions of science, namely: scientific science, namely science which can only be understood scientifically and is based on the results of scientific work and how to obtain them using scientific methods, therefore it is universal, objective and a value-free process, and the results can be accounted for. Scientific science is in the form of theories, laws, principles and concepts that are reproducible, that is, tested experimentally in the laboratory and have received recognition from the scientific community; Meanwhile, original science or community science is still in the form of knowledge, concrete experience (concrete experience knowledge). Original science is transformed through oral traditions or told orally by parents to children and grandchildren or the next generation and is a concrete experience resulting from interaction with the environment.

Acquisition of scientific knowledge based on original science on local wisdom conceptually through identification, verification, formulation and conceptualization of scientific knowledge called ethnoscience. The description of the stages in the formation of scientific knowledge based on local wisdom begins with identifying the selected local wisdom, conducting interviews to find all the necessary information, then analyzing the answers from the sources so that scientific concepts are known whether they are true or false. Furthermore, after the analysis and verification process, a reduction process occurs and community science is obtained which contains the concept of science. After the verification process continues with conceptualization to obtain a scientific concept (Pedaste et al., 2015; Mikalef & Gupta, 2021). The concept is then validated, continued with documentation and integrated into relevant study materials (Kraus et al., 2022; Gligorea et al., 2023).

The description above can explain that indigenous science is the concrete knowledge and experience of society (concrete experience knowledge) which contains scientific values, which is understood through oral traditions or told orally by parents to the next generation and without any scientific explanation. Original science is transformed through oral traditions or told orally by parents to their children and grandchildren or the next generation and concrete experiences when interacting with the environment in which they live. Original science studies follow traditional methods and are macroscopic in nature.

In fact, Ethnoscience can be used as a medium for science learning, Ethnoscience can be a contextual learning resource or science learning object. Integrating ethnoscience in learning becomes a means of science learning that is contextual and useful for students. Ethnoscience-based learning will strengthen literacy (science, data and technology) because students will learn to study original science and explain the potential of scientific knowledge contained in it. One way to increase scientific literacy for students in Indonesia is to use ethnoscience-based science learning (Risamasu & Pieter, 2024). Furthermore, it has been found that ethnoscience-based science learning provides positive results (Idrus, 2022). Knowledge of science and technology learned by exploring native science will give rise to a feeling of love for the culture. Therefore, it is considered important to elevate local Indonesian wisdom which contains original science into science learning, namely by exploring and identifying original science and then reconstructing it into ethnoscience, namely original science that has a scientific explanation (Suryani et al., 2022).

We can understand ethnoscience as the activity of transforming or restructuring (reconstructing) original science in society into scientific science, then obtaining an equivalent explanation between original science and scientific science. Ethnoscience educates students to see the relationship between science subject matter at school and native science around their community and region which can be tested for truth, so that students can know the direct impact of the material they have studied (Mebert et al., 2020). Ethnoscience stimulates students to get to know and study natural science around where they live. Ethnoscience that grows in society has not been utilized as a contextual learning resource optimally. For example, Papua has various local wisdom which contains ethnoscience values but has not been integrated into science learning in the classroom (Pieter et al, 2024). In fact, our daily lives always interact with real science, but science learning has not been utilized.

The reality in the field shows that in learning teachers still emphasize scientific knowledge and have not integrated real science into learning (Zhang & Wang, 2021; Thana et al., 2022). For example, the yellow tail fish cooking activity and the Barapen activity (cooking using burnt stones in the Byak tribe culture) both contain the concept of Ethnoscience which can be used by science teachers to teach Heat Transfer material for class VIII students, but the facts in the field show that this has not been applied in learning and this has an impact on students' low science process skills. The research results of Strat et al. (2024), show that science teaching that does not pay attention to students' local context causes learning difficulties and ultimately has a negative impact on students' science learning outcomes.

Based on the description that has been presented, it is deemed urgent to develop ethnoscience-based science teaching materials as an alternative solution to the availability of science learning resources. Teaching materials that are appropriate and appropriate to students' lives can be beneficial for students' lives. Students can learn completely, namely mastery of knowledge (content) and mastery of context. Impressive learning for students is generally directly related to students' daily lives (Almulla, 2020; Hollister et al., 2022). This research aims to reveal how the reconstruction of junior high school teaching materials with the theme of heat transfer based on Jayapura science and see its impact on the mastery of science process skills of junior high school students in Jayapura City.

Method

This type of research is a development research model in the field of education proposed by Borg & Gall (2003). The research and development model is a method of research that aims to produce certain products (Sugiyono, 2017). This research accommodates 8 stages of RnD research, namely: research and information collecting, planning, developing preliminary form of product, preliminary field testing, main product revision, operational field testing revision, final product revision and field testing. These eight steps are explained in Figure 1.

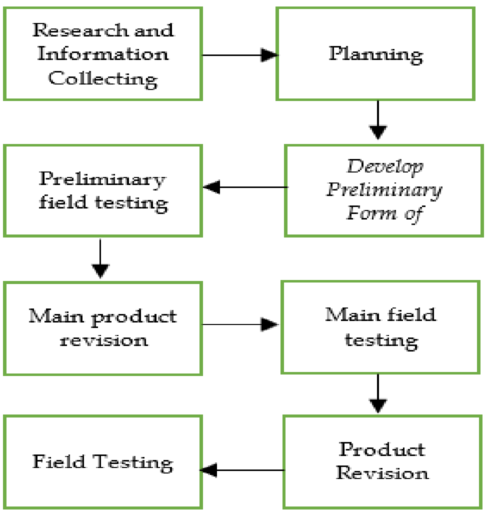

Figure 1. Borg & Gall model RnD research steps

The results of the development of teaching materials with Jayapura Ethnoscience were tested on class VII from four junior high school students in Jayapura City in the experimental class and control class in the 2024/2025 Academic Year. To obtain an assessment regarding the teaching materials developed, a questionnaire instrument was used which was then assessed by 5 expert validators consisting of two Physics Education lecturers at FKIP Cenderawasih University and three senior and certified Physics teachers from high schools in Jayapura City. The data obtained is quantitative data obtained based on the validator's assessment of the questionnaire. In the validation sheet for teaching materials, several aspects are assessed, namely cover, illustrations, format, content of teaching materials, and the language used. The results of this research were processed using a Likert scale with a scale of 1 to 4. Data on the validation of the developed teaching materials and the implementation of the learning tools were created in a questionnaire instrument and analyzed using descriptive statistical analysis techniques by calculating percentages using the following formula.

$$P = \frac{\sum x}{\sum xi} \times 100\% \quad (1)$$

Information:
P = percentage
$\sum x$ = total number of respondents answers
$\sum xi$ = total number of ideal scores in one item

The guidelines used to provide meaning and decision-making regarding product validity and implementation (product feasibility) are presented in Table 1.

Table 1. Five Absolute Scale Feasibility Conversion Guidelines

Score range (%)	Qualification
90– 100	Highly valid
75 – 89	Valid
65 – 74	Enough
55 – 64	Less
0 – 54	Very less

The criteria for success in the product feasibility test (product validity and suitability) is if it reaches a minimum score of 75% (valid) with minimum qualifications. If it is below the minimum score, it needs to be revised again. Next, validation and reimplementation are carried out. This is done continuously until the minimum good criteria are met. To determine whether there is an effect of using teaching materials based on Jayapura ethnoscience on students' science process skills in the experimental class and control class, a difference test (t-test) was used. The t-test calculation is assisted using the SPSS 23 program.

Furthermore, to find out the impact of the developed teaching materials on students' science process skills, N-gain analysis was used between the experimental class and the control class:

$$g = \frac{S_{Post} - S_{Pre}}{S_{Maks} - S_{Pre}} \quad (2)$$

Information:

g = normalized gain

S_{maks} = maximum score of tests

S_{Post} = posttest scoree

S_{Pre} = pretest scoree

The high and low normalized gain values can be classified in Table 2.

Table 2. Normalized N-gain Category Values

N-gain Value	Categories
$g > 0.70$	High
$0.30 \le g \le 0.70$	Medium
$g < 0.30$	Low

Result and Discussion

Result

As a result of preliminary research, information was obtained that in the science learning process, the teacher delivered the exact same teaching material as in the textbook from the Ministry of Education and Culture. Students learn using textbooks and there are no other learning resources. The school provides a limited number of textbooks so that not all students can borrow textbooks from the school. Students do not like science lessons because the material is difficult to understand. The results of interviews with students stated that science was a difficult subject, there were lots of questions with formulas so it was boring to learn. Observation results also show that science learning does not yet connect the learning material studied at school with the local wisdom encountered in students' daily lives. The textbooks used by students do not yet show the local wisdom of everyday students. As a result of interviews, students said they had never learned about barapen/burning stones, tifa, noken bags and others in science lessons. Students do not yet know that the things above can be explained by the science they study. In fact, local wisdom objects have scientific concepts and can be explained using the science that students learn in class (Hikmawati et al., 2021; Haleem et al., 2022). The teacher also stated that he had never linked the science concepts taught with local wisdom in the community.

Making teaching materials is preceded by carrying out ethnoscience reconstruction. Ethnoscience reconstruction begins by identifying the original science of Jayapura Papua which is in accordance with the KD that will be studied, namely KD 3.4 (knowledge aspect) and KD 4.4 (skills aspect) with the topic of heat transfer by conduction, convection and radiation. The corresponding ethnosciences are barapen, yellow sauce fish, and asar fish which correspond to the KD that will be studied, namely the topic of heat transfer (KD 3.4 and 4.4). The results of the ethnoscience reconstruction of Jayapura Papua ethnoscience are the basis for developing teaching materials. Teaching materials are made as attractive as possible by balancing short descriptions with language that is easy to understand and equipped with explanatory pictures in each description so that they are interesting for students to read/study and easy to understand.

Table 3. Results of Barapen Ethnoscientific Reconstruction

Original Science Activities	Traditional science explanations	Scientific science explanation	Material Suitability
Stone Burning Party Tradition (*Barapen*) 	Barapen is the Bakar Batu Party, which is a tradition of cooking and processing food together for party dishes as an expression of gratitude for births, weddings, welcoming guests or other important events that are usually carried out by people in Jayapura and Papua in general. Barapen means burning stones, namely a method or way of cooking food using very hot stones (stones that have been burned until red). The Barapen tradition is an activity that teaches how to	The tradition of burning stones (Barapen) is an event of heat transfer that occurs by conduction which is found in the lives of Papuan people in general. In the Barapen process, 2 heat transfer events occur by conduction. Heat transfer by conduction is the transfer of heat in a solid that is not accompanied by the movement of particles in the intermediate substance. The first event of heat transfer by conduction occurred in the initial Barapen process, namely burning cold stones with fire wood. The	3.4 Understand the concepts of temperature, expansion, heat, heat transfer, and their application in mechanisms for maintaining stable body temperature in humans and animals as well as in everyday life. 4.4 Investigate the characteristics of

Original Science Activities	Traditional science explanations	Scientific science explanation	Material Suitability
	create and strengthen togetherness/solidarity between communities in a village/region. That is why all Barapen activities are carried out together. The first step taken in Barapen is that the community collects sturdy river stones together, then burns them with wood until the stones become very hot, marked by red stones. The time it takes to burn a stone can reach 3-4 hours depending on the number of stones used. While waiting for the hot stones, people prepare a hole in the ground which will be used as a cooking vessel. The size of the hole varies depending on the amount of food to be cooked. Usually the size is 1 m x 1.5 meters with a depth of 70 cm. Once the hot stones are ready, the cooking process begins in the prepared earthen pit. Food is put into the hole and cooked until cooked.	stones are arranged in such a way and then burned. Stones that are cold when burned with wood fire will become hot because there is a transfer of heat from the wood fire to the cold stone which is not accompanied by the transfer of wood particles to the stone. As a result of this burning, cold stone will become very hot stone, which is indicated by the color of the stone turning red. The second event of heat transfer by conduction occurs during the activity of cooking food with very hot stones. Food ingredients (meat, tubers and vegetables) that are still raw are arranged in such a way that the raw food ingredients become cooked due to the transfer of heat from the hot stone to the food ingredients without any movement of particles from the hot stone. A hole in the ground that functions as a container and banana leaves or taro leaves that function as a cover for food will prevent heat from escaping from the hole so that the temperature remains hot.	heat propagation by conduction

The teaching materials contain explanatory descriptions of each stage of the barapen, yellow sauce, and asar fish processes, as well as scientific explanations accompanied by pictures of each ethnoscience process to help students understand the explanation of the ethnoscience being studied. Teaching materials help students understand the relationship between original science (the ethnoscience studied) and scientific science on the topic of heat transfer by conduction, convection and radiation, so that students understand that the barapen process, making yellow sauce fish, and making asar fish, can be explained with the science lesson material they studied in class 7. The reconstruction results are shown in table 3.

Furthermore, the results of the Jayapura ethnoscience reconstruction were developed in the form of teaching materials. The results of the validation of the use of ethnoscience-based teaching materials carried out by experts and practitioners are shown in table 4.

The results of feasibility validation by experts and practitioners for each aspect of ethnoscience-based science teaching material assessment are shown in Tables 4 and 5, while the results of feasibility validation of teaching materials by experts in Table 4 show an overall average score (M) = 94.44 so it is categorized as highly valid and suitable for use in learning.

Table 4. Validation Results for the Feasibility of Ethnoscience-based Science Teaching Materials by Experts

Component	Mark	Qualification
Cover and Illustration	95.83	Highly valid
Content/Material	91.67	Highly valid
Language	95.83	Highly valid
Mean	94.44	Highly valid

Table 5. Validation Results for the Feasibility of Ethnoscience-based Science Teaching Materials by Practitioners

Component	Mark	Qualification
Cover and Illustration	97.50	Highly valid
Content/Material	97.50	Highly valid
Language	100	Highly valid

Mean	98.33	Highly valid

The cover appearance of Jayapura ethnoscience-based science teaching materials which have been revised and are ready to be used in research is shown in Figure 2.

Figure 2. View of the cover of science teaching materials

The validation value for the suitability of teaching materials by practitioners in Table 5 shows an overall average value (M) = 98.33 so it is categorized as highly valid, this shows that expert validators and practitioner validators respond very positively to teaching materials so that they are suitable for use in science learning activities in schools. From the results of the analysis of teaching materials validated by practitioners, it was found that the average score was 98.33% (highly valid category). This validation value shows that practitioners assess the Jayapura ethnoscience-based teaching materials developed as suitable for use in science learning. The revision notes provided by the five validators have been corrected so that this learning material can be used in science learning at school. Next, the researchers used a difference test (t test) to see whether the Jayapura ethnoscience-based teaching materials developed had a different impact on the science process skills of students in the experimental group and the control group. The difference test (t test) can be carried out provided that the data is normally distributed and homogeneous (Liu et al., 2025). Researchers used SPSS 25 to carry out normality tests and homogeneity tests. The t test results are attached in table 6.

Table 6. Recapitulation of t-test Results for Both Class

	t-test		
Class data	t	Sig.	Conclusion
Pre-test control and experiment class	0.18	87	There were no significant differences between the two class
Post-test control and experiment class	5.56	0.00	There are significant differences between the two class

The t test results in Table 6 show that there are significant differences in the science process skills of students in the two classes with the use of Jayapura ethnoscience-based teaching materials in science learning. From the data in Table 6, it can be concluded that the Jayapura ethnoscience-based teaching materials used in science learning on the theme of heat transfer are better than learning with conventional teaching materials used by science teachers for students in class VII. To calculate the percentage increase in students' mastery of science process skills using Jayapura ethnoscience-based teaching materials, a normalized gain model (N-gain) was used. Data on the percentage increase in N-gain in students' science process skills is presented in Table 7.

Table 7. Percentage Increase in N-gain Concept Mastery

Class Data	N-gain (%)	Category
Experiment Class	54	Medium
Control Class	32	Low

Based on the results data presented in Table 7, it can be concluded that the percentage increase in N-gain in science process skills was higher in the experimental class which studied using Jayapura ethnoscience-based teaching materials compared to the control class which studied with conventional teaching materials sourced from teacher textbooks.

Discussion

Indigenous science is expressed in local wisdom as an understanding of natural and cultural riches that grow and develop among society. The scope of original community science related to ethnoscience studies includes the fields of: education (ethnopedagogics), physics, biology, chemistry, agricultural science (planting techniques to post-harvest processing), medicine (ethnomedicine) related to health and health care, agriculture, mathematics (ethnomathematics), botany (ethnobotany), the field of fisheries (time rules and techniques for catching fish to the processing process, the use of plants and certain types of shellfish as natural dyes for materials both for food and crafts, the use of plants as clothing materials, decoration and so on. Indigenous science or ethnoscience can be used in science learning. Local wisdom objects have scientific concepts and can be explained using the science that students learn in class (Yulia & Suttrisno, 2024). Through ethnoscience, students learn science contextually, that is, linking science learning material at school with native science around their community and region which can be tested for truth, so that students can know the direct impact of the science material they have studied in class. Ethnoscience becomes a contextual learning resource that encourages students to get to know and learn science through the use of the surrounding environment.

The public and students in particular, often do not realize that they apply scientific principles and concepts in their daily lives. Students often think that the science or science they study at school has nothing to do with events they experience in life or their local wisdom. Students think that the science they learn in class is not related to their lives. In fact, many activities in life and in their local wisdom can be explained using science or natural sciences. Cultural products found in the midst of people's lives show real objects and scientific activities (Wijaya et al., 2021). The validation test results of Jayapura local wisdom-based teaching materials show that the teaching materials that have been developed are in the good category, expert validators give an average rating (M) of 96.15 and practitioner validators give an average rating (M) of 97.12, where both assessment results are in the very good category. The validation results show that the teaching materials developed can be used easily by seventh grade students. The validators gave a very good assessment which shows that the teaching materials are easy for students to use, this is because the teaching materials use the diversity of Jayapura ethnosciences which are known, known and encountered in students' daily lives (Bramastia et al., 2023).

Theoretically, efforts to develop and validate learning products based on local wisdom are based on two propositions (Nurmasyitah et al., 2022). First, that learning models based on local wisdom are a very important part of the effectiveness of learning practice. The implication of this statement is that local wisdom should be used as the basis and/or basis for efforts to increase the effectiveness of educational outcomes. Second, that meaningful learning is the most important element in learning. This has the implication that the learning process should link the content and context in the area itself, in this way, learning will become more meaningful and attract students' interest in learning (Darling-Hammond et al., 2020). The results of the different test (t test) on the use of Jayapura ethnoscience-based teaching materials on students' mastery of science process skills showed that there were differences between the experimental group and the control group, a significance value of 0.000 was obtained (Table 6). This difference in mastery of science process skills is because students who study science using teaching materials developed from Jayapura ethnoscience find it easier to understand the teaching materials developed, so this has an impact on students' mastery of science process skills better than students who study using conventional learning.

Table 7 shows that the percentage of N-gain increase in science process skills is higher in the experimental class that studied using Jayapura ethnoscience-based teaching materials compared to the control class. This can be understood because the activities carried out in science process skills include observing, comparing, classifying, measuring, and communicating using traditional science that they usually encounter every day life (Chang et al., 2024). The process skills approach is an approach to science learning which assumes that science is formed and developed through a scientific process which must also be developed in students as a meaningful experience that can be used as a provision for further personal development (Kostiainen et al., 2018; Cents-Boonstra et al., 2021). The process skills approach emphasizes how students learn and manage their acquisition, so that they are easy to understand and use in life in society. In the learning process students can gain their own experience and knowledge, scientific investigations, train their intellectual abilities (Hlavac, 2023).

By developing skills with an emphasis on science process skills, it supports children to be able to discover and develop their own facts and concepts as well as grow and develop the attitudes and values required (Yildiz & Guler Yildiz, 2021; O'Reilly et al., 2022). In this way, these skills become the driving force for the discovery and development of facts and concepts, as well as the growth and development of attitudes and values (Osher et al., 2020; AlAli & Al-Barakat, 2024). Furthermore, the increase in students' science process skills is due to the Jayapura ethnoscience-based teaching materials produced having the advantage that they were developed by integrating the local science potential of the community so that students are very interested and easy to understand because they are in accordance with the context of the daily lives they live (Hunegnaw & Melesse, 2023; Sari et al., 2023). Integrating local cultural wisdom in science teaching material development activities makes learning appropriate to daily life and the real world, making learning meaningful because it is in accordance with the cultural ethnoscience of the Enggros and Tobati tribal communities in Jayapura.

Furthermore, the results of this research prove that every local wisdom and every local potential that exists in communities in the archipelago is a learning resource that can be used to support science learning activities in schools (Kamila et al., 2024). Jayapura's ethnoscience-based teaching materials help mediate students who are just starting to learn modern science, where students who are transitioning from an environment steeped in local culture often experience a cultural gap. The existence of teaching materials based on local wisdom links their local world with modern science lessons, thereby minimizing cultural shock and making it easier for students to learn modern science at school (Rahmawati et al., 2024).

Conclusion

Based on the results of the data analysis and discussions, the following conclusions are drawn: 1) The ethnoscience-based teaching materials that have been developed are very suitable for implementation in science learning activities in schools. The results of expert validation show an average value of 94.44%, while the results of validation by practitioners show an average of 98.33%, both of which are in highly valid category; 2) There is a significant difference regarding the ability of students' science process skills using Jayapura ethnoscience-based materials compared to students who study using conventional teaching materials in class VII science learning material on heat transfer; 3) The percentage increase in N-gain in students' science process skills using Jayapura ethnoscience-based teaching materials was 54% in the medium category, while for conventional learning it was 32% in the low category. For further research, it is possible to integrate culture-based learning with STEM to obtain a more ideal science learning model but does not forget or abandon Indonesia's national colors and culture.

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Author Contributions
Conceptualization; J.P., P. V., M. R.: methodology; J.P., validation; P. V: formal analysis.; J. P.: investigation.; P. V.; resources; P. V: data curation: J. P.: writing—riginal; J. P.: draft preparation; P, V.: writing—review and editing: J. P.;visualization: P. V. 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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