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The Effect of the STEM Learning Model on IPA Learning Outcomes of Grade 4 Students at SD Negeri 2 Kotabunan

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Abstract. The low outcome of IPA (*Ilmu Pengetahuan Alam*/Science) learning in the Ecosystem topic is a problem in this research so that the use of the STEM learning model is expected to improve IPA learning outcomes. The population in this study was SD Negeri 2 Kotabunan sampled using a cluster random sampling technique and 20 students in Grade 4A and 20 students in Grade 4B were the samples in this study. This research is quasi-experimental using a control group design. The data were collected using test and questionnaires instruments and analyzed using the T test. Test results showed that the significance value was 0.001<0.005, or it can be concluded that the STEM learning model affected IPA learning outcomes in the Ecosystem topic. Thus, the STEM learning model can be implemented in learning because it has an effect and can improve the learning outcomes of elementary school students.

Keywords: Ecosystem, Learning Outcomes, STEM, Elementary School, Grade 4

1. Introduction

Education in Indonesia faces problems in many aspects including input, output, outcome, and especially in the process so that the results are still not yet satisfactory. For example, in the 2018 PISA survey results, Indonesia scored 379 in mathematics, which was lower compared to the average OECD score of 489. In science, Indonesia scored 396, which was also lower than the average OECD score of 489. Indonesian learners, in the 2015 PISA survey, scored 386 in mathematics and 403 in science (Schlelilchelr, 2018). The influence of the globalization and the industrial revolution 4.0 is significant in the development of education. Various changes resulting from the industrial revolution 4.0 include new lifestyles, new norms, new models and new paradigms in managing everyday life. The discoveries made to achieve a goal effectively have been ineffective and irrelevant if they are implemented to achieve the same goal in the present and the future. As we enter the 21st century and the industrial revolution 4.0, technological development is very rapid and ever-increasing skills contribute to the development of a country's progress. Therefore, education must produce people who are able to compete globally and face today's challenges, especially in the fields of science and technology. 21st century learning requires critical thinking, creative, innovative, and collaborative learning skills. These skills are essential to solve various life problems which are increasingly complex. This means that classroom learning processes must be continuously examined and modified to reflect current real-world needs. Natural Sciences (*Ilmu Pengetahuan Alam*/IPA) is one of the developments that needs attention from educational institutions to fulfil learning achievements.

In Aprill 2013, the National Research Council, National Science Teachers Association, in America, released a science framework namely the Next Generation Science Standards (NGSS) (NGSS Lead State, 2013). Research was carried out for 3 years by the association and 26 countries applied to become the main country in the development of the NGSS. The basis of the standards was A Framework for K-12 Education by the National Research Council (NRC) entitled, (NGSS Lead States, 2013). The NGSS has 3 objectives to create a standard or framework that must be achieved by students in the field of science by involving engineering, technology, and science applications so that students can be more active in learning Science, Technology, Technology, and Mathematics (STEM) (Ali et al., 2023)

Students' ability to connect all the aspects in STEM is a good indicator of a deep cognitive understanding built by the students who are able to combine the 4 aspects of science in STEM. In many developed countries such as the United States, STEM education has been developed as a solution to face the challenges of the 21st century (Fauziyyah & Rina, 2020). The first implementation of STEM education in Indonesia was carried out in 2013 which was initiated with teacher training activities, the 2013 Curriculum and KTSP (*Kurikulum Satuan Tingkat Pendidikan*/Education Unit Level Curriculum) content analysis, as well as STEM education activities (Wijokongko, 2019). The output of the implementation is a STEM-based learning plan which is implemented in IPA learning in formal classrooms. In this research, the concept in focus was the non-uniform linear motion. The basic competence of this topic is analyzing experimental data on uniform linear motion and non-uniform linear motion and their application in daily life. The teacher designed the learning based on STEM education by using a balloon-powered car as the learning aid.

In STEM learning, students are expected to collaborate the skills and the learning processes in science, technology, engineering, and mathematics to solve a problem (Wulandari et al., 2023). This is line with current education which uses thematic so that students are equipped with skills to compete in the 21st century (Agung et al., 2021). The problems as a starting point in STEM-based learning are built and connected through the Engineering Design Process (EDP). Tiar Falentina et al. (2018) stated that EDP in STEM is a systematic, structured, and open way to approach problems and design solutions to existing problems. In the EDP process, the problems are presented to students in the learning process. This is based on the goal of STEM which is a form of innovation to solve problems in the real world. The use of learning media to support the success of the learning process is necessary so that students have the creativity and concrete experiences, and so that the students can understand the delivered material more easily. Moreover, the learning media are also important for teachers in learning achievement.

Learning using the STEM model is able to stimulate scientific thinking in elementary school students. In fact, the elementary school students' interest in learning science is high, but the lack of use of innovative learning models as well as the use of technology in the learning results in the decline of student's learning interest (Casado-mansilla et al., 2023). At the elementary school level, there are several materials related to saving energy. The aims are to identify changes in the form of wind energy in daily life and to do number rounding of the measurement results. In the implementation, teachers are still not familiar with the use of learning methods to represent the curriculum resulting in a form of learning based only on personal experience such as lectures and other methods. This leads to the lack of increasing student creativity (Karlina et al., 2023). This was also due to the fact that during the 2 years of the COVID-19 pandemic, children's creativity levels decreased because learning was carried out online without face-to-face and teachers provided learning only in the form of lectures and assignment (Nasution, 2022). The learning loss as a result of distant learning is the basis for changes to the education curriculum. The project-based learning process became an option in the prototypical curriculum which is considered capable of supporting learning recovery as due to the learning loss, and as a character development in accordance with the Pancasilla Student Profile (Faiz & Kurniawaty, 2022).

The Pancasilla student profile is one of the efforts to improve the quality of education in Indonesia which involves character development. In the current era of global technological progress, the role of value and character education is very much needed to create a balance between technological development and human development (Rachmawati et al., 2022). Strengthening the Pancasilla student profile focuses on building character and life skills in the students through school culture, intra-curricular and extra-curricular learning, Pancasila student strengthening projects, and work culture (Fauziyyah & Rina, 2020).

This is also in line with the results of the observations carried out in the Grade 4 of SD Negeri 2 Kotabunan (2 Public Elementary School of Kotabunan) in the IPA learning discussing the ecosystem topic. The learning methods implemented by the teacher were only lectures, questions and answers, and giving assignments. Moreover, the learning that should result in a product were not completed or not successful and the level of learning achievement or student learning outcomes was low. This was caused by teachers lacking knowledge in

learning models and only using conventional methods (lectures, questions and answers, and writing assignments). As a result of the impact of the COVID-19 pandemic, student learning outcomes are low. The success of a learning can be observed from the results of the evaluation carried out by the teacher to find out whether the students have improved or not. In addition, in the learning and teaching process, many students failed because the teacher only used limited methods, namely lectures and assignment, thus making the students bored and having difficulty understanding the material being taught. Based on the background of the existing problems, this research aims to find out the effect of the STEM learning model on the IPA learning outcomes of Grade 4 students at SD Negeri 2 Kotambunan.

1.1. Problem Statement

How is the effect of the STEM Learning Model on the IPA Learning Results of Grade 4 Students at SD Negeri 2 Kotabunan.

1.2. Related Research

Nyoman et al. (2023) studied the effect of the project-based learning model based on STEM on the students' critical thinking skills and learning outcomes. The research aimed to analyze the effect of the STEM-based PjBL model on students' critical thinking skills and IPA learning outcomes. It was quasi-experimental research with a Posttest-Only Control Group research design and the analysis using Manova. Based on the research results, it was concluded that the PjBL based on STEM had no effect on students' learning abilities and IPA learning outcomes. The difference between their research and this current research is that theirs used the PJBL model based on STEM to measure the students' critical thinking skills and learning outcomes, whereas this research uses the STEM learning model to measure students' learning outcomes.

The research carried out by Herak (2021) on improving the IPA learning outcomes of students in Grade 8 on the excretion system topic through the effect of the STEM model. The results of the quantitative research with a quasi-experiment method showed that the application of the STEM model in the IPA learning of Grade 8 of SMP Negeri 11 Kupang (11 Junior High School of Kupang) progressed. The research subject in the research was students in Grade 8 of middle school, meanwhile in this current research, the subject was elementary school students.

1.3. Research Objectives

This research aims to understand the effect of STEM learning model on IPA learning outcome of Grade 4 students at SD Negeri 2 Kotabunan.

2. Theoretical Framework

The Science, Technology, Engineering, and Mathematics (STEM) aproach is one of the alternative solutions for 21st century learning (Kara et al., 2021) and solves the problem of the quality of human resources and the nation's competitiveness (Kapilla, 2014: 47). Through STEM, research can provide greater meaning in the importance of science for technological development, and vice versa (Hasan et al., 2024). STEM is designed to increase global competitive power in the field of science and technological innovation, as well as to increase the understanding or to be STEM lilterate (Bardoe et al., 2023). STEM encourages the improvement of technological visibility and engineering/design to provide a context for students to test the development of their scientific knowledge and apply it in practice. This also improves their understanding of science, their interests in science, and communications between sciences, engineering and technology (Bardoe et al., 2023).

Learning outcomes are patterns of actions, values, definitions, attitudes, appreciation, and skills, as a result of interactions in learning (Blinkoff et al., 2023). Learning outcomes are also reports regarding what students have obtained in the learning process (Fandos-Herrera et al., 2023). Meanwhile, Horwart Kingsley (in Novitasari et al., 2023) divided learning outcomes into three types, namely: skills and habits, knowledge and direction, as well as attitudes and aspirations. From the description above, it can be concluded that learning outcomes are an

appreciation, a report of scores in the learning process that has been carried out in terms of attitudes, knowledge, actions, and skills.

Science is an expression of a dynamic relationship that includes three main elements, namely the foundation of existing scientific knowledge, the values of science, and scientific methods and processes (Rahmi & Ilmiah, 2023). As a body of scientific knowledge, science is the result of explanation/description of the natural world. Science is a process/method of investigation which includes thought patterns, attitudes, and scientific operational steps to obtain scientific products or scientific knowledge, for example observing, measuring, compiling and testing hypotheses, collecting data, testing, and predicting. In this context, science is not only a way of working, seeing and thinking, but also a way of knowing (Thurston et al., 2023). This means that science as a process can also include tendencies of attitudes/ actions, curiosity, habits of thought, and a series of processes. Science values relate to ethical responsibility, social values, benefits for science itself and human life, as well as behavioral attitudes, curiosity, honesty, thoroughness, perseverance, caution, tolerance, thriftiness, and wisdom in decision making (Michael et al., 2023).

3. Method

3.1. Research Design

This research is quantitative research using quasi-experimental method. The design of this research is the Pretest-Posttest Nonequivalent Group Design. In the research implementation, the experimental class were given a treatment, namely using the STEM learning model, and in the control class was not given treatment but used a conventional model. After being given the treatment, the students were given a posttest to find out the final results achieved to determine the effect of the learning model used.

Table 1. Researh Design

Class	Pretest	Treatment	Posttest
Esperimental	Q1	X	Q2
Control	Q3	-	Q4

Information

Q1 = *Pretest* of the experimental class

Q2 = *Posttest* of the experimental class

Q3 = *Pretest* of the control class

Q4 = *Posttest* of the control class

X = Treatment using the STEM learnjng model

\- = Not given treatment using the STEM learnjng model

3.2. Participants

This research was conducted at SD Negeri 2 Kotabunan for the 2023/2024 academic year. The population in this research was all fourth grade students at SD Negeri 2 Kotabunan. The samples in this research were 20 Grade 4A students as the experimental class, and 20 Grade4B students as the control class.

3.3. Data Collection

The data collection techniques used in this research are questionnaires and tests. The questionnaire was used to determine student responses to learning using the STEM learning model, and the test consisting of 15 question items wa used to measure student learning outcomes using the STEM learning model.

3.4. Data Analysis

The data analysis technique used in this research is using the Independent Sample t-Test which aims to see the difference in the average learning outcomes of the experimental class and the control class with decision making, namely if *sig.* < 0.05, then there is an average difference between the class using the STEM learning model and the class using conventional learning model. The N-gain test was also used to see the increase in learning outcomes using the STEM learning model. The N-Gain (g) formula is as follows:

Gain Standard < g ≥ = $\frac{X_{after-}\ X_{before}}{X-X_{before}}$

Keterangan:

X ; Maximum score

X_{after} : Average test scores after the treatment

X_{before} : Average test scores beforethe treatment

Dengan kriteria n-gain sebagai berikut.

Table 2. N-Gain Criteria

No	*N-gain score*	Criteria
1.	g ≥ 0.7	High
2.	0.3 ≥ g < 0.7	Medium
3.	g < 0.3	Low

The interpretation of the categories of the effectivenes from N-gain is as follows.

Table 3. Effectiveness criteria from N-Gain

No	Percentage (100%)	Criteria
1.	< 40	Inneffective
2.	40 – 55	Poorly Effective
3.	56 - 75	Quite Effective
4.	> 76	Effective

3.5. Validity and Reliability

In this research. The student learning outcomes instrument was tested on Grade 5 students at SD Negeri 2 Kotabunan with a total of 15 students as participants. The test is said to be valid if Rcount > Rtable using the Pearson product moment test. Table 4 presents the results of the instrument validity test using the Pearson product moment test.

Table 4. Validity Test Results of the Learning Outcome Instrument

No. Item	**R_{table}**	**R_{count}**	**Description**
Item 1	0.514	0.628*	Valid
Item 2		0. 556*	Valid
Item 3		0. 750**	Valid
Item 4		0.710**	Valid

No. Item	R_{table}	R_{count}	Description
Item 5		0. 773**	Valid
Item 6		0.576*	Valid
Item 7		0.671**	Valid
Item 8		0. 576*	Valid
Item 9		0. 628*	Valid
Item 10		0.592*	Valid
Item 11		0.714**	Valid
Item 12		0. 628*	Valid
Item 13		0.620*	Valid
Item 14		0.628*	Valid
Item 15		0. 591*	Valid

Based on the data described in table 4, it can be concluded that the 15 items of the learning outcome instrument are declared valid as evidenced by the Rcount > Rtable value so that the learning outcome instrument can be used to measure the learning outcomes of fourth grade students at SD Negeri 2 Kotambunan.

Next, a reliability test of the student learning outcomes instruments was carried out with the aim of seeing the consistency of the learning outcomes instruments. It is said to be reliable if *Sig.* > 0.60 using the Pearson product moment test. Table 5 presents the results of the reliability test.

Table 5. Results of the Research and Learning Results Test

Table 5. Reliability Test Results of the Learning Outcome Instrument

Reliability Statistics	
Cronbach's Alpha	*N of Item*
0.896	15

Based on the reliability test results presented in Table 5, it can be concluded that the learning outcome instrument is declared reliable as evidenced by the *Sig.* value > 0.60, namely 0.896. Therefore, the instrument can be used to measure the science learning outcomes of fourth grade students at SD Negeri 2 Kotambunan.

4. Findings

This research was carried out with the aim of finding out the effect of the STEM learning model on the science learning outcomes of Grade 4students at SD Negeri 2 Kotambunan. Before carrying out the research, the research instrument were prepared first, namely the student learning outcome test instrument and the tests for the instrument including validity and reliability tests for Grade 4 students or a class that had previously studied the topic in the research with a total of 15 students with the aim to find out whether the research instruments could be used to measure student learning outcomes. The student learning outcome instrument was said to be valid if Rcount > Rtabel. The results of the validity test of the student learning outcome instrument using the Cronbach's Alpha test has been presented.

After the instrument was declared valid and reliable, the next stage was carrying out the research at SD Negeri 2 Kotambunan with the research target being Grade 4students. In this research, 2 parallel classes in Grade 4 were involved, namely Grade 4A with 20 students as the experimental class or the class using the STEM learning model, and Grade 4B with 20 students as the control class or the class using conventional learning. The topic discussed in the classes in this research was ecosystem. After the data from the pretest and posttest results on student

learning outcome using the STEM learning model and using the conventional learning model were produced, the next step was to carry out the normality test.

The normality test used in this research was the Kolmogorov-Smirnov test with the help of IBM SPSS Statistics 27. The data is said to be normal if *sig.* > 0.05. Table 6 shows the results of the normality test.

Table 6. Normality Test Results

Class	Variable	*Kolmogorov-Smirnov*		*Conclusion*
		Z	***Sig.***	
Experimental Class using STEM learning model	*Pretest*	0.147	0.200*	Normal
	Posttest	0.146	0.200*	Normal
Control Class using conventional learning model	*Pretest*	0.151	0.200*	Normal
	Posttest	0.135	0.200*	Normal

Based on the normality test results presented in table 6, it can be concluded that the pretest and posttest data of student learning outcome in the experimental class or the class using the STEM learning model had a normal distribution, this was proven by the significance value of the Kolmogorov-Smirnov normality test, which was 0.200 or more than 0.05. Similarly, the pretest and posttest data of the learning outcome test data for the control class or the class using conventional learning model had normal distribution. This was proven by the significance value of the Kolmogorov - Smirnov normality test, which is 0.200 or more than 0.05. So it can be concluded that the pretest and posttest data on class learning outcomes using the STEM learning model and classes using the conventional learning model both had a normal distribution.

The next stage was to carry out a homogeneity test on student learning outcome data. Data is said to be homogeneous if *sig.* > 0.05. The homogeneity test was carried out with the help of IBM SPSS Statistics 27. The results of the homogeneity test is presented in Table 7.

Table 7. Homogenity Test Results

Homogenity test of learning oucome data				
No.	Data Type	*Sig.* Value	Condition	Conclusion
1	Experimental Class using STEM learning model	0.772	>0.05	Homogenous
2	Control Class using conventional learning model	0.323	>0.05	Homogeouse

Based on the results of the homogeneity test of the learning outcome data presented in the table, it can be concluded that the pretest and posttest data on the learning outcomes of the experimental class and the control class are declared homogeneous. This is proven by the *sig.* > 0.05, experimental class = 0.772 and control class = 0.323. Hence, it can be concluded that the learning outcomes data for the experimental class and control class are homogeneous.

After the learning outcomes data in the experimental class and control class were fulfilled or declared to be normally distributed and homogeneous, then the hypothesis testing was carried out. The hypothesis testing used in this research was independent sampe t-test to find out the effect of STEM learning model and the difference between the average scores of the class using the STEM learning model and the class using the conventional learning model. Before carrying out the independent sample t-test, a descriptive statistical test was done to see the difference in class averages using the STEM learning model and classes using the conventional learning model. The descriptive statistics results is presented in Table 8.

Table 8. Descriptive Statistics Test Results

Group Statistics					
	Class	N	Mean	Std. Deviation	Std.Error mean
Learning Outcome	Experimental	20	87.05	7.508	1.679
	Control	20	73.15	7.741	1.731

In the independent sample t-test, if *sig.* < 0.05 then H0 is accepted, Ha is rejected or there is an effect on the class using the STEM learning model, and vice versa. Based on the results of the independent sample t-test presented in Table 8, it is known that the average or mean value of learning outcomes for students in the experimental class is 87.05, while the average or mean value of the control class is 73.15. Thus, it can be concluded that there is a difference in the means of student learning outcomes between classes using the STEM learning model and classes using the conventional learning model.

Table 9. Independent Sample t-test Results

Independent Sample Test			
Data Type	*Sig. (2 tailed)*	Condition	Conclusion
Learning Outcome	0.001	< 0.05	H_0 Rejected

Based on the results of the independent sample t-test in the table, *sig.* (2 - tailed) is 0.001 < 0.05, so that based on the decision making in the independent sample t-test it can be concluded that H0 is rejected and Ha is accepted, hence there is a significant or real effect and difference between class learning outcomes using the STEM learning model and class using conventional learning models. Next, the results of differences in student learning averages are presented in the following table.

The next stage was to carry out the N-Gain test to find out the student learning outcome improvement in the experimental class using the STEM learning model and the control classes using conventional learning model. Below are presented the results of N-Gain for the experimental class and control class.

Table 10. N-gain Analysis Results

Descriptive Statistics						*N-Gain Score*	Criteria	*N-Gain Score (100%)*	Criteria
Learning Outcome		*N*	*Min*	*Max*	*Mean*				
Experimental Class	*Pretest*	20	50	72	61.45	0.62	Medium	62.49	Quite Effective
	Posttest	20	75	100	87.05				
Control Class	*Pretest*	20	53	75	62.35	0.27	Low	26.72	Ineffective
	Posttest	20	56	85	73.15				

Based on the results of the N-Gain test calculations in the above table, the average value of N-gain and N-gain score in the experimental class using the STEM learning model is 0.62, including in the medium category and the N-gain score value is 62.45% is included in the quite effective category. Meanwhile, the average N-gain and N-gain score in the control class using conventional learning models is 0.27, which is in the low category, and the N-gain score is 26.72%, which is in the ineffective category.

Thus, it can be concluded that the use of the STEM learning model in experimental class using the STEM learning model was quite effective in improving IPA learning outcomes in the ecosystem topic for Grade 4 students at SD Negeri 2 Kotambunan. Meanwhile, in the control class, the conventional learning model was not effective in improving IPA learning outcomes in the ecosystem topic for Grade 4 students at SDN 2 Kotambunan.

5. Discussion

This research aims to find out the effect of STEM and conventional learning models on students' learning outcome in the ecosystem topic for Grade 4 students at SD Negeri 2 Kotambunan. Based on the research results, it can be concluded that the STEM learning model had an effect the IPA learning outcomes of Grade 4 students at SD Negeri 2 Kotambunan. This was proven by the results of the independent sample t-test with a *sig.* value of to 0.001 < 0.05. This is in line with the research conducted by Andi et al. (2019) that the STEM learning model had a significant effect on IPA learning outcomes. Using the IPA learning model in IPA learning, especially in ecosystem topic, students were able to digest learning well so as to form creative thinking which has an impact on student learning outcomes (Topal & Korkmaz, 2023). Through the STEM learning model, students were able to have individual knowledge which can be seen in reading, writing, observing, and building students' creativity in learning. Some of the benefits of the STEM learning model are that students were able to solve problems better, be innovative, independent, and think logically (Yanni, 2018).

In terms of difference, the experimental class using the STEM learning model gained a mean mean value of 87.05, N-Gain Score of 62.49 with a quite effective criteria. Meanwhile, in the control class using conventional learning, the average score was 73.15, the N-Gain score was 26.72 with ineffective criteria. This indicates that the STEM learning model was superior to the conventional learning model. These results are in line with research conducted by Suharyat et al. (2023). The STEM learning model is a problem-solving learning strategy on students' thinking abilities, since in this learning model students are given the opportunity to find answers to problems in groups that are applied in real/natural life. The low average results in the conventional learning model according to Firdaus and Rahayu (2019) are because the learning process is dominated by teachers as transferers of knowledge while students are more passive as recipients of knowledge. Thus, the STEM learning model is superior to conventional learning models in IPA learning of the ecosystem topic. In line with research conducted by Syuhendri et al. (2021), student activity during the learning process is an important indicator to be realized and learning outcome is a performance that is indicated as abilities obtained after receiving experience in learning. Therefore, the STEM learning model is a solution to the problems faced by students in learning, especially in terms of learning outcomes in the ecosystem topic (Önal, 2023).

The increasie in learning outcomes using the STEM learning model in this research could also be proven by the N-gain results being higher than learning using conventional models. Thus, in this research, in Grade 4 of SD Negeri 2 Kotambunan the STEM learning model was more effective in improving IPA learning outcomes compared to conventional learning model. This is supported by the results of research conducted by Wijayanto et al. (2020) that the learning model is a learning tutorial plan that is structured systematically and forms a pattern that is used as a guide in planning classroom learning.

6. Conclusion

Based on the research results, it can be concluded that the STEM learning model influenced IPA learning outcomes and could improve elementary school students' learning outcomes. Apart from being able to improve learning outcomes, STEM learning models can also stimulate students to be able to think critically and creatively about real problems that occur in learning and can open students' insights. So based on the conclusions in this research, the STEM learning model can be implemented in elementary school learning because for students this learning model can improve learning outcomes. To improve process quality teaching and learning in the classroom, then this learning model can be applied. For teachers, the STEM learning model can be a creative and enjoyable learning solution to improve student learning outcomes. Hopefully, researchers will continue to be more active and creative in learning by using learning models that suit learning goals and needs.

Limitation

In the research process, there were several limitations, namely, the research carried out only used the STEM learning model, and only examined the learning outcomes of elementary school students, more specifically fourth grade students at SD Negeri 2 Kotabunan.

Recommendation

Based on the research results, this research can be recommended. The STEM learning model can be implemented in learning to improve student learning outcomes which will later be able to make a positive contribution to students.

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Conflict of Interest

The authors declare no conflict of interest.

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