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The Effectiveness of the Local Wisdom-Based INSETS Learning Model on the Critical Thinking Skills of Tenth-Grade Students at SMA Dharma Ayu Kefamenanu

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Abstract: This study aims to integrate a valid, practical, and effective local wisdom-based science learning model (INSETS) so that it is feasible to improve the critical thinking skills of high school students. The research design uses a development research design with a one-group pretest-posttest design. The subjects in the limited trial were conducted in class X at SMA Dharma Ayu, consisting of 19 students. The data collection process was carried out through documentation, tests, and questionnaires. The data analysis techniques used were quantitative and qualitative descriptive, n-gain, and paired t-test. The research results indicate: (1) the content validity of the INSETS learning model meets the criteria of very valid, (2) the consistency of the construct validity of the INSETS learning model meets the criteria of very valid, (3) the implementation stages of the INSETS learning model in limited and extensive trials fall within the good and fairly good criteria, and (4) students' critical thinking skills in limited trials and widespread tests increased significantly. It is concluded that the INSETS learning model developed is feasible to be used to effectively improve the critical thinking skills of students at SMA Dharma Ayu Kefamenanu. The results of the pretest and posttest trials were normally distributed and homogeneous. The paired t-test results showed that the significance level was < 0.05. This means that the INSETS learning model based on local wisdom is effective in improving the critical thinking skills of tenth-grade students at SMA Dharma Ayu.

Keywords: Critical thinking skills; Effectiveness; INSETS science learning model

Introduction

The rapid development of science, technology, and knowledge today is one of the characteristics of the era of globalization. This condition enables people to obtain information quickly and easily (Asari, 2014). Skills or competencies are highly needed for individuals to utilize critical thinking abilities in facing the challenges of modern developments (Kalelioglu & Gulbahar, 2013; Kriel, 2013; Kartini et al., 2019; Aizikovitsh-Udi & Cheng, 2015). Students are expected to possess knowledge that enables them to understand metacognition, conceptual understanding, and scientific facts, as well as the relationship between science, technology, and society, and to apply their knowledge to solve problems within society (Odegard et al., 2015; Wang & Zhao, 2016; Sopacua et al., 2024).

Critical thinking skills are essential for everyone in examining the validity of information so that they can determine whether the information should be accepted or rejected (Haryani, 2011; Kalelioglu & Gulbahar, 2013; Muliyadi et al., 2026; Asari, 2014). Therefore, critical thinking skills must be possessed by every individual so that they are not easily influenced by circulating information whose truth has not been confirmed and do not rush into making decisions or taking actions.

Natural Science is one of the fields of study that examines natural phenomena. Natural Science is defined as a collection of knowledge about objects and phenomena obtained through the thoughts and scientific investigations of scientists conducted

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systematically and scientifically (Sund & Trowbridge, 1973; Walker, 2014). Science education has an effective contribution to the development of positive attitudes toward science and critical thinking skills (Hake, 1998; Huann et al., 2012; Doyan et al., 2022; Rakhmawan et al., 2015). Students who study natural sciences directly are able to provide rational explanations about nature that can be understood easily, objectively, and fairly, while also supporting open-minded thinking, reliance on empirical evidence, and the need to critically evaluate ideas, assumptions, testing processes, and the interpretation of data or information (Soh et al., 2010; Rakhmawan et al., 2015; Wulandari & Solihin, 2016; Basam et al., 2018).

Critical thinking refers to an individual's ability to connect ideas, evaluate information, and develop logical understanding to solve complex problems. It is not a single skill, but rather a combination of knowledge, dispositions, and cognitive abilities that enable individuals to reason reflectively and make judgments based on strong reasoning (Hitchcock, 2017; Lestari et al., 2021).

Critical thinking is highly beneficial in supporting teaching and learning activities in schools because it provides students with opportunities to learn and respond to the lessons delivered by teachers in the classroom and can also be applied through discovery-based learning (Facione, 2015; Simbolon & Tapilouw, 2015). Furthermore, critical thinking skills refer to an understanding of cognitive domain skills that enable individuals to make decisions and draw conclusions based on logical reasoning supported by strong empirical evidence (Nurhayati et al., 2018; Badruttamam et al., 2025; Hidayah & Kuntjoro, 2022).

The inquiry model emphasizes how students utilize learning resources. These learning resources are used to identify and formulate problems (Dharma, 2019). The inquiry learning model is a learning model that seeks to develop the foundations of students' scientific thinking abilities as active learners. In the learning process, students learn more independently and expand their creativity to solve problems. According to Sudjana (2017), the inquiry learning model is a learning model that creates effective and conducive learning conditions. The inquiry model is a sequence of learning activities that emphasizes critical and analytical thinking processes to independently search for and discover answers to the problems being questioned (Purnamawati & Ertikanto, 2022). The inquiry model also emphasizes how students use learning resources, where these resources are utilized to identify and formulate problems.

An appropriate combination is the use of the SETS model because this model enables students to think comprehensively in viewing a learning theory based on the four elements of science, environment, technology, and society. Students can understand the influence of technology on the development of science and its impact on the environment. In addition, learning becomes more interesting because it is related to real-life situations (Yulistiana, 2015).

In the SETS learning approach, a suitable learning model is problem-based learning. According to Arends, problem-based learning is a learning approach designed to develop students' knowledge, skills, and self-confidence by using authentic (real-world) problems. An appropriate problem-based model is the inquiry learning model, which is useful in connecting scientific disciplines with various skills, including critical thinking, discussion, collaboration, argumentation, information-seeking, data evaluation, interpretation, and communication skills (Faizah, 2013).

This study is important to conduct to explore the integration of local wisdom into the curriculum and school learning materials as an effort to improve students' critical thinking skills. The integration of local wisdom into learning materials is an important step in shaping a generation that possesses a strong cultural identity and critical thinking abilities.

Method

Research Location and Time

This research was conducted at SMA Dharma Ayu in grade X from August to October to measure the validity of the INSETS learning model. Furthermore, students' critical thinking skills were assessed through the implementation of the INSETS model in biology learning to determine the effect of the INSETS learning model on students' critical thinking skills.

Research Model

This learning model emphasizes students' active involvement in the learning process and encourages them to relate their knowledge to real-life applications.

Preliminary Stage

The preliminary stage involved conducting a field study on: (1) higher-order thinking skills; (2) the methods used in local wisdom-based science learning; (3) the forms of problems presented; and (4) learning support facilities, including media and teachers' perspectives on learning approaches that could increase student activity. At the preliminary stage, several conclusions were obtained: (1) students' critical thinking skills are highly needed (OECD, 2017); (2) the learning models/forms and teaching methods used by teachers were still dominated by one-way information delivery; (3) the student textbooks used were sourced from only

one publisher without additional supporting references; and (4) laboratory facilities were inadequate.

Design Stages
Design of the INSETS Model

The draft design of the local wisdom-based INSETS learning model was developed based on supporting theories aimed at improving the structure and components of the model. The developed learning model includes: (a) supporting concepts within the model components; (b) the determination of model elements; and (c) the elaboration of technical guidelines for the model. The activities carried out in designing the model elements included: (a) the stages of the model, (b) social rules, (c) reaction principles, and (d) supporting systems.

Development of Learning Instruments

The development of learning instruments was carried out simultaneously with the development of the learning model. Other developed instruments included instruments for measuring students' critical thinking skills. The specifications for the development of supporting learning instruments were also established.

Expert Validation

This validation stage aimed to obtain a revised form of the learning model and learning instruments based on expert validation results. Before conducting the learning model trial, the researcher and the teacher collaboratively discussed the learning instruments, followed by simulations and training on the implementation of the developed model. Based on the simulation results, the learning implementation was considered ready to apply the developed model.

Learning Model Trial Stage

A limited trial was conducted to empirically analyse the practicality and effectiveness of the model. The purpose of the limited trial was to test the prototype of the learning model and its supporting learning instruments.

Table 1. One-Group Pretest–Posttest Design

O1	X	O2
Pre	Treatment	Post

Population and Research Sample

The population in this study consisted of all tenth-grade students at SMA Dharma Ayu. A total of 16 tenth-grade students were fully involved in this study. The sampling technique used was total sampling. According to Sugiyono (2013), total sampling is a sampling technique in which all members of the population are used as samples because the population size is relatively small, consisting of fewer than 100 individuals.

Research Instruments
Validation Sheet for Learning Instruments

The validation sheets for the learning model and learning instruments were completed by experts to validate and evaluate the learning model and instruments developed by the researcher. The learning instruments included the syllabus, lesson plans (RPP), student worksheets (LKS), and test instruments consisting of pretest and posttest questions to measure critical thinking skills.

Model Validation Instrument

Content validity refers to the suitability of the intervention based on current needs and up-to-date knowledge. Construct validity refers to the assessment obtained from validators regarding the components of the developed product and the extent to which they are interrelated. The model validity instrument was designed in the form of a checklist. The validity assessment scale consisted of four levels: 1 = incorrect, 2 = less correct, 3 = correct, and 4 = very correct.

Test Instrument

The test instrument was used to measure critical thinking skills using a critical thinking skills rubric developed by Zubaidah et al. (2005). The measurement of critical thinking skills was conducted by scoring students' responses on the pretest and posttest.

Data Collection Techniques
Validation Data

The data collection techniques included: (a) the learning model and critical thinking skills test instruments were validated by two validators; (b) data from the validators were collected using validation sheets; (c) the collected data consisted of descriptive data presented qualitatively; and (d) the validity results of the model and instruments were obtained by calculating the average scores from the two validators and drawing conclusions accordingly.

Test

The data collection technique used in this study was testing. The critical thinking skills test was conducted in two stages: the pretest was administered before the implementation of the local wisdom-based learning model, and the posttest was administered after the implementation of the local wisdom-based learning model.

Data Analysis Techniques

Analysis of Learning Model Validation Data

To answer the first research question, validation was conducted on the learning model and students' critical thinking skills instruments. Validity refers to the degree of accuracy between the data occurring in the research object and the data reported by the researcher. Therefore, validity is very important in research to determine the accuracy of the investigated object. The validity data obtained from experts were analysed by calculating the average score for each aspect. The criteria for categorizing the validity of the learning model and learning instruments are presented in Table 2.

Table 2. Criteria for Assessing the Validity of Learning Instruments (Ratumanan & Laurens, 2006)

Score Interval	Assessment Category	Description
3.00 <P< 4.00	Highly Valid	Used without revision
2.75 <p< 3.00	Valid	Used with minor revisions
1.75 <P< 2.7	Less Valid	Used with major revisions
1.00 <P< 1.7	Invalid	Cannot yet be used and still requires consultation

The reliability of the model validity assessment results and the validity of the learning instruments were calculated using the Percentage of Agreement formula (Borich, 1994).

$$R = \left[1 - \frac{A - B}{A + B}\right] X100 \quad (1)$$

Analysis of Critical Thinking Skills Data

Students' critical thinking skills before and after participating in learning using the INSETS learning model were analyzed using the following formula 2 (Hake, 1998):

$$n_{gain} = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \quad (2)$$

Learning was considered effective if there was an increase in the n-gain score of at least 0.31, which falls into the moderate category. The data obtained from the pretest and posttest of students' analytical abilities in learning were further analyzed using inferential statistical tests to determine the significance of the INSETS learning model in improving students' critical thinking skills. To determine whether there was a significant difference between the pretest and posttest scores, a paired t-test was conducted.

Result and Discussion

Result

Validity of the INSETS Learning Model

In general, the data on the content validity of the INSETS learning model were obtained through the following content validity assessment instrument.

Aspect: The Need for Model Development

The INSETS learning model aims to improve students' critical thinking skills in accordance with the need for 21st-century graduate competencies, obtaining an average score of 3.33 with the category of highly valid.

The development of the INSETS learning model bridges the gap between the expectations of 21st-century graduate competencies and the current reality of education in Indonesia, where critical thinking skills are still relatively low, with an average score of 3.33 categorized as highly valid. The INSETS learning model fulfils the need for a learning process that prioritizes scientific inquiry activities, with a score of 3.33 categorized as highly valid.

The development of the INSETS learning model considers recommendations for improvement from previous studies on students' critical thinking skills, obtaining a score of 3.00 categorized as highly valid. The INSETS learning model applies a transdisciplinary approach to fulfil state-of-the-art scientific knowledge, meet the need for model development, and maintain consistency among the model components, with a score of 3.00 categorized as highly valid.

Aspect: Model Design Fulfils Knowledge Novelty

The novelty of the INSETS learning model was developed by considering the strengths and weaknesses identified in recommendations from previous researchers, obtaining a score of 3.33 categorized as highly valid. The development objectives of the INSETS model were based on primary sources from reputable journals, obtaining a score of 3.33 categorized as highly valid. The development of the INSETS learning model used theoretical foundations from standard and up-to-date educational psychology scholars, obtaining a score of 3.33 categorized as highly valid. The development of the INSETS learning model also applied empirical foundations derived from studies and references from various relevant studies, obtaining a score of 3.33 categorized as highly valid.

Aspect: Description of the INSETS Learning Model

The INSETS learning model was developed with the main objective of facilitating students' critical thinking skills, obtaining a score of 3.66 categorized as highly valid. The syntax of the INSETS learning model can be categorized as innovative syntax, obtaining a score of 3.00 categorized as highly valid. The learning environment of the INSETS learning model supports the achievement of optimal learning, obtaining a score of 3.33 categorized as highly valid. The development of the INSETS learning model utilized empirical foundations derived from studies and references from various relevant studies, obtaining a score of 3.33 categorized as highly valid. The development of assessment and evaluation in the INSETS learning model used up-to-date reference sources, obtaining a score of 3.33 categorized as highly valid.

The data indicate that the content validity score of the INSETS learning model, viewed from the need for learning model development to produce graduate competencies in accordance with 21st-century skill demands, achieved the highly valid category. The content validity of this model, viewed from the novelty of knowledge by considering theoretical and empirical support as well as recommendations from relevant studies, also achieved the highly valid category. Furthermore, the content validity of this model, viewed from the model description in developing model objectives, learning implementation, learning environment management, assessment, and evaluation, achieved the valid to highly valid category.

Implementation of the INSETS Learning Model

The implementation of the learning model refers to the activities carried out by the teacher in conducting classroom learning while considering several components, namely: model syntax, social system, and teacher reaction principles/behaviours in applying the developed INSETS model. The implementation data were obtained from observations conducted by two observers who monitored the teacher's learning activities. The observation results regarding the implementation of the model in the limited trial are briefly presented in the table 3.

Based on the data, it was found that the overall implementation results of the learning model in the limited trial obtained average scores for the model syntax components in the orientation, invitation, problem formulation, hypothesis formulation, data collection, hypothesis testing, conclusion formulation, feedback, and application phases of 3.16, 3.59, 3.16, 3.16, 3.16, 3.16, 3.16, 3.16, and 3.16, respectively, which were categorized as fairly good and good. The social system component obtained a score of 3.50, categorized as good, while the reaction principles/teacher behavior component obtained a score of 3.54, also categorized as good.

Table 3. Implementation of the INSETS Learning Model in the Limited Trial

Component	Mean score	Des
Orientation Phase	3.16	Fairly Good
Invitation Phase	3.59	Good
Problem Formulation Phase	3.16	Fairly Good
Hypothesis Formulation Phase	3.16	Fairly Good
Data Collection Phase	3.16	Fairly Good
Hypothesis Testing Phase	3.16	Fairly Good
Conclusion Formulation Phase	3.16	Fairly Good
Feedback Phase	3.16	Fairly Good
Application Phase	3.16	Fairly Good
Social System	3.5	Good
Reaction principles/teacher behavior	3.54	Good

Results of the Critical Thinking Skills Test

The critical thinking test was designed to evaluate the learning materials acquired by students during the learning process through the implementation of the INSETS learning model. The test construction was based on the abilities to be measured from the students. The critical thinking skills test included both individual and classical achievement on each critical thinking indicator and determined the achievement or improvement of students' critical thinking skills using the n-gain score. The results of the students' individual critical thinking skills test in the limited trial are presented in the table 4.

Table 4. Results of the Analysis of Students' Critical Thinking Skills in the Limited Trial

Student Code	Pretest	Posttest	Mastery	n-gain
A 1	14.28	75.00	T	0.93
A 2	10.71	66.07	TT	0.63
A 3	14.28	83.92	T	0.97
A 4	17.85	83.92	T	0.81
A 5	23.21	83.92	T	0.85
A 6	14.28	76.78	T	0.97
A 7	14.28	80.35	T	0.97
A 8	25.00	87.50	T	0.83
A 9	16.07	75.00	T	0.94
A 10	17.85	75.00	T	0.91
A 11	14.28	69.64	TT	0.65
A 12	16.07	75.00	T	0.94
A 13	19.64	71.42	T	0.87
A 14	16.07	71.42	T	0.93
A 15	16.07	78.57	T	0.94
A 16	21.42	83.92	T	0.94
A 17	23.21	80.35	T	0.84
A 18	14.28	83.92	T	0.97
A 19	14.28	69.64	TT	0.65
Total	323.13	1,396.34	89.47 %	
Mean	17,006	73.49		0.87

The results of the normality test for students' pretest and posttest critical thinking skills scores are presented in the table 5. The data show the results of the normality test for the pretest and posttest data of students' critical thinking skills, where the Asymp. Sig. (2-tailed significance) value was > 0.05. Therefore, it can be concluded that the pretest and posttest data of students' critical thinking skills were normally distributed.

Table 5. Results of the Normality Test of Students' Critical Thinking Skills in the Trial Class

Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre Test Class A	223.	20	100.*	896.	20	134.
Post Test Class A	170.	19	148.*	943.	19	.297

The results of the homogeneity test of students' critical thinking skills also showed that the Asymp. Sig. (2-tailed significance) value was > 0.05, indicating that the students' critical thinking skills data were homogeneous. To determine the differences in the mean pretest and posttest scores of students' critical thinking skills in both the limited and extensive trials, a parametric statistical test using the paired t-test was conducted with the assistance of the SPSS-25 program, since the pretest and posttest data were normally distributed and homogeneous.

Based on the data in Table 5, the results of the normality test for the pretest and posttest data of students' critical thinking skills showed that the Asymp. Sig. (2-tailed significance) value was > 0.05. Thus, it can be concluded that the pretest and posttest data of students' critical thinking skills were normally distributed.

The results of the paired t-test are presented in the table 6. The data presented in the table 6 show that the significance value of students' critical thinking skills was < 0.05. This indicates that the local wisdom-based INSETS learning model was effective in improving the critical thinking skills of tenth-grade students at SMA Dharma Ayu.

Table 6. Results of the Paired t-Test of Students' Critical Thinking Skills

Description	Mean	Std. Deviation	t	df	Sig (2- tailed)
Pre Test - Post Test Class A	-60.43211	5.02436	1.15267	18	.000

Discussion

The INSETS model is considered to have good content validity when viewed from the novelty of the model (state-of-the-art). The description of the novelty of this model can be observed in the rationale section of the model. Experts who reviewed this model during the focus group discussion activities suggested that the rationale section should further emphasize the elements of novelty so that the model could achieve strong content validity.

The novelty of the INSETS learning model compared to the SETS and Inquiry learning models lies in its learning stages/syntax. The SETS and Inquiry learning models do not include an orientation phase. According to the findings of Vermunt et al. (2017), learning orientation refers to students' willingness to learn, including their goals, motives, objectives, and concerns related to their studies. Situmorang (2016) stated that students' critical thinking skills are reflected in their ability to apply scientific activities through identifying problems, making decisions, and drawing conclusions.

The difference between the INSETS learning model and the SETS and Inquiry learning models also lies in the reliability of the model in improving higher-order thinking skills, thereby encouraging students to work collaboratively through scientific inquiry activities. Students can enhance their motivation through activities such as formulating goals and problems appropriately, identifying investigation variables, and developing hypotheses based on the problems presented. Students collaborate and develop responsibility in designing and conducting experiments, while also fostering honesty in analysing experimental data. Another novelty of the INSETS learning model is its relevance to the implementation of the Merdeka Curriculum.

The INSETS learning model is categorized as highly valid in terms of construct validity, viewed from the consistency between the syntax levels and the phases within the learning model. The consistency among the syntax components of the model, as well as the consistency among the underlying theories, further support its construct validity. The construct validity of the INSETS model can be observed and traced through the model handbook and the items included in the construct validation sheet. The consistency among the phases within the model syntax can also be identified from the rationale underlying the sequence of phases that form the model syntax.

The implementation of each syntax phase in both the limited and extensive trials applying the INSETS learning model is described as follows. The first phase is the orientation phase. In this phase, learning activities are focused on establishing a conducive learning atmosphere or climate. The implementation of Phase 1 was categorized as good. This finding is in accordance with the ARCS theory proposed by Arends (2012), which states that students will be motivated to learn if teachers are able to present interesting learning materials. Students' motivation can also be enhanced when learning is directly related to their needs, so that increased motivation leads to greater self-confidence and satisfaction.

The second phase is the invitation phase, in which students are asked to explore problem issues. The learning activities in this phase focus on encouraging students to identify problems first. The implementation of Phase 2 in the trial class was generally categorized as good. This finding is consistent with the opinions of Fatmawati et al. (2015), Doyan et al. (2024), Ristina et al. (2018), and Botlolona et al. (2023), who stated that learning activities involving inquiry processes to solve problems can improve critical thinking skills.

The third phase is the problem formulation phase. This phase aims to help students understand the steps involved in solving a problem. The implementation of Phase 3 in the first meeting was categorized as good because learning activities involving scientific inquiry skills were rarely implemented in the school. This finding is in line with Aulia et al. (2018), who argued that inquiry-based learning activities, such as identifying problems, formulating hypotheses, determining investigation variables, designing investigation procedures, recording investigation data, and formulating conclusions, can improve scientific literacy skills.

The fourth phase is the hypothesis formulation phase. In this phase, teachers can develop students' ability to formulate hypotheses. The implementation of Phase 4 was categorized as good.

The fifth phase is the data collection phase. The results of the analysis of the implementation of the INSETS learning model in the first meeting of the trial class indicated that Phase 5 was implemented in the good category. In this phase, students were given opportunities to carry out the data collection process, which required not only strong learning motivation but also persistence and the ability to utilize their thinking potential.

The sixth phase is the hypothesis testing phase, which develops students' rational thinking abilities. In this phase, the validity of the proposed answers must not only be based on arguments but also supported by data that can be justified scientifically.

The seventh phase is the conclusion formulation phase. In this phase, the conclusions serve as the basis or solution for constructing concepts derived from describing the findings obtained through hypothesis testing. Conclusion formulation represents the outcome based on the conducted analyses. The implementation of Phase 7 was generally categorized as good.

The eighth phase is the feedback phase, which serves as a concept reinforcement stage. The implementation of Phase 8 was generally categorized as good.

The test of students' critical thinking skills included the assessment of students' mastery of each learning indicator and the determination of students' achievement using the n-gain score. The assessment of individual critical thinking skills used a minimum mastery criterion (KKM) of ≥ 70. Since the pretest and posttest data were normally distributed and homogeneous, a paired t-test was subsequently conducted. This is in line with the theory explaining that parametric tests can be applied when the data are normally distributed and homogeneous (Ghasemi & Zahediasl, 2012). In the limited trial, 16 students achieved individual mastery, while 3 students did not. The difficulties experienced by students were related to explaining questions about the tapping and distillation processes, as well as the role of sopi in society.

Conclusion

The developed INSETS model was highly valid in terms of both content and construct validity and was supported by valid student test instruments, science attitude observation instruments, and student character behavior observation instruments. The data showed that the significance value of students' critical thinking skills was < 0.05. This indicates that the local wisdom-based INSETS learning model was effective in improving the critical thinking skills of tenth-grade students at SMA Dharma Ayu. The research subjects involved in this study were still limited in number; therefore, this study can serve as a reference for future researchers to conduct studies on a larger scale.

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Author Contributions
FO: Ensured that all research activities were properly implemented; prepared the learning materials used in the research activities; supervised the preparation of the research activities; prepared the research article for publication; and coordinated with the research institution at Universitas Timor regarding research administration. LN: Assisted in preparing the materials discussed during the research activities; prepared online and offline e-modules as well as research data collection instruments; assisted in publishing the research article in a SINTA 2 accredited journal; coordinated with the school regarding scheduling and other matters required during the research activities; and facilitated the implementation of the research activities. All authors have read and approved the published version of the manuscript.

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