HISTORY OF MANUSCRIPT PUBLICATION

(*JOURNAL of ASIA-PACIFIC SCIENCE EDUCATION*)

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"Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement Among Indonesian High School Students."

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UNIVERSITAS MUHAMMADIYAH MALANG KORESPONDENSI APSE
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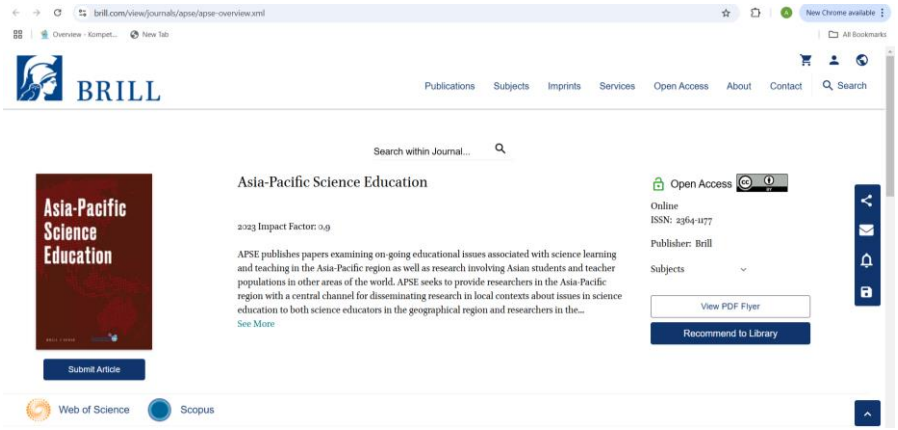

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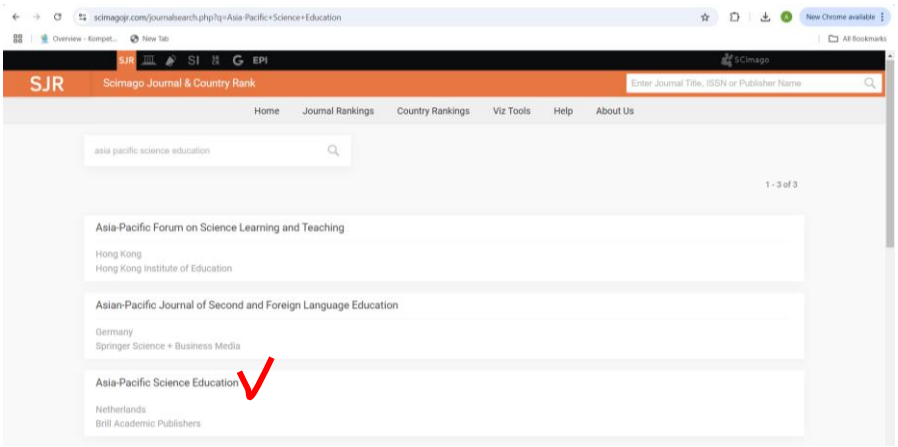

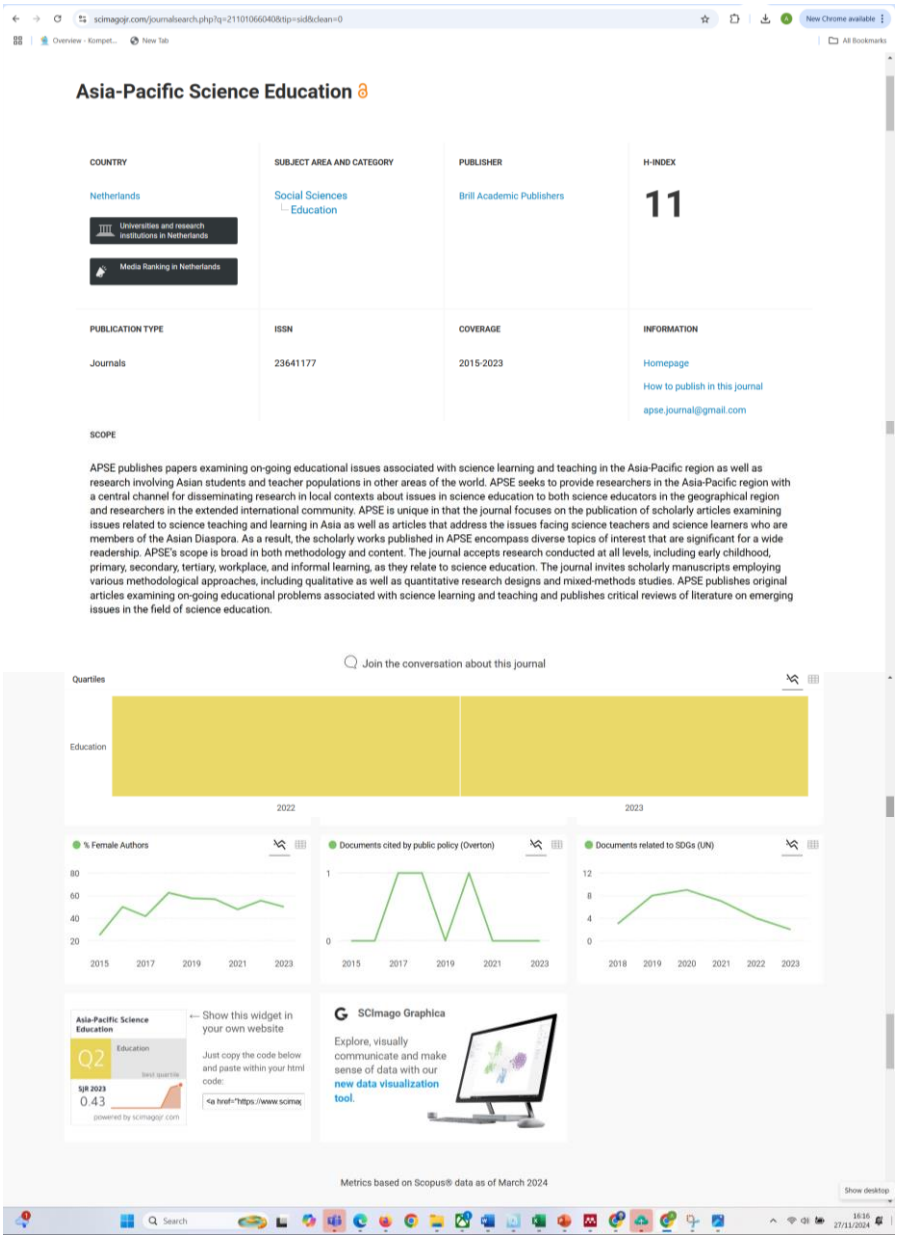
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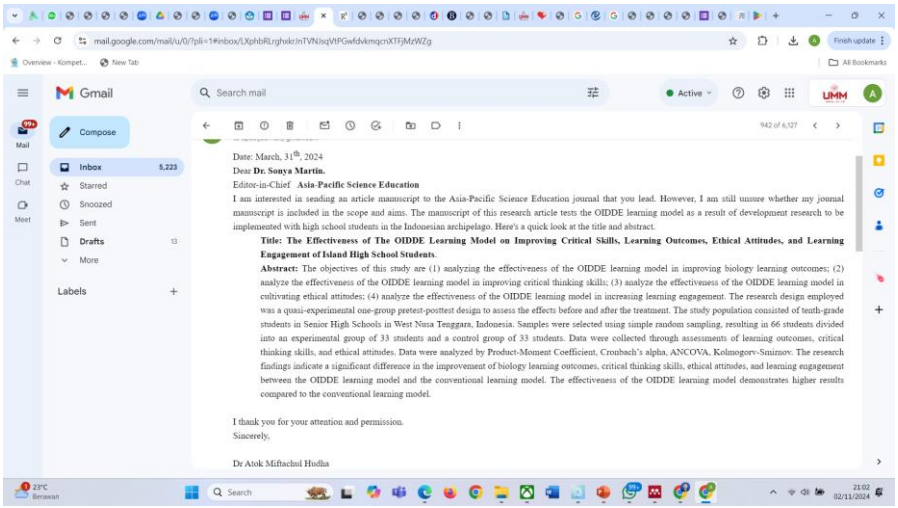


Date: March, 31th, 2024
Dear **Dr. Sonya Martin.**
Editor-in-Chief **Asia-Pacific Science Education**
I am interested in sending an article manuscript to the Asia-Pacific Science Education journal that you lead. However, I am still unsure whether my journal manuscript is included in the scope and aims. The manuscript of this research article tests the OIDDE learning model as a result of development research to be implemented with high school students in the Indonesian archipelago. Here's a quick look at the title and abstract.

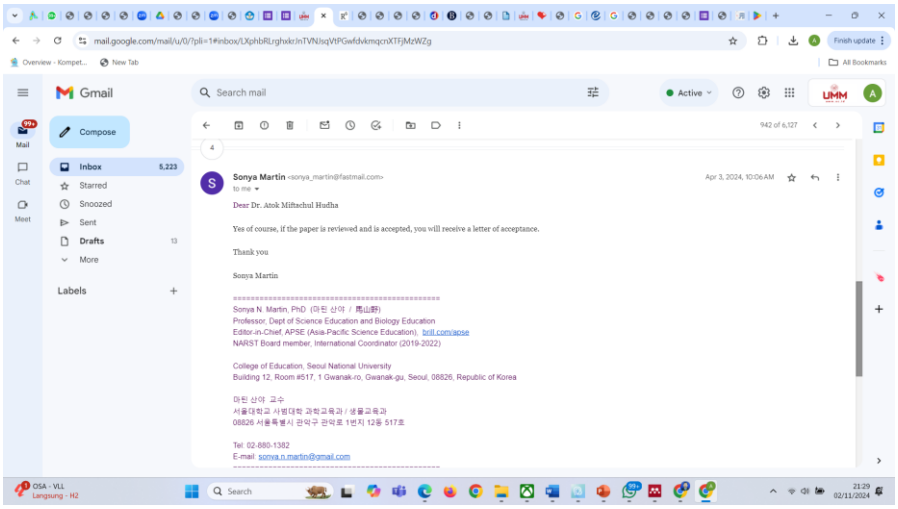
Title: The Effectiveness of The OIDDE Learning Model on Improving Critical Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students.

Abstract: The objectives of this study are (1) analyzing the effectiveness of the OIDDE learning model in improving biology learning outcomes; (2) analyze the effectiveness of the OIDDE learning model in improving critical thinking skills; (3) analyze the effectiveness of the OIDDE learning model in cultivating ethical attitudes; (4) analyze the effectiveness of the OIDDE learning model in increasing learning engagement. The research design employed was a quasi-experimental one-group pretest-posttest design to assess the effects before and after the treatment. The study population consisted of tenth-grade students in Senior High Schools in West Nusa Tenggara, Indonesia. Samples were selected using simple random sampling, resulting in 66 students divided into an experimental group of 33 students and a control group of 33 students. Data were collected through assessments of learning outcomes, critical thinking skills, and ethical attitudes. Data were analyzed by Product-Moment Coefficient, Cronbach's alpha, ANCOVA, Kolmogorv-Smirnov. The research findings indicate a significant difference in the improvement of biology learning outcomes, critical thinking skills, ethical attitudes, and learning engagement between the OIDDE learning model and the conventional learning model. The effectiveness of the OIDDE learning model demonstrates higher results compared to the conventional learning model.

I thank you for your attention and permission.
Sincerely,

Dr Atok Miftachul Hudha

5. E-mail from the Editor-in-Chief of APSE (April 3, 2024)



Sonya Martin <sonya_martin@fastmail.com>
to me

Dear Dr. Atok Miftachul Hudha

Yes of course, if the paper is reviewed and is accepted, you will receive a letter of acceptance.

Thank you

Sonya Martin

Sonya N. Martin, PhD (마틴 산야 / 馬山野)
Professor, Dept of Science Education and Biology Education
Editor-in-Chief, APSE (Asia-Pacific Science Education), brill.com/apse
NARST Board member, International Coordinator (2019-2022)

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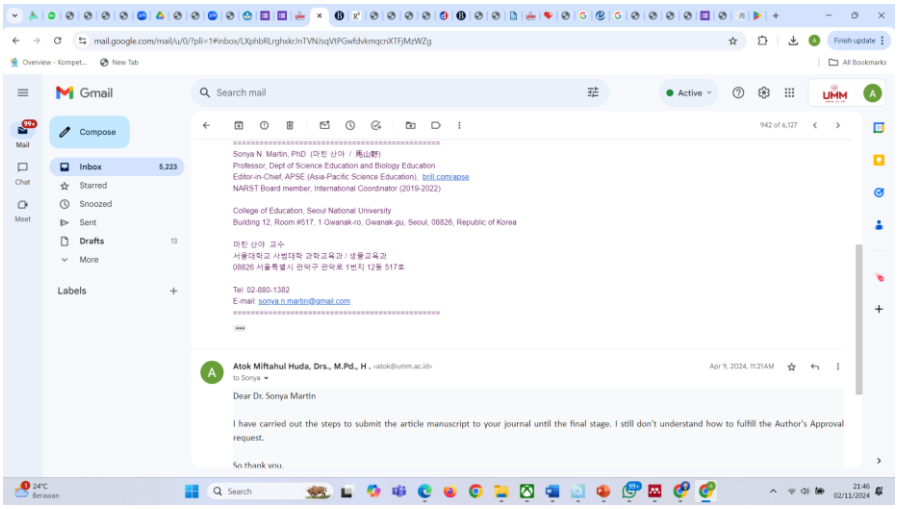
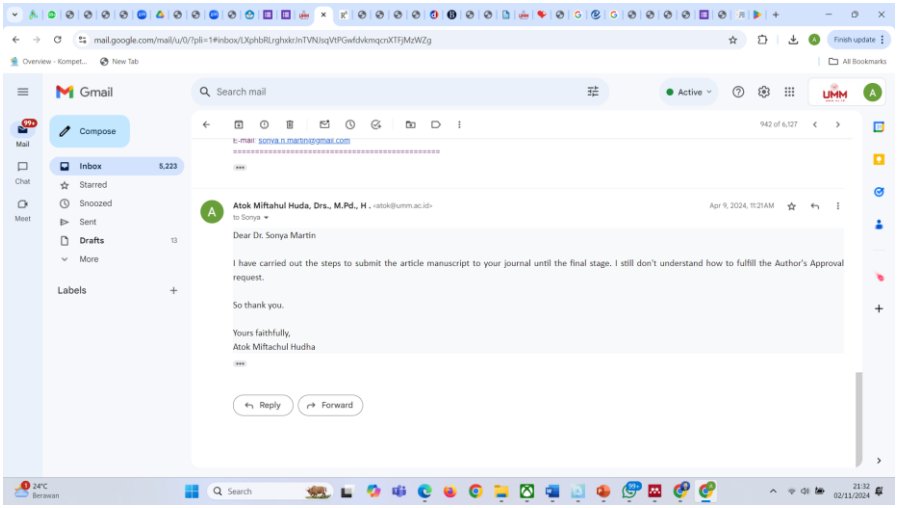
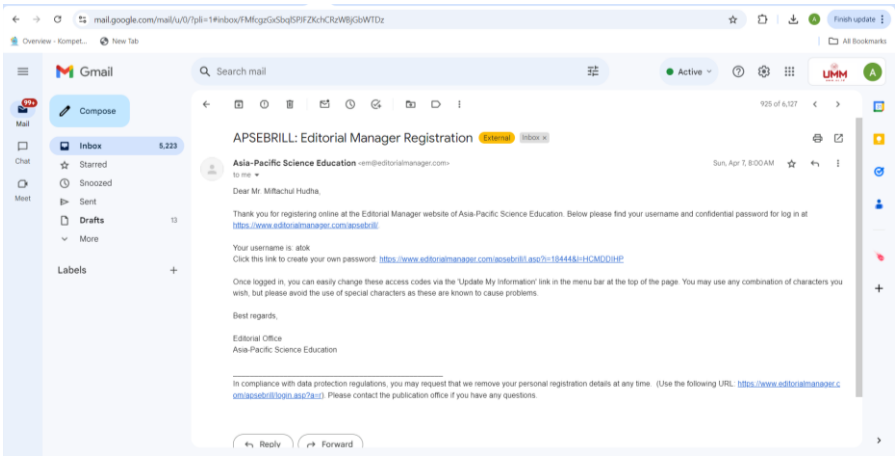


6. Manuscript submission address via OJS APSE and and email correspondence with APSE's Editor in Chief (April 9, 2024)

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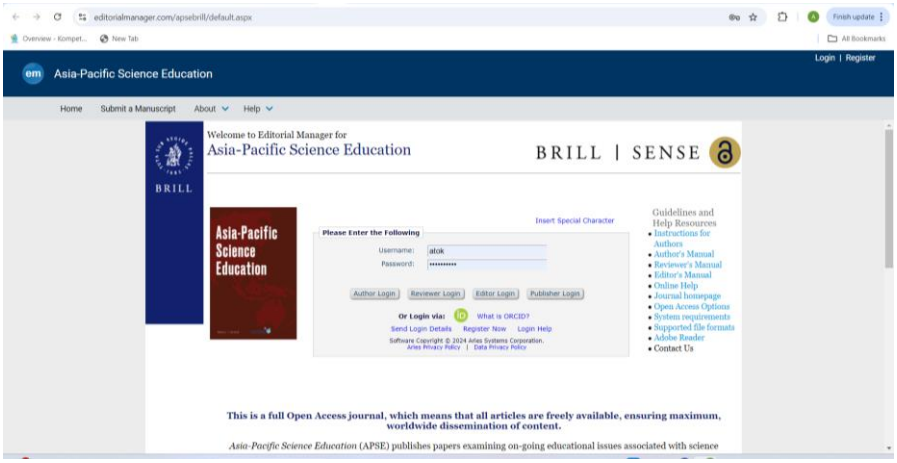
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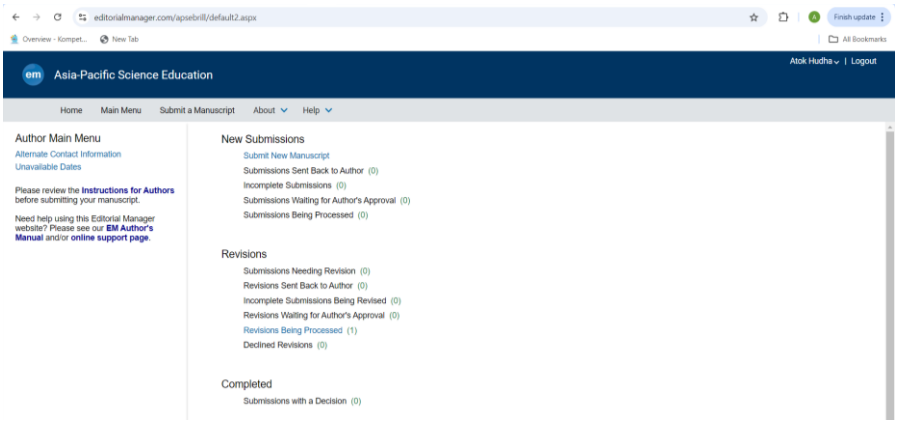
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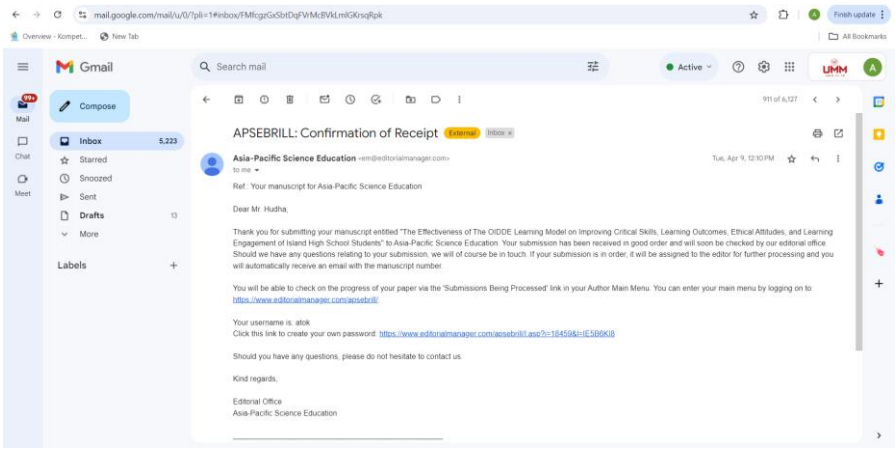

7. Submitted Manuscript to Asia-Pacific Science Education (April 9, 2024)

The Effectiveness of The OIDDE Learning Model on Improving Critical Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of High School Students

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Abstract. The objectives of this study are (1) analyzing the effectiveness of the OIDDE learning model in improving biology learning outcomes; (2) analyze the effectiveness of the OIDDE learning model in improving critical thinking skills; (3) analyze the effectiveness of the OIDDE learning model in cultivating ethical attitudes; (4) analyze the effectiveness of the OIDDE learning model in increasing learning engagement. The research design employed was a quasi-experimental one-group pretest-posttest design to assess the effects before and after the treatment. The study population consisted of tenth-grade students in Senior High Schools in West Nusa Tenggara, Indonesia. Samples were selected using simple random sampling, resulting in 66 students divided into an experimental group of 33 students and a control group of 33 students. Data were collected through assessments of learning outcomes, critical thinking skills, and ethical attitudes. Data were analyzed by Product-Moment Coefficient, Cronbach's alpha, ANCOVA, Kolmogorv-Smirnov. The research findings indicate a significant difference in the improvement of biology learning outcomes, critical thinking skills, ethical attitudes, and learning engagement between the OIDDE learning model and the conventional learning model. The effectiveness of the OIDDE learning model demonstrates higher results compared to the conventional learning model.

Keywords: *critical thinking, ethical attitudes, learning engagement, learning outcomes, OIDDE learning*

1. Introduction

Learning is a process of becoming aware of something unknown that continues continuously, and its result is a change in behaviour. Behavioural changes from the learning process produce new experiences (Djamaluddin & Wardana, 2019) and the change in behaviour as a result of learning is known as learning outcomes. Learning outcomes are the achievement of an individual's knowledge after undergoing a learning process over time in the cognitive, affective, and psychomotor domains, demonstrated by changes in individual behaviour independently (Mahananingtyas, 2017; Nurrita, 2018). Therefore, for the achievement of learning outcomes to be maximized and holistic, the learning process must be implemented to guide and equip learners with holistic skills and abilities. Holistic skills are crucial in the global era as they can be used to solve global issues (Miseliunaite et al., 2022) and specifically as a perspective in 4.0 learning 4.0 (Kolu & Nayar, 2020).

Learning in the 4.0 era, and even in the 5.0 era, especially in the field of biology in Indonesia at the high school level, has not been deeply studied, especially regarding the effectiveness of a learning model on improving learning outcomes (Azizah & Alberida, 2021; Herman & Rahmat, 2023; Imama & Rochmawati, 2021), as well as its effectiveness on critical thinking skills and ethical attitudes. It is known that learning outcomes are an important part of measuring the extent of mastery of the material taught to an individual (Fitrianingtyas & Radia, 2017), and depict what learners have achieved (Mahajan & Singh, 2017). Therefore, learning outcomes must be specific and focus on their expectations, centered on learners, and explain the performance behaviour or understanding of learners (García, 2021). The achievement of critical thinking skills will indicate an individual's ability to analyze, synthesize, evaluate, draw conclusions, and reflect on issues. Ethical attitudes depict moral actions imbued with individual responsibility for specific and holistic issues.

Biology learning cannot be separated from critical thinking skills, although Suharsono et al. (2017) state that learning outcomes do not differ significantly from critical thinking skills. However, critical thinking skills are essential in today's global life, especially in science education recognized by Kinoshita (2022) to have a broad impact on life. Therefore, the achievement of critical thinking skills must be pursued by efforts to enhance these skills. Moreover, effective teaching for the development of students' critical thinking can be developed (Kinoshita, 2022; Setyowati et al., 2018), through the development of teaching materials (Setyowati et al., 2018), and various learning models (Fuad et al., 2017). However, good learning outcomes and critical thinking skills are not meaningful if not balanced with the ethical attitudes of individuals.

If learning outcomes indicate indicators of learning achievement and the level of ability of a learning program, research related to the biology learning outcomes of students must be conducted because there have been few studies on the biology learning outcomes of students. This is one of the important issues for conducting research on biology learning outcomes in high school students through the testing of the effectiveness of the OIDDE learning model. OIDDE stands for *Orientation, Identify, Discussion, Decision, Engage in Behaviour* (Hudha et al., 2016, 2018; Hudha & Husamah, 2019).

Biology learning cannot be separated from critical thinking skills (Agnafia, 2019; Danil, 2021; Fitriyyah & Wulandari, 2019), because critical thinking skills are important for solving various problems, such as environmental issues (Santi et al., 2018), and are done in diverse learners (Hwang et al., 2023). The fact shown by Susilawati et al. (2020), is that the critical thinking skills of high school students are dominant at a low level of critical thinking skills. Critical thinking skills in biology learning can be pursued through cooperative learning (Erdogan, 2019; Leniati & Indarini, 2021; Pratiwi, 2015). Even specifically, research by Husamah, et al., (2018) on prospective

biology teacher students shows that the OIDDE learning model significantly influences the improvement of critical thinking skills. Developing critical thinking skills is essential because, according to Syafitri et al. (2021) it has a significant impact on the daily lives of students. However, research on improving students' critical thinking skills in biology learning in high school by implementing the OIDDE learning model (Hudha et al., 2018; Hudha & Husamah, 2019) is not widely found. This is partly due to the fact that the OIDDE learning model found in 2016 by Hudha et al. (2017) has not been widely socialized, so research related to the OIDDE learning model must continue to be conducted as part of its widespread socialization.

Similarly, ethical attitudes of high school students have not been widely studied. However, ethical attitudes are essential for students' lives in the global century (Hudha et al., 2018; Hudha & Husamah, 2019). Ethical attitudes are a "general feeling, both positive and negative, of an individual about ethical or unethical behaviour" (Ajzen, 2005; Madden et al., 1992). If examined, the study of ethical attitudes is broad, even the issue of how to use and utilize computers properly becomes a study of ethical attitudes (Jamil et al., 2013), pelayanan kesehatan juga menjadi cakupan kajian sikap etis yang serius (Asare et al., 2022; Sakr et al., 2022). Moreover, the study of ethical attitudes towards students and professionals (Lesińska-Sawicka et al., 2023; Wood et al., 1988), is a very important study in today's global life, but rarely made a significant focus in research.

Ethical attitudes are strongly shaped by ethical aspects because ethical aspects are consistency in applying principles, values, morals, and ethics into actions. It must be recognized that ethical attitudes play a very important role in shaping character and values in each individual. Moreover, educational character in society truly functions to shape individuals to be moral, noble, tolerant, and well-behaved (Tsoraya et al., 2023). However, the problem is that in biology learning, there are not many teachers or lecturers who reinforce the ethical attitudes of their students through the study of learning materials in the teaching and learning process in the classroom, including at the high school level. This is evidence that research on ethical attitudes in learning related to the effectiveness of a learning model has not been widely conducted. However, according to Chowdhury (2016) education and teaching related to science need to emphasize morals, values, and ethical attitudes.

The importance of research on students' ethical attitudes is based on the fact that the increasing prevalence of negative student behaviour, such as violating school rules, skipping school, cheating in exams, disrespecting teachers, and fighting (Dari, 2014; Hudha, et al., 2018), and the emergence of ethical behaviour deviations of high school students (Ardiana et al., 2022) Must be sought for appropriate solutions and ways out. Therefore, learning aimed at improving ethical attitudes needs to be examined through research, and the OIDDE learning model (Hudha et al., 2016, 2018; Hudha & Husamah, 2019) is chosen as the preferred solution. Especially in addressing ethical issues among high school students, the effectiveness of the OIDDE learning model in improving the ethical attitudes of students needs to be analyzed through research.

Similarly, the study and research of learning engagement are crucial because learning engagement are related to the behaviour of students who genuinely undergo the learning process, building changes in their behaviour through learning. Efforts to enhance learning engagement are carried out by many researchers, including using the Student Facilitator and Explaining learning model (Purbayanti et al., 2022), contextual learning models and Problem-based Learning (As-Sa'idah & Dedih, 2022), and even associated with the blended web mobile learning model (Hariadi et al., 2022). However, research related to learning engagement has not been widely studied using the OIDDE learning model, in fact it seems that it has never been carried out by any researcher. Therefore, the OIDDE learning model is a new hope for the birth of innovative learning models in the global era to answer holistic problems of education and learning. These holistic issues are learning outcomes, critical thinking skills, ethical attitudes, and

learning engagement. For this reason, the aim of this research is to analyze the effectiveness of the OIDDE learning model in improving learning outcomes, critical thinking skills, ethical attitudes, and learning engagement in biology learning for high school students.

The OIDDE learning model is a learning model resulting from valid, reliable, practical and effective development research by Hudha (2016). The OIDDE learning model is an acronym for *Orientation, Identification, Discussion, Decision*, and *Engage in Behaviour* has five syntaxes as in Table 1.

Table 1. Syntaxes of OIDDE learning model

Syntaxes	Teacher/Lecturer Activities	Students Activities
Phase 1: ***Orientation***	a. Prepare and direct students to learn about the material or subject to be studied. b. Presenting learning material is associated with strengthening values or character elements regarding the ethical problems of life (bioethics). c. Presenting case stories from authentic facts, historical narratives, videos or documentaries that support the problems of the material being studied (for moral values, you can direct them to ethical problems)	a. Prepare and direct himself to learn about the material or subject matter that will be studied with the teacher. b. Receive material by listening, observing and taking notes independently and carefully. c. Pay careful attention to case stories from authentic facts, historical narratives, videos or documentary films related to the problems presented by the teacher or lecturer.
Phase 2: ***Identify***	a. Directing and assigning individual students to identify findings of various (ethical) dilemmas from problems presented by teachers or lecturers through case stories, authentic facts, historical narratives, videos or documentary films related to the material being studied. b. Ask students to randomly provide a brief explanation of the (ethical) dilemma that has been identified.	a. Identify dilemmas (directed towards ethical issues) in problematic presentations related to teaching material presented by teachers or lecturers through case stories, authentic facts, historical narratives, videos or documentary films. b. Select priority (ethical) dilemma issues as material for group discussion. c. Briefly explain to the teacher or lecturer the identified (ethical) dilemma (become a topic for class discussion).
Phase 3: ***Discussion***	a. Divide students into small heterogeneous groups of 4-5 people in each group. b. Directing students to deliberate to determine the topic of group discussion from the results of identifying each individual's (ethical) dilemma. c. Direct all discussion groups to determine roles or positions that are appropriate to the discussion topic. d. Become a facilitator for group discussions. e. Become a moderator for the presentation of the discussion results for each group.	a. Form heterogeneous discussion groups of 4-5 people per group. b. Deliberate to agree on priority discussion topics for the group based on the results of identifying each individual's (ethical) dilemma. c. Agree on a role or position that suits the discussion topic. d. Carry out discussions democratically, honestly and ethically. e. Present together the results of the group discussion in front of the class and conduct questions and answers with other groups.

	f. Direct each discussion group to write down the results of their group discussion to be used as a basis for (ethical) decision making.	f. Compile the results of discussions to be used as a basis for (ethical) decision making.
Phase 4: ***Decision***	a. Direct each discussion group to determine (ethical) decision formulations from the results of their group discussions. b. Direct each student to formulate (ethical) decisions on their group discussion topics individually. c. Direct each student to write individually the formulation of their (ethical) decision based on the problems of the discussion topic.	a. Determine the formulation of (ethical) decisions resulting from group discussions. b. Formulate individual (ethical) decision formulations regarding (ethical) dilemmas based on the group discussion topic. c. Determine and write individual (ethical) decision formulations on sheets of paper that have been prepared by the teacher or lecturer.
Phase 5: ***Engage in behaviour***	a. Encourage students to write honestly their form of (ethical) behavioural involvement regarding the discussion problems based on (ethical) decisions expressed verbally on the piece of paper provided. b. Inviting students to draw conclusions from learning results and class (group) discussions by providing motivation to become good and responsible academic people.	a. Write honestly the form of behavioural (ethical) involvement in the problematic discussion based on the (ethical) decision stated verbally on the piece of paper provided. b. Draw conclusions from learning results and group discussions with teachers or lecturers in a good and responsible manner.

(Hudha, 2016)

1.1 Research Focus

This research focuses on testing the effectiveness of the OIDDE learning model for high school students through biology learning materials, namely: (1) How does the effectiveness of the OIDDE learning model improve high school students' biology learning outcomes?; (2) How does the effectiveness of the OIDDE learning model improving critical thinking skills?; (3) How does the effectiveness of the OIDDE learning model improve the ethical attitudes of high school students?; (4) How does the effectiveness of the OIDDE learning model increasing high school students' learning engagement?

2. Research Methodology

2.1 General Background

This research is a quasi-experimental study with a control group using a non-equivalent pre-test post-test research design. The implementation of the OIDDE learning model is carried out in the experimental group, while the conventional learning model is implemented in the control group, as shown in Table 2.

Table 2. ***Research design table***

Group	Pre-test	Treatment	Post-Tes
E	O_1	X_1	O_2
C	O_3	X_2	O_4

This research was conducted on tenth-grade students at a Senior High School through biology learning on the topic of ecosystems. During the research, students covered eight topics: components of ecosystems, interactions between components, succession, types of ecosystems,

ecological paradigms, food chains, biogeochemical cycles, and environmental changes. Teaching and learning engagement were held once a week, with each session lasting 100 minutes.

The OIDDE learning model was applied in each session following the steps outlined by Hudha et al. (2017) and Hudha et al. (2018), which include *Orientation, Identify, Discussion, Decision, and Engage in Behaviour*. The conventional learning model, on the other hand, represents the commonly employed teaching method in the subject by teachers. This prompted the need for innovative teaching models in the implementation of biology education in Senior High School. This is supported by various research findings indicating that innovative teaching models provided to the experimental group enhance conceptual understanding more than conventional teaching methods in the control group (Artayasa, 2017).

The implementation of the OIDDE learning model followed each phase systematically. Phase 1: *Orientation*. In this phase, the teacher presented the lesson to stimulate students' curiosity about ecosystem issues through a documentary film on human behaviour towards ecosystems that are unethical. Phase 2: *Identify.* The teacher assigned each student to identify ecosystem problems and ethical issues related to the taught material and the presented documentary film for discussion. Phase 3: *Discussion*. Students were divided into small, heterogeneous groups (4-5 individuals) to initiate discussions and decide discussion topics based on the identified ecosystem problems and ethical issues from the identification phase. Discussion results were presented in front of the class by each group member, not by a representative spokesperson. It is in this phase that the critical thinking abilities of each student, both individually and as a group, can be observed. Phase 4: *Decision*. Each group's discussion results became ethical decisions based on their respective discussion topics. These ethical decisions from group discussions became critical skills for each group member. Besides each group determining ethical and critical decisions, each group member individually also had to make critical decisions about their discussion topic for further action and behaviour. Phase 5: *Engage in Behaviour*. Ethical and critical decisions from each group discussion were followed by ethical behaviour in the form of honest statements in writing. Written statements about honest and confident ethical actions describe the true ethical behaviour of the students.

2.3 Research Sample

The population in this study consisted of class X Odd Semester students at SMA Muhammadiyah Masbagik, East Lombok, and West Nusa Tenggara, Indonesia, totaling 66 people. The research sample was taken from the population, namely 33 students in class X-A as the experimental group and 33 students in class X-B as the control group.

2.3 Instrument dan Prosedur

Data on learning outcomes, critical thinking skills, ethical attitudes, and biology learning engagement were obtained through test results (pre-test and post-test). The implementation of the OIDDE learning model was assessed using an observation sheet to measure four aspects: (1) the implementation of the OIDDE learning model syntax, (2) the implementation of the social system, (3) the implementation of reaction principles, and (4) the implementation of support systems. Observations were conducted throughout the learning process from the beginning to the end. The scoring categorization for the implementation of the learning model had four categories: (1) Low (not implemented well), (2) Moderate (implemented sufficiently), (3) High (implemented well), and (4) Very High (implemented very well).

Tests were administered to both groups twice, namely the pre-test and post-test. Before the test instrument was applied, item validation was conducted using Pearson Correlation and processed using SPSS 22.0 for Windows. The results of the test instrument validation showed that each test item was deemed valid, with a p-value < 0.05. The reliability of the test items was assessed using

the Cronbach alpha technique, and the Cronbach's alpha value of 0.669 indicated that the test items were reliable for use (Arikunto, 2006; Siegar, 2015; Sudjana, 2008).

2.4 Data Analysis

The difference in the effectiveness of the OIDDE learning model and the conventional learning model in improving learning outcomes, critical thinking skills, and ethical attitudes was analyzed using Analysis of Covariance (ANCOVA). The values obtained in the pre-test served as covariates to determine whether the post-test results differed significantly. Before applying ANCOVA, tests for normality using Kolmogorov-Smirnov and homogeneity using Levene were conducted. The assessment of learning effectiveness was performed by analyzing the percentage difference in the effectiveness of the OIDDE and conventional learning models in improving ethical attitudes using the ANCOVA test. All data analyses were conducted using statistical software, specifically SPSS for Windows version 22.

3. Research Results

The results of the data analysis to assess the improvement in biology material learning outcomes in the experimental and control groups are presented in Table 2. The ANCOVA analysis results in Table 3 indicate the difference in the effectiveness of the OIDDE learning model in achieving biology learning outcomes.

Table 3. ***Results of one-way ANCOVA test on biology learning outcomes of high school students***

Source	*df*	*F*	*Sig.*
Xlearning Outcomes	1	9.434	.004
Class	1	27.643	.000
Error	37		

Based on the results of the One-Way ANCOVA test, as shown in Table 3, it is known that the difference in the calculated F value for the learning model is 27.643 with a p-value of <0.0001. Thus, it is established that the null hypothesis (HO), which states that there is no difference in learning outcomes between the experimental and control classes, is rejected. The research hypothesis, which posits that there is a difference in learning outcomes between the experimental and control groups, is accepted. Therefore, the OIDDE learning model has an impact on improving the learning outcomes of high school students.

The analysis of the corrected means in each group, namely the experimental group with the OIDDE learning model and the control group with the conventional learning model, is presented in Table 4

Table 4. ***Mean corrected scores of high school students' learning outcome***

Group	Pre-test	Post-test	Difference	Enhancement	Corrected Mean
Conventional	45.85	65.05	19.2	42	65.850
OIDDE	49.85	78.15	28.3	57	77.350

According to Table 4, it is evident that the biology learning outcomes in the experimental class with the OIDDE learning model are more effective compared to the biology learning outcomes in the control class using the conventional learning model. The improvement in learning outcomes for high school students in the experimental group is 57%, while the improvement for high school students in the control group is 42%. This indicates that the OIDDE learning model has an impact on achieving improvement in biology learning outcomes for high school students.

Further analysis involves testing the influence of the OIDDE learning model on the achievement of critical thinking skills, as shown in Table 5.

Table 5. ***ANCOVA test results on high school students' achievement of critical thinking skills.***

Source	*df*	*F*	*Sig.*
XCritical Thinking	1	26.466	.000
Class	1	25.183	.000
Error	37		
Total	40		

Based on the results of the ANCOVA test, as shown in Table 5, it is known that the calculated F value for the difference in the OIDDE learning model treatment is 25.183 with a p-value of < 0.0001. Thus, the null hypothesis (HO) stating that there is no difference in the improvement of critical thinking skills between the experimental and control groups is rejected. Therefore, the research hypothesis, which suggests a difference in the improvement of critical thinking skills between the experimental and control groups, is accepted. Hence, it can be stated that the OIDDE learning model has an influence on improving critical thinking skills in high school students. In this study, the Least Significance Different (LSD) test is not required since the study consists of only two treatments. The analysis of the corrected means for each class in the experimental and control groups is presented in Table 5.

Based on the results of the ANCOVA test, as shown in Table 5, it is known that the calculated F value for the difference in the OIDDE learning model treatment is 25.183 with a p-value of < 0.0001. Consequently, we reject the null hypothesis (H0) positing no difference in the enhancement of critical thinking skills between the experimental and control groups. As a result, the research hypothesis, indicating a distinction in the improvement of critical thinking skills between the experimental and control groups, is accepted. Thus, it can be affirmed that the OIDDE learning model significantly contributes to the enhancement of critical thinking skills in high school students. Notably, the study, comprising only two treatments, does not necessitate the application of the Least Significant Difference (LSD) test.

The analysis of the corrected means for each class in the experimental and control groups is presented in Table 6.

Table 6. ***Corrected mean of critical thinking skills for high school students***

Group	*Pre-test*	*Post-test*	Difference	Enhancement	Corrected Mean
Conventional	67.20	8.39	7.65	11%	74.490
OIDDE	66.00	7.73	17	26%	83.360

Based on Table 6, it is evident that the achievement of improvement in critical thinking skills in the experimental group, i.e., high school students receiving the OIDDE learning model, is significantly higher compared to the critical thinking skills of the control group, i.e., high school students receiving conventional learning. The improvement in critical thinking skills for the experimental group is 26%, while for the control group, it is 11%. This indicates that the OIDDE learning model has an impact on enhancing critical thinking skills in high school students.

Further analysis involves testing the influence of the OIDDE learning model on the attainment of ethical attitudes in high school students, as shown in Table 7.

Table 7. ***Results of one-way ANCOVA test on ethical attitudes of high school students.***

Source	*df*	*F*	*Sig.*
Class	1	24.439	.000
Error	37		
Total	40		

Based on the results of the One-Way ANCOVA test in Table 7, the calculated F value for the OIDDE learning model treatment is 24.439 with a p-value of 0.001. Thus, the null hypothesis

(HO) stating that there is no difference in the achievement of improvement in ethical attitudes between the experimental and control groups is rejected.

Therefore, the research hypothesis, which suggests a difference in the achievement of ethical attitudes between the experimental and control groups, is accepted. This means that the OIDDE learning model has an impact on enhancing the ethical attitudes of high school students. The analysis of the corrected means for each class is presented for both the experimental and control groups, as shown in Table 8.

Table 8. ***Corrected mean of ethical attitudes for high school students*.**

Group	*Pre-test*	*Post-test*	Difference	Enhancement	Corrected Mean
Conventional	67.00	74.85	7.85	12.00%	74.612
OIDDE	66.20	83.00	21.80	25.00%	83.233

Based on Table 8, it is evident that the attainment of ethical attitudes among high school students who received the OIDDE learning model in the experimental group is significantly higher compared to high school students who received the conventional learning model in the control group. The achievement of ethical attitudes for high school students in the experimental group is 25%, while the achievement for high school students in the control group is 12%. This indicates that the OIDDE learning model has an impact on achieving an improvement in the ethical attitudes of high school students.

The research results showed that the OIDDE learning model had a significant impact on improving learning outcomes, critical thinking skills and ethical attitudes of the experimental group. The overall learning engagement aspect shows that the learning involvement of the experimental group is higher than the learning engagement of the control group, which is different between the experimental group and the control group, as seen in Table 9.

Table 9. ***The level of learning engagement of high school students in the learning model***

Learning Model	Percentage	Criteria
Conventional	70%	Active
OIDDE	78%	Active

Based on Table 9, it can be seen that the application of the OIDDE learning model increases the learning engagement of high school students by 78%, while the conventional learning model increases the learning engagement of high school students by 70%. The results of this study can illustrate the positive impact of the OIDDE learning model on the experimental group's high school students. The results of this study illustrate the response to the influence of the OIDDE learning model on high school students of the experimental group.

The results showed that high school students in the experimental group really enjoyed learning biology with the OIDDE learning model which was shown by their increased learning engagement. The learning environment is very enjoyable, providing engaging experiences that enhance learning outcomes, critical thinking skills, and ethical attitudes. In particular, the problems presented in biology learning encourage ethical behaviour in everyday life. Another interesting thing is that students in the experimental group felt that the time provided for learning biology in class felt insufficient because the teaching and learning process seemed to run quickly. This shows a conducive, interesting, and fun learning atmosphere with the OIDDE learning model, so it does not feel that learning time is over.

Different scenarios unfolded in high school seniors in the conventional group, who did not provide feedback on the applied learning model. Students in conventional groups (control groups) simply express enjoyment in learning biology because the material is beneficial to life. However, it is different when compared to students in the experimental group who suggest, that the OIDDE learning model should not only be applied in biology but also in other subjects such

as physics, chemistry, and others. What appealed to students in the experimental group was that each syntax of the OIDDE learning model was new and fun.

4. Discussion

The research results indicate that the average scores for biology learning outcomes in the ecosystem, critical thinking skills, and ethical attitudes in the experimental group are significantly higher than those in the control group. This suggests that the implementation of the OIDDE learning model is more effective in enhancing the learning outcomes, critical thinking skills, and ethical attitudes of high school students compared to the conventional model. This aligns with previous research findings that both qualitative and quantitative analyses play a crucial role in determining learning outcomes (Orsmond et al., 2006), Moreover, studies have shown that the OIDDE learning model improves the critical thinking abilities of biology teacher candidates (Fatmawati, et al., 2018), and enhances 21st-century skills, including critical thinking and creative thinking (Ma'rifatillah et al., 2019). Other researchers emphasize the importance of ethical attitudes in biology learning (Kohli et al., 2015; Chen & So, 2017), and specifically, the OIDDE learning model has been found to enhance the ethical attitudes of prospective biology teachers (Hudha et al., 2018).

While educators use various learning models, the OIDDE learning model stands out due to its significant syntax in improving learning outcomes, critical skills, and ethical attitudes. As highlighted Hudha et al. (2017) and Hudha et al. (2018), the five syntaxes of the OIDDE learning model—*Orientation, Identify, Discussion, Decision*, and *Engage in Behaviour*—promote learner-centered education. This is particularly relevant given the current emphasis on learner-centered education (Dada et al., 2022; Khoury, 2022 ; Berg & Lepp, 2023).

In the first syntax of the OIDDE learning model, *Orientation*, students receive conceptual-factual learning related to environmental issues around them and global challenges. This is reinforced visually through video presentations and documentary films supporting the learning material. This approach aligns with the notion that providing orientation can make learning interesting by presenting stories, historical narratives, or documentaries Joyce et al. (2009). Orientation in learning has a significant impact on performance (learning outcomes) and learner attitudes (Ekhsan et al., 2019).

The learning outcomes of high school students in the experimental group are higher than those in the control group, proving the reliability of the first syntax (Orientation) of the OIDDE learning model in improving learning outcomes. This is consistent with the view that orientation is a focal point for learning outcomes Breen-wenninger and Louis, (2020). Learning outcomes are crucial for measuring the success of students in various subjects, including biology (Rahmi et al., 2021; Sari, 2019; Toman, 2018). The implementation of the OIDDE learning model in high school biology education is particularly apt as it encourages students to actively engage in their learning process.

Furthermore, the importance of learning outcomes has been studied in various instructional models, such as history education (Mahardika et al., 2023). However, the implementation of the OIDDE learning model in high school biology education is particularly suitable for enhancing learning outcomes. This is because the OIDDE learning model has encouraged students to actively engage in their learning process.

In the second syntax implementation, *Identify,* it was observed that high school students were capable of identifying life dilemmas presented contextually and factually during the orientation phase (first syntax). The ability to identify life dilemmas presented by the teacher indicates that the OIDDE learning model enhances the critical thinking abilities and skills of high school students, especially in the 21st century (Heard et al., 2020; Kuloğlu & Karabekmez, 2022; Rahardhian, 2022; Saleh, 2019). This is also emphasized by Suciono et al. (2020), stating that improving critical thinking skills in students requires a learning model that encourages the

enhancement of critical thinking skills. The results of this study have answered and demonstrated that the OIDDE learning model is capable of improving the critical thinking skills of students. According to Suciono et al. (2020), and Rosmaini (2023) attention must still be paid to the physical condition, intellectual development, and motivation of students in order to achieve an improvement in their critical thinking skills.

Similarly, in the third syntax, *Discussion,* the implementation of discussions follows the views of Arends (2009) and Arends (2012) where students are divided into small groups (4-5 people), in a heterogeneous manner, avoiding large groups. Through small group discussion activities, the atmosphere of biology learning becomes more tangible and conducive to creating learning engagement, thereby enhancing critical thinking skills both individually and in groups. Moreover, when the implementation of this syntax becomes part of the learning strategy, the learning strategy impacts the improvement of critical thinking skills (Benedicto & Andrade, 2022; Samani et al., 2019), and critical thinking skills have an impact on improving student learning (Ahmed & Ibrahim, 2023). his also reinforces the idea that improving critical thinking is crucial for students at any educational level (Sheergojeri, 2020), for success in the 21st century (Živkovic, 2016). Especially since critical thinking drives the development of teaching approaches, instructional models, and modern education, especially in the current era of digital-based education (Varenina et al., 2021). The biology learning process provided to high school students through discussion, among other things, encourages the formation of teamwork character. As stated by Kvellestad et al. (2021), teamwork fosters the development of specific interactions, namely cooperation and collaboration..

The process of discussing ethical dilemmas in the ecosystem within heterogeneous discussion groups in the OIDDE learning model not only enhances learning outcomes but also improves critical thinking skills. This is supported by findings that the exploration and analysis of a problem through discussion methods are more effective than lecture methods. The discussion method has an effect on increasing students' knowledge (Sakiyah et al., 2015), and learning outcomes (Ermi, 2015), and enhancing students' interest in learning, teamwork skills, improving retention of knowledge and skills, enhancing the transfer of concepts to innovative issues, and promoting students' self-directed learning (Agustina et al., 2020), and satisfaction in learning (Arja et al., 2020).

As indicated in the research findings, the thought patterns of high school students are always based on the importance of saving the ecosystem, namely: (1) viewing the Earth's ecosystem must be protected from damage; (2) the Earth's ecosystem is damaged due to irresponsible human behaviour; (3) the Earth's ecosystem must always be approached with a conservation concept to preserve biodiversity; (4) the importance of preserving the ecosystem for the sustainability of the current and future generations. These four aspects, in relation to ecosystem preservation, involve efforts to save biodiversity, conservation, and ecosystem restoration (Paiola et al., 2020; Fischer et al., 2021). This means that the syntax of the OIDDE learning model supports the improvement of learning outcomes, critical thinking, and the emergence of ethical attitudes in students.

Another new finding is the presentation of group discussion results presented in front of the class by all members of the group. Contrary to the conventional practice of having a representative present the group's discussion results, this new finding brings forth many positive aspects, including: (1) fostering collaboration among group members; (2) students gaining experience in presenting and expressing their opinions independently in front of their peers; (3) learning centered on students emerging; (4) the cultivation of mutual respect and the emergence of critical thinking, collaboration, communication, and even; (5) the creation of enjoyable learning for students.

The implementation of the fourth syntax, *Decision*, is closely related to aspects of learning outcomes, critical thinking skills, and ethical attitudes. This syntax supports the improvement of

learning outcomes, critical thinking skills, and ethical attitudes. This is demonstrated by a new finding in the research, namely, the students' ability to present the coverage of ecosystem learning materials followed by making ethical decisions that have never been done before. Ethical decisions resulting from group discussions become collective decisions that depict the excellence and effectiveness of the applied OIDDE learning model.

The fifth syntax stage, *Engage in behaviour*, represents a form of involvement in behaviour that is the culmination of implementing the OIDDE learning model. The behavioural involvement of high school students, as demonstrated through ethical attitudes, aligns perfectly with the OIDDE learning model and is unlikely to be found in other learning model syntaxes. This is based on the finding that the behavioural involvement of students after participating in periodic ecosystem biology learning with the OIDDE learning model is honest evidence of their actions, both in verbal statements in oral form (Azwar, 2012) and in affective and conative attitudes(Ajzen, 2005; Azwar, 2012).

The attainment of improved ethical attitudes among students, complementing the enhancement of biology learning outcomes and critical thinking skills in the experimental group compared to the control group, is evidence that the OIDDE learning model has a high level of effectiveness compared to the conventional learning model. Therefore, the OIDDE learning model is of higher quality, as it generates a more conducive, comprehensive, competitive, and holistic learning process. This positions the OIDDE learning model as an advanced learning model that places students as the subjects of learning (*Student-centered Learning*) rather than being the objects of learning (Doyle, 2023).

Regarding the ethical attitudes of students, the findings of this research indicate that the improvement in ethical attitudes among high school students in the experimental group is better than the ethical attitudes of high school students in the control group. This suggests that the OIDDE learning model is more effective than conventional learning. The fifth syntax of the OIDDE learning model, *Engage in behaviour*, emphasizes the honesty of students in the experimental class to demonstrate their ethical attitudes as a form of behavioural involvement that must be carried out sincerely. Moreover, strong ethical attitudes can serve as a foundation for honest actions and behaviours (Ellemers et al., 2019; Engelbrecht et al., 2015; Priyana & Jasuni, 2022). This is the advantage of the OIDDE learning model, which can bring forth statements of ethical attitudes through learning, expressed sincerely by students in the implementation of the fifth syntax, Engage in Behaviour.

The superiority of the OIDDE learning model also encourages students to express their behavioural involvement ethically individually, independently, with integrity, and honestly. This is not found in other learning models, especially according to Chairilsyah (2016), where honesty is the most important aspect of daily life. Similarly, honesty encourages someone to behave honestly (Cooper et al., 2023). and even honesty is closely related to well-being (Bonnie et al., 2022). Therefore, ethical attitudes become a mirror of honesty, and honesty is a fundamental aspect needed in various aspects of life.

Shaping ethical attitudes is not an easy task, especially in the learning process in the classroom through the study of subject matter. However, this research proves that through the identification of ethical problems, followed by discussions on ethical dilemmas and ethical decision-making, behavioural involvement decided becomes the ethical attitudes of students. This is supported by the *tripartite attitude theory* (Azwar, 2012) which asserts that beliefs about specific attributes or the entirety of an object (cognitive), emotions or feelings toward specific attributes or the entirety of an object (affective), and behavioural intentions related to specific attributes or the entirety of an object (conative) will result in overall attitudes, particularly ethical attitudes.

Ethical attitudes require an individual's responsibility and integrity, which should not be compromised by anyone. This suggests a recommendation that cultivating ethical attitudes

requires strong and sturdy attitudes of responsibility and integrity. Responsibility and integrity are two crucial aspects of values and character that need to be nurtured in students. These two crucial elements are the foundation for the growth of ethical attitudes and provide findings to be further pursued in subsequent research. Integrity is defined as the quality of being honest and having strong moral principles (Cambridge Dictionary, 2023) in an individual. It represents a person's honest nature (Endro, 2017), and consistent actions in line with values (Mubin, 2018).

The research results, showing that the level of learning activity in the experimental group is higher than in the control group, indicate that the OIDDE learning model can cultivate a conscious attitude among students to genuinely build behavioural change through learning. Regardless of its impact, an individual's personality turns out to be a factor influencing learning outcomes Fandos-Herrera et al. (2023). The OIDDE learning model is highly significant in building personality because, through its learning steps, it builds the personality of students to become individuals with high integrity.

Therefore, it is important to recommend that fostering integrity is about nurturing commendable attitudes that depict the alignment of one's words and actions. Thus, it can be stated that the OIDDE learning model can improve biology learning outcomes, critical thinking skills, shape and strengthen the ethical attitudes of students, and also enhance students' engagement in learning. The results of this research encourage further investigation related to measuring attitudes and attitude formation based on Fishbein and Ajzen (Martin & Ajzen, 1975) supported by aspects of responsibility, honesty, moral aspects, and self-integrity in broader research studies on students, while still being connected through the implementation of the OIDDE learning model.

5. Conclusion

The effectiveness of the OIDDE learning model surpasses conventional learning, particularly in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among high school students. The efficacy of the OIDDE learning model in this research is evident from the positive responses received from all participants in the experimental group. The experimental group expressed great satisfaction with learning biology through the OIDDE learning model, citing a delightful learning atmosphere, engaging experiences, and the encouragement of the growth and honing of critical thinking skills. This indicates a conducive, appealing, and enjoyable learning atmosphere created by the OIDDE learning model. The experimental group also voiced their opinion that the OIDDE learning model should not only be applied in biology but also in other subjects such as physics, chemistry, and others. What the experimental group found intriguing was that each syntax of the OIDDE learning model brought something new and enjoyable, prompting them to express confidence that the OIDDE learning model would remain captivating when implemented in subjects beyond biology. Therefore, it can be recommended that the OIDDE learning model is a preferred choice for problem-solving education in the global era (21st century) across various life domains and disciplines.

6. Limitations

The main limitation of this study is that the research findings originate from a single high school in the subject of biology, making it not possible for generalization. However, this study serves as a solid foundation for implementing the OIDDE instructional model in other subject contexts. Another limitation is that the OIDDE instructional model is a newly introduced learning model for high school students and teachers in the research location. Nevertheless, the study is strengthened by introducing and enriching teachers with the model's application.

7. Recommendations

The research found that experimental class students had interesting experiences in learning biology using the OIDDE learning model. Therefore, in line with the statement of experimental class students who asked for the application of the OIDDE model to subjects other than biology, it is recommended that: (1) the OIDDE learning model be disseminated more widely to teachers

and lecturers in various fields of science to be implemented in learning at schools and universities; (2) the OIDDE learning model is an alternative innovative learning model in the global era.

8. Author Contributions

All authors have provided sufficient contributions to this research and have agreed with the findings, discussions, and conclusions.

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8. First revision suggestion from Reviewer 2 and Reviewer 3 Via E-Mail (May 1, 2024).

APSE-1136: Please revise your manuscript External Inbox ×

Sonya N Martin <em@editorialmanager.com> May 1, 2024, 8:27 PM
to me

Ref.: Your submission (APSE-1136)

Dear Mr. Hudha,

The review of your article "The Effectiveness of The OIDDE Learning Model on Improving Critical Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students" (APSE-1136) is complete. Based on the reviewer comments, the decision is made to "accept, with moderate revision".

While the suggestions for edits made by the reviewers are numerous, the revisions primarily involve clarifying and expanding upon existing content rather than conducting extensive new research or data collection. If you can revise the paper in a short period (4-6 days) there is a possibility that if your paper could be revised and reviewed again in the next 5-8 days - if accepted, it could potentially be included in the June 2024 issue. However, we have limited time.

You will find the submission in the 'Submissions Needing Revision' folder in your Author Main Menu. When submitting the revised article, please also include a detailed, point-by-point response to the review comments of the reviewers at the bottom of this email. This should be uploaded as 'Response to Reviews'. To assist in your revisions, I have made some clear recommendations below.

REVISIONS REQUESTED:

Title
Clarify the title by including the phrase "Critical Thinking Skills" in the title (Reviewer #3)

Abstract
- Provide a clearer rationale and background for the study, addressing ambiguities such as "high school students in the islands."
- Clarify the effectiveness of the OIDDE learning model compared to conventional models.

Introduction Section
- Improve clarity and coherence in the introduction, including explanations of key concepts.
- To strengthen the rationale for using the OIDDE Learning Model, emphasize the originality of the OIDDE model and its comparison with prior research.
- Ensure coherence within and between paragraphs, and clarify complex concepts such as "Learning in the 4.0 and 5.0 eras" (Reviewer #3).

The OIDDE Learning Model
- Strengthen the argumentation and conceptual framework of the OIDDE learning model, including its relationship with other learning models and its intended outcomes, particularly critical thinking skills.
- Address the discrepancy highlighted by Reviewer #3 regarding the focus on moral and ethical dimensions versus other variables investigated in the study.

Research Questions
- Correct the title of this section to "Research Questions" as suggested by Reviewer #3.

Methodology Section
- Provide a detailed explanation of the research design, including methods for determining the experimental and control groups, number of meetings, and activity design.
- Clarify the instruments used, their characteristics, validity, reliability testing methods, and definitions of research variables.

Results Section
- Explain the meaning of the Enhancement value in Tables 4, 6, and 8, addressing inconsistencies in symbols and difficulties in interpreting percentage values in Table 9 (Reviewer #3).

Discussion Section
- Ensure that citations directly support arguments and are relevant to the study's findings, addressing concerns raised by Reviewer #3 about citation relevance and support.
- Align the discussion with the research questions based on the results, and consider relocating certain paragraphs to the results or introduction sections for better coherence and understanding of the OIDDE model (Reviewer #2).

Recommendations Section
- Revise the recommendations to be more specific and avoid sounding like direct quotes (Reviewer #3).

Overall
- Use spell and grammar check (but note that accepted papers will be provided English proofreading by APSE).
- Use APA style manual to format your manuscript, tables, figures, in-text citations and references.

Considering that the requested changes are moderate, please return a revised version of this article by May 07, 2024 visiting the website at https://www.editorialmanager.com/apsebrill/ with the access codes listed below. Should you require more time, please let me know and we can move this article to consideration for issue 10(2). This will give you more time for revision.

Your username is: atok
Click this link to create your own password: https://www.editorialmanager.com/apsebrill/l.asp?i=18748&l=5AMOY7OE

NOTE: If your article contains images, please include high resolution source files for each of the images in your revised submission. Requirements for figure source files are as follows: min. 300 dpi for photographs, min. 600 dpi for linework images. This is the minimum resolution required at the dimensions at which the images should eventually be reproduced. Please bear in mind that the images themselves should also be of high quality (e.g., the images should be clear and sharp; any text contained in the images should be sharp and legible).

Should you have any questions, please do not hesitate to contact me.

I look forward to receiving the revised article.

Yours sincerely,

Sonya N Martin, PhD
Editor-in-Chief
Asia-Pacific Science Education

Comments from the editor and reviewers:
One or more referees or the editor(s) have supplied additional documents in addition to the comments included in this letter. To access the file(s), please click on the link below. You can also access the files online via the 'View Attachments' action link for the manuscript.
https://www.editorialmanager.com/apsebrill/l.asp?i=18749&l=YHKGHJNP

Reviewer #2:
1. Have any papers been published that utilize this model after it was developed by the authors? Please provide information about such papers. As you have not presented any research utilizing the OIDDE model, it is necessary to provide examples of previous publications and explicitly describe your originality. You can extract paragraphs from the discussion section to differentiate your work from previous research.

2. You have provided information regarding the development of the instrument. There is an observation sheet for four aspects. Could you clarify which aspect is used for each research question? Additionally, explain how your research questions can be answered with this instrument.

3. In your results, you have presented statistics describing the efficiency of the OIDDE model for learning. Furthermore, you have provided general descriptions from your observations. I recommend integrating qualitative descriptions into each table. Your results are presented in tables regarding critical thinking and ethical attitudes, among others. Combining statistical data with qualitative descriptions in each table will enhance readability and logical coherence. I am interested in gaining more insight from your observations regarding concrete teaching and learning focus.

4. Some paragraphs in the discussion section should be relocated to either the results or introduction part. Your discussion is disproportionately lengthy compared to other sections. For instance, on page 15, the paragraph from line 7 to 17 could be moved to the results section as evidence from your observations. Please ensure that the discussion aligns with your research questions based on the results. Additionally, consider transferring certain paragraphs from the discussion to the introduction for better understanding of the OIDDE model.

Reviewer #3:
This is an interesting paper that presents a new instructional model for teaching biology and investigating various learning outcomes. However, there are still numerous weaknesses in terms of systematic writing and the substance of the content. The manuscript contains several spelling errors, incomplete sentences, and inconsistencies in the use of terms related to research variables. The quality of English translation also needs to be improved. Below are my comments on each section of the manuscript.

Title
Critical Skills in the title should be revised to be Critical Thinking skills

Abstract
The abstract lacks the necessary rationale and background of the study. There are some ambiguous sentences like "high school students in the islands," which require clarification. Although the research design is a one-group pretest-posttest design, there are two classes, namely experiment and control. Additionally, the abstract does not provide a clear description of the effectiveness of the OIDDE learning model compared to conventional learning models.

Introduction Section
This section lacks clarity in presenting the context of the problem being studied and the rationale of the use of the OIDDE Learning Model. Additionally, there is a lack of coherence between sentences in one paragraph and between paragraphs in the introduction section. Some of the author's ideas are unclear and difficult to understand, such as the concept of Learning in the 4.0 and 5.0 eras mentioned in the second paragraph.

The OIDDE Learning Model
In this section, the author discusses the significance of improving critical thinking skills, learning outcomes, ethical attitudes and learning engagement in teaching and learning activities. However, the lack of arguments presents the conceptual framework of the OIDDE learning model or the relationship between the OIDDE learning model and other learning models that promote the intended learning outcomes such as the critical thinking skills. Moreover, from the explanation of the OIDDE learning model syntax, it is more related to moral and ethical dimensions. However, in this study, the researchers investigated other variables such as critical thinking skills, learning outcomes, and student engagement.

Research Focus
The title of this section should be the Research Questions not Research Focus.

Methodology section
In the methodology section, it is important to explain the research design and methods used by the authors to determine the experimental group and control group. A detailed comparison of the two learning models in the experimental and control groups, including the number of meetings and activity design in the research context should be presented. Additionally, it is important to explain the research instruments used, whether the measurement of all research variables uses the same or different instruments. The characteristics of the instrument used, such as the number of items and indicators/criteria assessed, should also be explained. Furthermore, the method for testing the validity and reliability of the research instrument needs to be explained. Lastly, the authors should define the research variables, such as learning outcomes, etc.

Results section
It would be helpful if the authors could explain the meaning of the Enhancement value in Tables 4, 6, and 8. I noticed that the Enhancement value in each table uses different symbols; some use percentages while others do not. Moreover, it is difficult to understand the meaning of the percentage values in Table 9.

Discussion section
In this section, the authors have cited various quotes and justifications to support their claims and research findings. However, some of these citations do not directly support their arguments. For instance, in the first paragraph, the authors use Orsmond et al's (2006) qualitative and quantitative analyses to support their claim about the effectiveness of the OIDDE learning model in improving students' learning outcomes. Similarly, in the fourth paragraph, the authors cite Rahmi et al (2021), Sari (2019), and Toman (2018) to underscore the importance of learning outcomes in determining students' success and reliability of the first syntax (Orientation) of the OIDDE learning model. It is also essential to note that comparing students' engagement in specific learning activities between the two models is not relevant, given that the two learning models have different syntax.

Recommendations section
The first recommendation is too general, while the second one sounds like a direct quote.

9. Submission of the first revision with the reviewers' suggestions through a rebuttal letter and sent via OJS (May 1, 2024)

A Rebuttal Letter (*First Revision*) : (Perbaikan dari masukan reviewer 2 dan 3)

"The Effectiveness of The OIDDE Learning Model on Improving Critical Thinking Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students"

Subject: APSE-1136: Please revise your manuscript

Ref.: Your submission (APSE-1136)

Dear Editor,

I hereby express my sincere gratitude for the attention and time you have given to review my text, up to the pre-final manuscript. I also express my sincere gratitude to the reviewers, for the time provided for commenting and evaluating my text, so that it is better than before.

I have tried to understand each comment and try to fix it as suggested and commented on. The result of the improvement that I am working on is the revised script that I sent. I always hope my script will be better.

Finally, I hope my text can be published in your journal. Enclosed I submit a letter of rebuttal to my text. Greetings,

Best regards,

Atok Miftachul Hudha

No	Reviewer Note Comment	Revision Author
Reviewer #2:		
1.	Have any papers been published that utilize this model after it was developed by the authors? Please provide information about such papers. As you have not presented any research utilizing the OIDDE model, it is necessary to provide examples of previous publications and explicitly describe your originality. You can extract paragraphs from the discussion section to differentiate your work from previous research.	Hudha, A. M,m Amin. M., Sumitro, S. B., & Akbar, S. (2018). **The Effectiveness of OIDDE Learning Model in the Improvement of Bioethics Knowledge, Ethical Decision, and Ethical Attitude of Biology Pre-Service Teachers**. *Journal of Baltic Science Education, 17*(6): 960-971. doi:10.33225/jbse/18.17.960 **Extract paragraphs from previous research:**

		The findings of this study which indicate the improvement of ethical attitude of biology pre-service teachers in the experimental group is better than the improvement of ethical attitude of biology pre-service teachers in the control group. It indicates that the OIDDE learning model is more effective than the conventional learning. The existence of the syntax engaged in behaviour support is increasing the ethical attitude of biology pre-service teachers in the experimental group, because with the growth of involvement behaviours form self-concept in the form of ethical attitude. Establishing an ethical attitude is not an easy thing due to the widespread contradiction between the facts in society and the implementation of classroom learning. Solomon's (2001) findings suggest that ethical attitudes require specific responsibility for achieving their development. In educational institutions, ethical attitudes are well established, but in a community environment the formation of ethical attitudes is hard to find. Such a situation is also expressed by Tanyid (2014), that there is currently a gap in the right values, if in school the values of good and right are well planted, but in society it can happen not to give good ethical values and be correct. Attempts to shape ethical values and attitudes have been done through school culture, living, ethics, honesty, compassion, love to learn, being responsible, respecting laws and regulations, respecting others, loving jobs, saving, hardworking, on time (Maryamah, 2016). As for the stages undertaken according to Maryamah (2016) include: value, technical level development, social level development, school culture development among students, and evaluation of school culture. Based on the results of this research one can indicate that the ethical attitude of biology pre-service teachers increased significantly after given learning with OIDDE model of learning compared to biology pre-service

		teachers in the control group. Thus, the formation of ethical attitude through learning on the students should begin by providing knowledge about ethics with learning model that is, in line with the findings of Sari (2016) which shows that students who are equipped with knowledge of ethics and able to apply it, in the future no longer commit violations of the code of ethics, so that after graduation they can improve the image of their profession **Extract paragraphs from this research** The research results indicate that the average scores for biology learning outcomes in the ecosystem, critical thinking skills, and ethical attitudes in the experimental group are significantly higher than those in the control group. This suggests that the implementation of the OIDDE learning model is more effective in enhancing the learning outcomes, critical thinking skills, and ethical attitudes of island high school students compared to the conventional model. This aligns with previous research findings that both qualitative and quantitative analyses play a crucial role in determining learning outcomes (Orsmond et al., 2006), Moreover, studies have shown that the OIDDE learning model improves the critical thinking abilities of biology teacher candidates (Fatmawati, et al., 2018), and enhances 21st-century skills, including critical thinking and creative thinking (Ma'rifatillah et al., 2019). Other researchers emphasize the importance of ethical attitudes in biology learning (Kohli et al., 2015; Chen & So, 2017), and specifically, the OIDDE learning model has been found to enhance the ethical attitudes of prospective biology teachers (Hudha et al., 2018).
2.	You have provided information regarding the development of the instrument. There is an observation sheet for four aspects. Could you clarify which aspect is used for each research	**Answer:** In implementing a learning model, it is necessary to measure the implementation

	question? Additionally, explain how your research questions can be answered with this instrument	of the learning model, and according to Weil, M. & Joyce, B., (1978), to measure the implementation of a learning model, four measurement indicators are needed as the main aspects, namely: (1) model syntax; (2) social system model; (3) reaction principle; and (4) support system. Each main aspect is assigned a descriptor to measure its appearance in learning. The recapitulation of all measurement results of all descriptors from the four indicators is used to determine the final conclusion value which is converted to the category value. Based on the final value from the accumulation of all scores in each descriptor given, it is concluded that the implementation of the OIDDE learning model is 78% (good category) compared to the conventional learning model of 70% (fairly good category). This provides the basis that the implementation of the learning model is closely related to student learning involvement. Based on the conclusions of the learning implementation category, the implementation of the OIDDE learning model increases the learning involvement of experimental group students better than the involvement in implementing conventional model learning in the control group. [Weil, M. & Joyce, B., (1978). *Social Models of Teaching, Expanding Your Teaching*, New Jersey: Repertoire.Printice-Hall, Inc. Englewood Cliftas].
3.	In your results, you have presented statistics describing the efficiency of the OIDDE model for learning. Furthermore, you have provided general descriptions from your observations. I recommend integrating qualitative descriptions into each table. Your results are presented in tables regarding critical thinking and ethical attitudes, among others. Combining statistical data with qualitative descriptions in each table will enhance readability and logical coherence. I am interested in gaining more insight from your	**Answer:** Thank you for the recommendation, and we'll pay attention. We will fulfill your suggestions below. **Critical Thinking Skills**. We add the following description to the description of table 5. Based on the results of the ANCOVA test as in Table 5, it is known that the calculated

	observations regarding concrete teaching and learning focus.	F difference in the treatment of the OIDDE learning model is 25.183 with a p-value < 0.0001. Thus, the HO which stated that there was no difference in increasing critical thinking skills between the experimental group and the control group was rejected. This means that there is a significant difference, that the OIDDE learning model in the experimental group has a significant effect on increasing the critical thinking skills of high school students compared to the conventional learning model in the control group, so the research hypothesis which states that there is a difference in increasing critical thinking skills between the experimental group and the control group is accepted. Notably, the study, comprising only two treatments, does not necessitate the application of the Least Significant Difference (LSD) test. Improving critical thinking skills in experimental group students cannot be separated from implementing the syntax of the OIDDE learning model, especially the second syntax (Identify). In this second syntax, the teacher develops the ability to identify problems in class This makes learning fosters critical thinking skills in students, because the critical power of class X high school students is encouraged to find their own problems in the teaching material. Considering that such learning activities only appear in the OIDDE learning model, the OIDDE learning model improves the critical thinking abilities and skills of high school students in class X and is valid data. The corrected average analysis for each class in the experimental group and control group is presented in Table 6. **Ethical attitudes:** **Answer:**

		Based on the results of the One-Way ANCOVA test in Table 7, the calculated F value for the OIDDE learning model treatment was 24.439 with a p-value of 0.001. Thus the null hypothesis (HO) which states that there is no difference in the achievement of improving ethical attitudes between the experimental and control groups is rejected. Therefore, the research hypothesis which states that there is a difference in the achievement of ethical attitudes between the experimental group and the control group is accepted. This means that the OIDDE learning model has an impact on improving the ethical attitudes of Class X high school students. Increasing ethical attitudes through the OIDDE learning model is very real. This is because the syntax of the OIDDE learning model really fosters aspects of attitude. Ethical attitudes were measured in the fifth syntax (Engage in behaviour). The reason is, engagement in behaviour is the culmination of the learning process which describes the real attitude involvement of students regarding all learning events and problem solving in problematic dilemmas which are topics of discussion in teaching materials.
4.	Some paragraphs in the discussion section should be relocated to either the results or introduction part. Your discussion is disproportionately lengthy compared to other sections. For instance, on page 15, the paragraph from line 7 to 17 could be moved to the results section as evidence from your observations. Please ensure that the discussion aligns with your research questions based on the results. Additionally, consider transferring certain paragraphs from the discussion to the introduction for better understanding of the OIDDE model.	**Answer:** We thank you very much for your suggestions and input which means a lot to us. We pay attention to everything and we try to improve the manuscript that you suggest, hopefully, it matches what you expected.
Reviewer 3:		

1.	**Title:** Clarify the title by including the phrase "Critical Thinking Skills" in the title.	**"The Effectiveness of The OIDDE Learning Model on Improving <u>Critical Thinking Skills,</u> Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students"**
2.	**Abstract** - Provide a clearer rationale and background for the study, addressing ambiguities such as "high school students in the islands." - Clarify the effectiveness of the OIDDE learning model compared to conventional models. **Abstract** The abstract lacks the necessary rationale and background of the study. There are some ambiguous sentences like "high school students in the islands," which require clarification. Although the research design is a one-group pretest-posttest design, there are two classes, namely experiment and control. Additionally, the abstract does not provide a clear description of the effectiveness of the OIDDE learning model compared to conventional learning models.	Biology learning must be taught through Student-Centered Learning in order to achieve holistic learning, so innovative and appropriate learning models are needed. This research aims to analyze the effectiveness of the OIDDE learning model in improving: 1) biology learning outcomes; 2) critical thinking skills; 3) ethical attitude; and 4) learning engagement class X high school students in the West Nusa Tenggara Islands, Indonesia. The research design uses a quasi-experimental nonequivalent control group design. The research population was class X students, and a non-probability sampling research sample, with 66 students divided into an experimental group of 33 students and a control group of 33 students. Data were analyzed using Product-Moment Coefficient, Cronbach's alpha, ANCOVA, and Kolmogorv-Smirnov. The research results show that the OIDDE learning model is more effective and significant in improving biology learning outcomes, critical thinking skills, ethical attitudes, and learning engagement compared to conventional learning models.
3.	**Introduction** This section lacks clarity in presenting the context of the problem being studied and the rationale of the use of the OIDDE Learning Model. Additionally, there is a lack of coherence between sentences in one paragraph and between paragraphs in the introduction section. Some of the author's ideas are unclear and difficult to understand, such as the concept of Learning in the 4.0 and 5.0 eras mentioned in the second paragraph	**Introduction** Learning is a process of becoming aware of something unknown that continues continuously, and its result is a change in behaviour. Behavioural changes from the learning process produce new experiences (Djamaluddin & Wardana, 2019) and the change in behaviour as a result of learning is known as learning outcomes. Learning outcomes are the achievement of an individual's knowledge after undergoing a learning process over time in the cognitive, affective, and psychomotor domains, demonstrated by

		changes in individual behaviour independently (Mahananingtyas, 2017; Nurrita, 2018). Therefore, for the achievement of learning outcomes to be maximized and holistic, the learning process must be implemented to guide and equip learners with holistic skills and abilities. Holistic skills are crucial in the global era as they can be used to solve global issues (Miseliunaite et al., 2022) and specifically as a perspective in 4.0 learning 4.0 (Kolu & Nayar, 2020). The global world is currently entering the industrial era 4.0 and even the industrial era 5.0 and the broad impacts related to learning in Indonesia, especially learning in the field of biological sciences in high schools, have not been studied in depth, including in the archipelagic region. Moreover, it is related to the effectiveness of an innovative learning model in improving learning outcomes (Azizah & Alberida, 2021; Herman & Rahmat, 2023; Imama & Rochmawati, 2021), as well as its effectiveness on critical thinking skills and ethical attitudes. It is known that learning outcomes are an important part of measuring the extent of mastery of the material taught to an individual (Fitrianingtyas & Radia, 2017), and depict what learners have achieved (Mahajan & Singh, 2017). Therefore, learning outcomes must be specific and focus on their expectations, centered on learners, and explain the performance behaviour or understanding of learners (García, 2021). The achievement of critical thinking skills will indicate an individual's ability to analyze, synthesize, evaluate, draw conclusions, and reflect on issues. Ethical attitudes depict moral actions imbued with individual responsibility for specific and holistic issues. Biology learning cannot be separated from critical thinking skills, although Suharsono et al., (2017) state that learning outcomes do not differ significantly from

		critical thinking skills. However, critical thinking skills are essential in today's global life, especially in science education recognized by Kinoshita (2022) to have a broad impact on life. Therefore, the achievement of critical thinking skills must be pursued by efforts to enhance these skills. Moreover, effective teaching for the development of students' critical thinking can be developed (Kinoshita, 2022; Setyowati et al., 2018), through the development of teaching materials (Setyowati et al., 2018), and various learning models (Fuad et al., 2017). However, good learning outcomes and critical thinking skills are not meaningful if not balanced with the ethical attitudes of individuals. If learning outcomes indicate indicators of learning achievement and the level of ability of a learning program, research related to the biology learning outcomes of students must be conducted because there have been few studies on the biology learning outcomes of students. This is one of the important issues for conducting research on biology learning outcomes in high school students through the testing of the effectiveness of the OIDDE learning model. OIDDE stands for Orientation, Identify, Discussion, Decision, Engage in Behaviour (Hudha et al., 2016, 2018; Hudha & Husamah, 2019). Biology learning cannot be separated from critical thinking skills (Agnafia, 2019; Danil, 2021; Fitriyyah & Wulandari, 2019), because critical thinking skills are important for solving various problems, such as environmental issues (Santi et al., 2018), and are done in diverse learners (Hwang et al., 2023). The fact shown by Susilawati et al., (2020), is that the critical thinking skills of high school students are dominant at a low level of critical thinking skills. Critical thinking skills in biology learning can be pursued through cooperative learning (Erdogan, 2019;

		Leniati & Indarini, 2021; Pratiwi, 2015). Even specifically, research by Husamah, et al., (2018) on prospective biology teacher students shows that the OIDDE learning model significantly influences the improvement of critical thinking skills. Developing critical thinking skills is essential because, according to Syafitri et al., (2021) it has a significant impact on the daily lives of students. However, research on improving students' critical thinking skills in biology learning in high school by implementing the OIDDE learning model (Hudha et al., 2018; Hudha & Husamah, 2019) is not widely found. This is partly due to the fact that the OIDDE learning model found in 2016 by Hudha et al., (2017) has not been widely socialized, so research related to the OIDDE learning model must continue to be conducted as part of its widespread socialization. Similarly, ethical attitudes of high school students have not been widely studied. However, ethical attitudes are essential for students' lives in the global century (Hudha et al., 2018; Hudha & Husamah, 2019). Ethical attitudes are a "general feeling, both positive and negative, of an individual about ethical or unethical behaviour" (Ajzen, 2005; Madden et al., 1992). If examined, the study of ethical attitudes is broad, even the issue of how to use and utilize computers properly becomes a study of ethical attitudes (Jamil et al., 2013), Health services are also the scope of serious ethical attitude studies (Asare et al., 2022; Sakr et al., 2022). Moreover, the study of ethical attitudes towards students and professionals (Lesińska-Sawicka et al., 2023; Wood et al., 1988), is a very important study in today's global life, but rarely made a significant focus in research. Ethical attitudes are strongly shaped by ethical aspects because ethical aspects are consistency in applying principles, values, morals, and ethics into actions. It

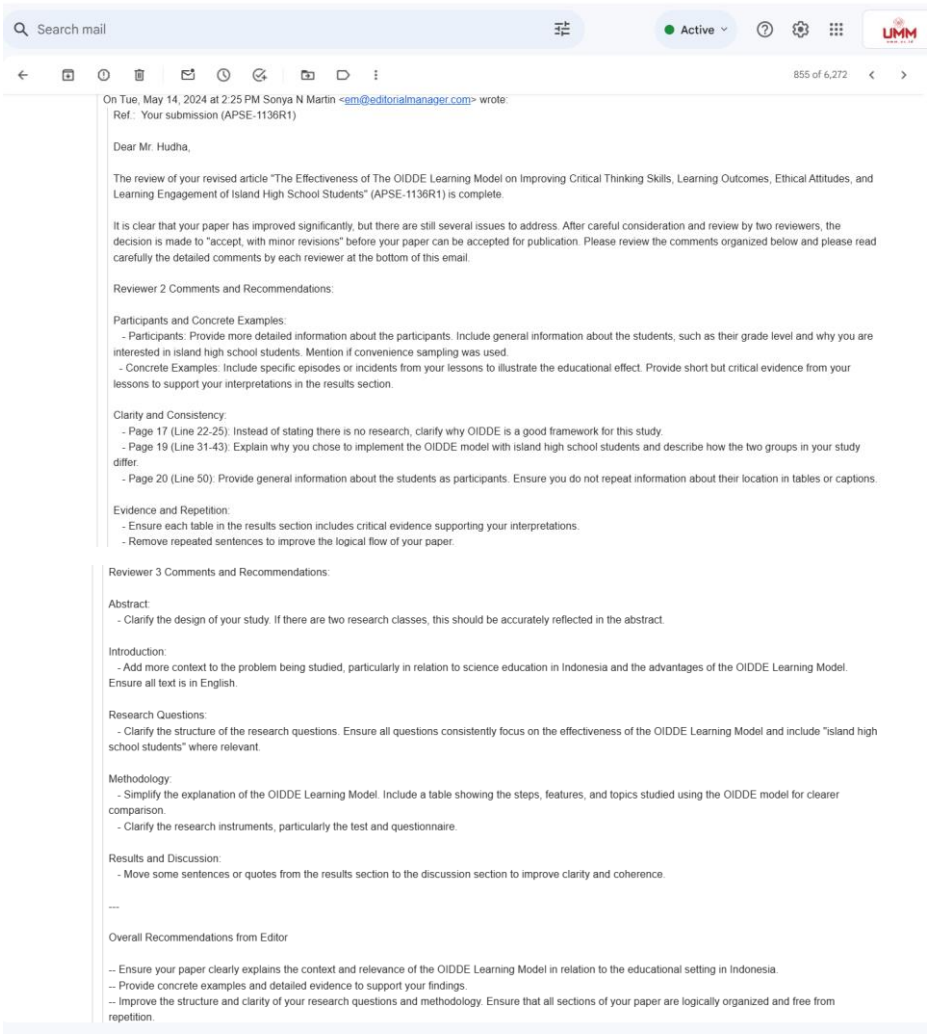
		must be recognized that ethical attitudes play a very important role in shaping character and values in each individual. Moreover, educational character in society truly functions to shape individuals to be moral, noble, tolerant, and well-behaved (Tsoraya et al., 2023). However, the problem is that in biology learning, there are not many teachers or lecturers who reinforce the ethical attitudes of their students through the study of learning materials in the teaching and learning process in the classroom, including at the high school level. This is evidence that research on ethical attitudes in learning related to the effectiveness of a learning model has not been widely conducted. However, according to Chowdhury (2016) education and teaching related to science need to emphasize morals, values, and ethical attitudes. The importance of research on students' ethical attitudes is based on the fact that the increasing prevalence of negative student behaviour, such as violating school rules, skipping school, cheating in exams, disrespecting teachers, and fighting (Dari, 2014; Husamah, Hudha, et al., 2018), and the emergence of ethical behaviour deviations of high school students (Ardiana et al., 2022) Must be sought for appropriate solutions and ways out. Therefore, learning aimed at improving ethical attitudes needs to be examined through research, and the OIDDE learning model (Hudha et al., 2016, 2018; Hudha & Husamah, 2019) is chosen as the preferred solution. Especially in addressing ethical issues among high school students, the effectiveness of the OIDDE learning model in improving the ethical attitudes of students needs to be analyzed through research. Similarly, the study and research of learning activities are crucial because learning activities are related to the behaviour of students who genuinely

		undergo the learning process, building changes in their behaviour through learning. Efforts to enhance learning activities are carried out by many researchers, including using the *Student Facilitator and Explaining learning mode*l (Purbayanti et al., 2022), *contextual learning models* and *Problem-based Learning* (As-Sa'idah and Dedih, 2022), and even associated with the *blended web mobile learning model* (Hariadi et al., 2022). However, learning activities have not been widely associated with the OIDDE learning model. Therefore, the OIDDE learning model becomes the hope for the birth of innovative learning models in the global century. For this reason, the purpose of this study is to analyze the effectiveness of the OIDDE learning model in improving learning outcomes, critical thinking skills, ethical attitudes, and learning activities through ecosystem learning materials for high school students.
4.	**The OIDDE Learning Model** In this section, the author discusses the significance of improving critical thinking skills, learning outcomes, ethical attitudes and learning engagement in teaching and learning activities. However, the lack of arguments presents the conceptual framework of the OIDDE learning model or the relationship between the OIDDE learning model and other learning models that promote the intended learning outcomes such as the critical thinking skills. Moreover, from the explanation of the OIDDE learning model syntax, it is more related to moral and ethical dimensions. However, in this study, the researchers investigated other variables such as critical thinking skills, learning outcomes, and student engagement.	**Answer:** After we considered it, we collaborated on the contents of the sub-chapter The OIDDE Learning Model in the introduction to strengthen the problems and importance of the OIDDE learning model. Especially in strengthening the argument for the importance of the OIDDE learning model, its effectiveness was tested in answering the importance of improving critical thinking skills, learning outcomes, ethical attitudes and student learning engagement in biology learning.
5.	**Research Focus** The title of this section should be the Research Questions.	**Research Question** This research focuses on testing the effectiveness of the OIDDE learning model on high school students through ecosystem

		learning materials, namely: (1) Is it effective in improving the biology learning outcomes of high school students; (2) Is it effective in enhancing critical thinking skills; (3) Is it effective in improving ethical attitudes for high school students; (4) Is it effective in increasing the learning activity of high school students.
6.	**Methodology** In the methodology section, it is important to explain the research design and methods used by the authors to determine the experimental group and control group. A detailed comparison of the two learning models in the experimental and control groups, including the number of meetings and activity design in the research context should be presented. Additionally, it is important to explain the research instruments used, whether the measurement of all research variables uses the same or different instruments. The characteristics of the instrument used, such as the number of items and indicators/criteria assessed, should also be explained. Furthermore, the method for testing the validity and reliability of the research instrument needs to be explained. Lastly, the authors should define the research variables, such as learning outcomes, etc.	**Answer:** Thank you for the suggestions and input. We immediately updated all suggestions and input provided for the methodology section in the manuscript.
7	**Results** It would be helpful if the authors could explain the meaning of the Enhancement value in Tables 4, 6, and 8. I noticed that the Enhancement value in each table uses different symbols; some use percentages while others do not. Moreover, it is difficult to understand the meaning of the percentage values in Table 9.	**Answer:** Suggestions related to explaining the meaning of Enhancement values in Tables 4, 6, and 8 as well as the use of percentage measures in Table 9, are revisions for all explanations related to Enhancement. We made improvements directly to the journal manuscript.
8.	**Discussions** In this section, the authors have cited various quotes and justifications to support their claims and research findings. However, some of these citations do not directly support their	**Answer:** Thank you for your review of the Discussion section. We use our citation of Orsmond et al., (2006) to understand that learning outcomes in learning, as the variable we

	arguments. For instance, in the first paragraph, the authors use Orsmond et al's (2006) qualitative and quantitative analyses to support their claim about the effectiveness of the OIDDE learning model in improving students' learning outcomes. Similarly, in the fourth paragraph, the authors cite Rahmi et al (2021), Sari (2019), and Toman (2018) to underscore the importance of learning outcomes in determining students' success and reliability of the first syntax (Orientation) of the OIDDE learning model. It is also essential to note that comparing students' engagement in specific learning activities between the two models is not relevant, given that the two learning models have different syntax.	measure in this research, are very important. Likewise, our citations from Rahmi et al., (2021), Sari (2019), and Toman (2018) are actually intended to support the statement, that learning outcomes are very important for measuring student success in various subjects, including biology, as stated by them (Rahmi et al., 2021; Sari, 2019; and Toman, 2018). However, we welcome the important note you have provided. Thank you also for the related note, that comparing student engagement in certain learning activities between the two models is not relevant, because the two learning models have different syntax. Based on this research, in the conventional learning model teachers teach with unclear syntax, because they use teaching methods that are classical and not innovative, so we call it a conventional learning model. Hopefully this will be our initial finding so that we can pay attention to the notes you provide in future research.
9.	**Recommendations** The first recommendation is too general, while the second one sounds like a direct quote.	**Answer (Improvements to the content of recommendations):** The research found that experimental class students had interesting experiences in learning biology using the OIDDE learning model by giving very positive comments. Therefore, in line with the results of this research it can be recommended; (1) The OIDDE learning model is a new learning model to be applied in learning at various levels of education in various subjects; (2) The OIDDE learning model is a reference for 21st century learning models to improve critical thinking skills, learning outcomes, ethical attitudes, and learning engagement of students at various levels of education.

10. Second Revision Suggestion from Reviewer 2 and Reviewer (May 14, 2024).



Search mail

Active

855 of 6,272

On Tue, May 14, 2024 at 2:25 PM Sonya N Martin <em@editorialmanager.com> wrote:

Ref.: Your submission (APSE-1136R1)

Dear Mr. Hudha,

The review of your revised article "The Effectiveness of The OIDDE Learning Model on Improving Critical Thinking Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students" (APSE-1136R1) is complete.

It is clear that your paper has improved significantly, but there are still several issues to address. After careful consideration and review by two reviewers, the decision is made to "accept, with minor revisions" before your paper can be accepted for publication. Please review the comments organized below and please read carefully the detailed comments by each reviewer at the bottom of this email.

Reviewer 2 Comments and Recommendations:

Participants and Concrete Examples:
- Participants: Provide more detailed information about the participants. Include general information about the students, such as their grade level and why you are interested in island high school students. Mention if convenience sampling was used.
- Concrete Examples: Include specific episodes or incidents from your lessons to illustrate the educational effect. Provide short but critical evidence from your lessons to support your interpretations in the results section.

Clarity and Consistency:
- Page 17 (Line 22-25): Instead of stating there is no research, clarify why OIDDE is a good framework for this study.
- Page 19 (Line 31-43): Explain why you chose to implement the OIDDE model with island high school students and describe how the two groups in your study differ.
- Page 20 (Line 50): Provide general information about the students as participants. Ensure you do not repeat information about their location in tables or captions.

Evidence and Repetition:
- Ensure each table in the results section includes critical evidence supporting your interpretations.
- Remove repeated sentences to improve the logical flow of your paper.

Reviewer 3 Comments and Recommendations:

Abstract:
- Clarify the design of your study. If there are two research classes, this should be accurately reflected in the abstract.

Introduction:
- Add more context to the problem being studied, particularly in relation to science education in Indonesia and the advantages of the OIDDE Learning Model. Ensure all text is in English.

Research Questions:
- Clarify the structure of the research questions. Ensure all questions consistently focus on the effectiveness of the OIDDE Learning Model and include "island high school students" where relevant.

Methodology:
- Simplify the explanation of the OIDDE Learning Model. Include a table showing the steps, features, and topics studied using the OIDDE model for clearer comparison.
- Clarify the research instruments, particularly the test and questionnaire.

Results and Discussion:
- Move some sentences or quotes from the results section to the discussion section to improve clarity and coherence.

Overall Recommendations from Editor

-- Ensure your paper clearly explains the context and relevance of the OIDDE Learning Model in relation to the educational setting in Indonesia.
-- Provide concrete examples and detailed evidence to support your findings.
-- Improve the structure and clarity of your research questions and methodology. Ensure that all sections of your paper are logically organized and free from repetition.

We believe that addressing these recommendations will significantly strengthen your manuscript. You will find the submission in the 'Submissions Needing Revision' folder in your Author Main Menu. When submitting the revised article, please also include a detailed, point-by-point response to the review comments below. This should be uploaded as 'Response to Reviews'.Please submit a revised version of your paper, addressing all the points mentioned above.

Please return your revised article by Jun 13, 2024 at https://www.editorialmanager.com/apsebrill/ with the access codes listed below.

Your username is: atok
Click this link to create your own password: https://www.editorialmanager.com/apsebrill/l.asp?i=18835&l=SUQGETF2

NOTE: If your article contains images, please include high resolution source files for each of the images in your revised submission. Requirements for figure source files are as follows: min. 300 dpi for photographs, min. 600 dpi for linework images. This is the minimum resolution required at the dimensions at which the images should eventually be reproduced. Please bear in mind that the images themselves should also be of high quality (e.g., the images should be clear and sharp; any text contained in the images should be sharp and legible).

Thank you for your contributions to the field. We look forward to receiving your revised manuscript.Below is a summary of the feedback provided by the reviewers, along with specific recommendations to help you improve your manuscript. Should you have any questions, please do not hesitate to contact me.

I look forward to receiving the revised article.

Yours sincerely,

Sonya N Martin, PhD
Editor-in-Chief
Asia-Pacific Science Education

11. Request for second revision from Editor in Chief Via E-Mail (May 19, 2024)

Extension for Submission of Revised Paper APSE-1136R1 External Inbox ×

Sonya Martin <sonya_martin@fastmail.com> Sun, May 19, 2:56 PM
to me

Dear Mr. Hudha

I hope this message finds you well. I understand that you have been ill and want to assure you that it is perfectly fine to take the time you need for your health.

You do not need to submit your revised paper until the end of June. If you find that you still need more time, please let me know, and we can make further arrangements.

The current issue [10(1)] of the journal is complete. Therefore, any papers accepted between now and November will be published in the December issue. Once your paper is accepted and the proofs are completed, it will appear in the "Online First" section on the journal's website until we prepare the December issue.

Please take care and feel free to reach out if you need any additional time or support.

Best regards,

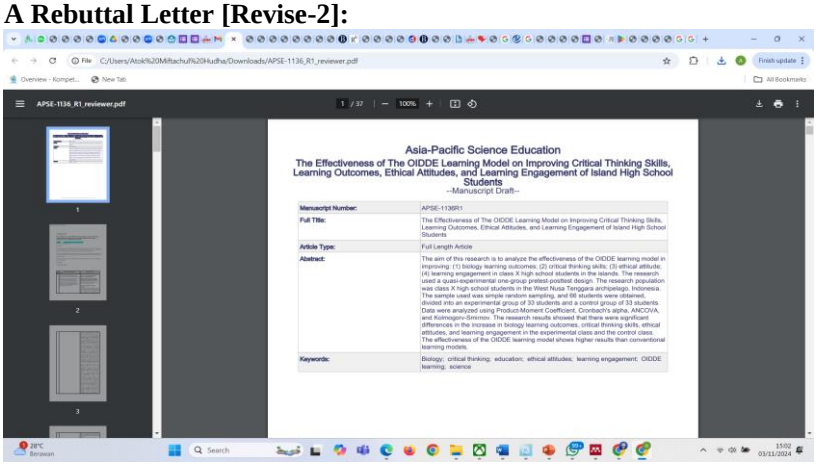
Sonya Martin

==========
Sonya N. Martin, PhD (마틴 산야 / 馬山野)
Professor, Dept of Science Education and Biology Education
Editor-in-Chief, APSE (Asia-Pacific Science Education), brill.com/apse
NARST Board member, International Coordinator (2019-2022)

College of Education, Seoul National University
Building 12, Room #517, 1 Gwanak-ro, Gwanak-gu, Seoul, 08826, Republic of Korea

12. Submission of Second Revision through a Rebuttal Letter and OJS (July 1, 2024)

A Rebuttal Letter [Revise-2]:



"The Effectiveness of The OIDDE Learning Model on Improving Critical Thinking Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students"

Subject: APSE-1136: Please revise your manuscript

Ref.: Your submission (APSE-1136)

Dear Editor,

I hereby express my sincere thanks for the attention and time you have given me to review my revised-2 manuscript, up to the pre-final manuscript. I also express my sincere thanks to the reviewers, for the time provided to comment and evaluate my revised-2 manuscript, so that it is better than before.

I have tried to understand each comment and tried to fix it as suggested and commented. The result of the improvements that I am working on is the 2nd revision manuscript that I sent. I always hope my script will be better.

Finally, I hope that my article manuscript can be published in your journal. Attached I submit a rebuttal letter of my revision-2 manuscript globally. As for the contents of the manuscript, I have tried to be detailed.

Yours faithfully,
Atok Miftachul Hudha

No	Reviewer Note Comment	Revision Author
Reviewer #2:		
	Participants and Concrete Examples:	**Answer:** The sample in this study were high school students in the Islands who were in classes XA and cognitive

	- Participants: Provide more detailed information about the participants. Include general information about the students, such as their grade level and why you are interested in island high school students. Mention if convenience sampling was used. - Concrete Examples: Include specific episodes or incidents from your lessons to illustrate the educational effect. Provide short but critical evidence from your lessons to support your interpretations in the results section.	aspects, teachers rarely touch on students' affective and psychomotor aspects. Therefore, I was interested in choosing students at this school to become research subjects. The educational effects that are proof that the OIDDE learning model is successful in this research are: (1) increasing students' orientation skills towards ecosystem problems as shown by increasingly critical discussion skills, this is shown in group presentation skills which always present the results of their presentations based on data; (2) Increasing positive responses from teachers and students, that learning with the OIDDE learning model becomes more enjoyable and creates a conducive learning atmosphere.
	Clarity and Consistency: - Page 17 (Line 22-25): Instead of stating there is no research, clarify why OIDDE is a good framework for this study.	**Answer:** The basic thing is that the OIDDE learning model is a good framework in this research, because of six things, namely: (1) *The syntax structure is systematic.* Starting from orientation towards relevant material and examples or cases, then identification or inventory of ethical dilemmas that arise in problematic cases at the orientation stage, followed by a discussion to explore deeper understanding and decision making. Decision) to apply critical thinking in certain situations resulting from discussions, and engagement in behaviour (Engage in behaviour) to reflect the results of decisions in the form of actions through honest verbal or written statements; (2) *Stimulation of Critical Thinking Skills*: Each step in OIDDE stimulates critical thinking skills; (3) *Ethics Integration*: This model naturally integrates ethical aspects because it considers the consequences of the decisions taken; (4) *Support for holistic and learner-centered learning*: OIDDE not only focuses on cognitive aspects (critical thinking skills and learning outcomes), but also on socio-emotional aspects (ethical attitudes). This model recognizes the importance of building holistic skills in students, which include not only conceptual understanding but also the application of values and ethics in daily life practices; (5) *Creating a conducive, interesting, enjoyable, meaningful and quality learning atmosphere.* Meaningful and quality learning increases students' motivation and learning achievement so that it will raise the quality of students (Astra, et al., 2015: Weurlander, et al., 2009); (6) *The formation of a cooperative situation in learning*, so that the learning atmosphere becomes positive. As Johnson, et al. (2004) emphasized that cooperative

		learning situations create two responsibilities for students, namely studying the assigned material, and ensuring that all group members actually learn the material. The choice of the OIDDE learning model for Pulau SMA students was based on the fact that so far biology learning carried out by teachers is still a conventional learning model. This means that the teaching and learning process carried out by teachers has been dominant in the lecture aspect, and tends to be more towards cognitively oriented learning. Learning that sharpens students' affective competencies to improve critical thinking skills, as well as students' psychomotor aspects to improve biology learning activities, is rarely implemented by teachers. Therefore, to test the effectiveness of the OIDDE learning model, researchers divided the sample into two groups. The experimental group is students who receive learning using the OIDDE learning model, and the control group is a group of students who receive learning using the conventional model (as a comparison).
	- Page 19 (Line 31-43): Explain why you chose to implement the OIDDE model with island high school students and describe how the two groups in your study differ.	**Answer:** The differences between the two groups in this study are: One class as a control group which is used as a comparison for the experimental class. Where the experimental class uses the model that is being researched in this research.
	- Page 20 (Line 50): Provide general information about the students as participants. Ensure you do not repeat information about their location in tables or captions.	**Answer:** Thank you for the suggestions and input.
	Evidence and Repetition: - Ensure each table in the results section includes critical evidence supporting your interpretations. - Remove repeated sentences to improve the logical flow of your paper.	

1. Hypothesis Testing (Evidence Table 5)

Ancova One-Way Test for Biology Learning Outcomes

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2141.846[a]	2	1070.923	23.731	.000	.562
Intercept	3217.010	1	3217.010	71.286	.000	.658
XHB	425.746	1	425.746	9.434	.004	.203
Kelas	1247.480	1	1247.480	27.643	.000	.428
Error	1669.754	37	45.128			
Total	208874.000	40				
Corrected Total	3811.600	39				

2. Hypothesis Testing (Evidence Table 7)

Ancova One-Way Test for Critical Thinking Skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1485.958[a]	2	742.979	23.929	.000	.564
Intercept	902.673	1	902.673	29.072	.000	.440
XKBK	821.733	1	821.733	26.466	.000	.417
Class	781.908	1	781.908	25.183	.000	.405
Error	1148.817	37	31.049			
Total	251801.000	40				
Corrected Total	2634.775	39				

3. Hypothesis Testing (Evidence Table 9)

Ancova One-Way Test for Ethical Attitude

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1513.636[a]	2	756.818	24.977	.000	.574
Intercept	893.357	1	893.357	29.483	.000	.443
XSE	849.411	1	849.411	28.032	.000	.431
Class	740.525	1	740.525	24.439	.000	.398
Error	1121.139	37	30.301			
Total	251801.000	40				
Corrected Total	2634.775	39				

Reviewer #3:

Abstract:
- Clarify the design of your study. If there are two research classes, this should be accurately reflected in the abstract.

Answer:
This research aims to analyze the effectiveness of the OIDDE learning model in (1) improving biology learning outcomes; (2) improve critical thinking skills; (3) improving ethical attitudes; (4) increasing learning engagement in class X high school students in the West Nusa Tenggara Islands, Indonesia. This research is a quasi-experiment research using a non-equivalent pre-test and post-test research design. The research population was class X high school students in West Nusa Tenggara, Indonesia. The sampling technique used simple random sampling and obtained 66 students who were divided into an experimental group of 33 students and a control group of 33 students. The research instrument used an observation sheet on the implementation of the learning model, a questionnaire measuring ethical attitudes, and tests. Before use, the observation sheet and questionnaire instruments were validated by a validator and measured using five Likert scales (1 = Very Bad; 2= Not Good; 3= Fairly Good; 4= Good; 5= Very Good) and the learning model implementation category used seven standard assessments (>80.0=Outstanding; 75.0-80.0= Excellent; 70.0-74.9=Very good; 60.0-69.0=Good; 55.0-59.9=Fair; 40.0-54.0=Pass; <40.0=File). Test the validity of the test instrument using

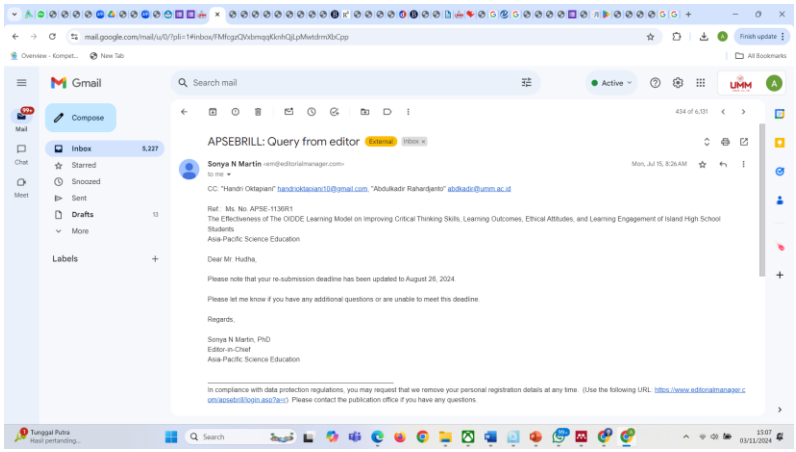
		Pearson Correlation and test the reliability of the test instrument using Cronbach Alpha. The research data was analyzed using ANCOVA, which was previously carried out by the Kolmogorov-Smirnov normality test and the Levena homogeneity test. The research results showed that there were significant differences in the increase in biology learning outcomes, critical thinking skills, ethical attitudes, and learning engagement in the experimental class and the control class. The effectiveness of the OIDDE learning model shows higher results than conventional learning models.
	Introduction: - Add more context to the problem being studied, particularly in relation to science education in Indonesia and the advantages of the OIDDE Learning Model. Ensure all text is in English.	**Answer:** Science education in Indonesia faces various complex problems including didactic factors, curriculum, content, and also learning facilities that are different from developed countries (Khoiri et al. 2020). From the teacher's side, various critical analyses can be found regarding science teachers in Indonesia. Several findings related to critical analysis of science teachers include, the number of integrated science teachers is still limited, this is supported by various factors, namely: (1) teacher backgrounds are different from their teaching duties; (2) science teacher training services are not evenly distributed throughout Indonesia; (3) It was found that science teachers were not familiar with laboratory equipment; (4) Many schools do not yet have laboratory facilities that support science material. Responding to the problems of science education in Indonesia, there is no other way than to improve the quality of human resources to master science. Teachers are a key factor in improving science, so access to science education, science education literacy, and linking technology with science education are priorities for teachers to improve. Likewise, the factor of students with various family backgrounds is also a problem in science learning. Families that are far from using technology and science in their daily lives also create an atmosphere that does not support the mastery of science. As stated by Faisal & Martin (2024), there are various efforts to improve science education in Indonesia, including: (1) science teacher education and certification processes; (2) the role of Educational Personnel Education Institutions in increasing teacher competency, curriculum innovation, increasing student learning activities through developing and disseminating research results; (3) international collaborative research for science education researchers In this regard, the OIDDE Learning Model ensures its role in helping teachers and students master scientific literacy. Through its syntax steps, the OIDDE Learning Model tries to create a better science

<table>
<tr><td></td><td></td><td>learning atmosphere. Therefore, through proper implementation, the advantages of the OIDDE Learning Model can be felt in a measurable and valid manner.</td></tr>
<tr><td></td><td>Research Questions:
- Clarify the structure of the research questions. Ensure all questions consistently focus on the effectiveness of the OIDDE Learning Model and include "island high school students" where relevant.

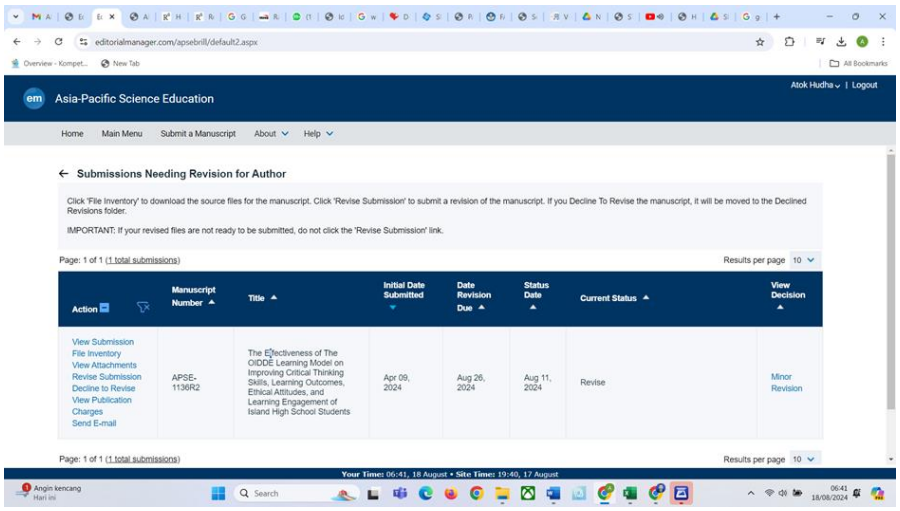
.</td><td>Answer:
(1) How is the effectiveness of the OIDDE learning model improving the biology learning outcomes of Island High School students?
(2) How is the effectiveness of the OIDDE learning model improving the critical thinking skills of Island High School students?
(3) How does the effectiveness of the OIDDE learning model improve the ethical attitudes of Island High School students?
(4) How is the effectiveness of the OIDDE learning model improve the learning engagement island high school students'?</td></tr>
<tr><td></td><td>Methodology:
- Simplify the explanation of the OIDDE Learning Model. Include a table showing the steps, features, and topics studied using the OIDDE model for clearer comparison.
- Clarify the research instruments, particularly the test and questionnaire</td><td>Answer:
The summary of the learning material provided through the OIDDE learning model is shown in Table 3.
TABLE 3 Implementation of biology learning topics (ecosystem material) through the oidde learning model at three meetings.
<table><tr><th>Syntax</th><th>Students Activities in 1st-2nd meeting</th><th>Students Activities in 3rd meeting</th></tr><tr><td>Orientation</td><td>Students analyze material presented about ecosystem components and interactions between components in biomes throughout the earth's surfaces.</td><td>Students analyze the material presented on Biogeochemical cycles and environmental changes currently occurring on the earth's surface with great motivation</td></tr><tr><td>Identify</td><td>Students identify interaction dilemmas in the schematic patterns of ecosystem interactions in biomes that are observed to determine aspects of interactions between species and food webs (mutualism, commensalism, parasitism, and predation), and the ecological paradigm that emerges.</td><td>Students identify ecological dilemmas regarding Biogeochemical cycles associated with environmental changes currently occurring, including the carbon Cycle, Nitrogen Cycle, Water Cycle (Hydrological Cycle), Sulfur Cycle. Phosphorus Cycle. The identification results are used as material for group discussions to discuss biogeochemical cycles related to aspects of environmental change and efforts to maintain environmental balance.</td></tr><tr><td>Discussion</td><td>Students hold group discussions to discuss the findings resulting from identifying interaction dilemmas by creating a food web scheme to determine the trophic level of each organism about mutualism, commensalism, parasitism and predation, as well as studying the emerging ecological paradigm.</td><td>Students held group discussions to discuss the findings resulting from identifying ecological dilemmas based on Biogeochemical Cycles associated with environmental changes that are currently occurring. By continuing to pay attention to aspects of the edaphic cycle and atmospheric cycle in the Biogeochemical cycle, it is critically and ethically related to environmental changes that are currently occurring as well as critical thinking solutions to maintain environmental balance</td></tr><tr><td>Decision</td><td>Students in groups and individuals make decisions on the results of their discussions to provide a critical attitude towards (1) interactions between components in the biome; (2) Ecological paradigm.</td><td>Students in groups and individuals determine their ethical decisions on the results of their discussions to provide analysis and critical thinking attitudes regarding the problems of Biogechenical Cycles and environmental changes that occur.</td></tr><tr><td>Engage in behavior</td><td>Individual students determine their ethical attitude to involve honest behaviour in maintaining the survival of an ecosystem.</td><td>Individual students determine their ethical attitude honestly in their behavioural involvement in maintaining the survival of an ecosystem by paying attention to the continuity of biogeochemical cycles and anticipating behavior that contributes to environmental change.</td></tr></table>
The research instruments used to obtain research data on critical thinking skills and learning outcomes were obtained from test results (pre-test and post-test). Ethical attitude data was obtained from a questionnaire assessment instrument with four Likert scales to assess each item. namely: (1) strongly disagree; (2) disagree; (3) agree; (4) strongly agree (Azwar, 2012, 2013). For research data on learning engagement, observation sheets on learning</td></tr>
</table>

		implementation are used. Learning implementation observation sheets are used in learning with the OIDDE learning model and conventional learning models. The completeness of the instrument is presented in Table 4. TABLE 4 Questionnaire on the ethical attitudes of high school students on the island towards the ecosystem. **No** / **Aspects of Ethical Attitudes towards Ecosystems** / **Total Students** (Strongly Disagree / Disagree / Agree / Strongly Agree) 1. Ecosystem caring attitude. 2. The role of humans in the ecosystem. 3. Impact of ecosystem destruction. 4. Ecosystem exploitation. 5. The environment is not just for human. 6. Humans are the main actors in preserving ecosystems. 7. Humans are the main perpetrators of ecosystem damage. 8. Ethical behavior towards ecosystems. 9. Environmental ethics and life interests. 10. Impact of ecosystem destruction. 11. The importance of identifying ecosystem management. 12. Feasibility of an ethical attitude to care for the ecosystem. 13. Feasibility of actions that destroy ecosystem. 14. The importance of analyzing the concept of ethical attitudes regarding the environment. 15. Impact Analysis of the concept of environmental care.
	Results and Discussion: - Move some sentences or quotes from the results section to the discussion section to improve clarity and coherence	The results showed that island high school students in the experimental group really enjoyed learning biology with the OIDDE learning model which was shown by their increased learning engagement. The learning environment is very enjoyable, providing engaging experiences that enhance learning outcomes, critical thinking skills, and ethical attitudes. In particular, the problems presented in biology learning encourage ethical behaviour in everyday life. Another interesting thing is that students in the experimental group felt that the time provided for learning biology in class felt insufficient because the teaching and learning process seemed to run quickly. This shows a conducive, interesting, and fun learning atmosphere with the OIDDE learning model, so it does not feel that learning time is over. Different scenarios unfolded in high school seniors in the conventional group, who did not provide feedback on the applied learning model. Students in conventional groups (control groups) simply express enjoyment in learning biology because the material is beneficial to life. However, it is different when compared to students in the experimental group who suggest, that the OIDDE learning model should not only be applied in biology but also in other subjects such as physics, chemistry, and others. What appealed to students in the experimental group was that each syntax of the OIDDE learning model was new and fun.

13. **Postponement of Acceptance of revisions from the editor via E-mail Editor in Chief to the Author until August 26, 2024 (July 15, 2024).**



14. **Third Revision Suggestion from Reviewer 2 and Reviewer 3 Via OJS (August 11, 2024) [https://www.editorialmanager.com/apsebrill/default2.aspx]**



A Rebuttal Letter [*Revise-3*]:
"The Effectiveness of The OIDDE Learning Model on Improving Critical Thinking Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students"

Subject: APSE-1136: Please revise your manuscript

Ref.: Your submission (APSE-1136)

Dear Editor,

I hereby extend my highest respect and gratitude for the attention and time given to reviewing my Revision-3 manuscript up to the pre-final stage. I also sincerely thank the reviewers for their time in providing comments and evaluations on my Revision-3 manuscript, which have helped improve it significantly.

I have made every effort to understand each comment and to address them according to the suggestions, directions, and feedback provided. I have gained valuable experience in refining the manuscript, and I hope it meets your expectations and is an improvement over the previous version.

Finally, I hope that my article manuscript can be published in your journal. Attached, please find a response letter addressing the overall revisions made to the Revision-3 manuscript in detail. I appreciate your continued corrections and feedback. Thank you.

Yours faithfully,
Atok Miftachul Hudha

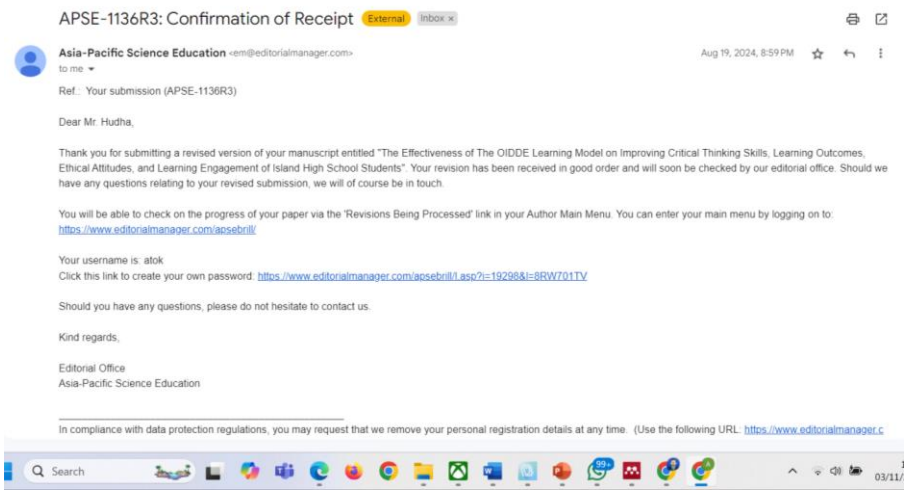
No	Comment	Revision Author
1	1) Review and Remove Unnecessary Citations: -Currently, your paper contains approximately 80 references for a 7,500-word manuscript. This is quite extensive, and many citations appear to be used only once without further discussion. We recommend you go through your manuscript and remove citations that do not significantly contribute to your argument or that are redundant.	**Answer (For Example):** Learning is a process of becoming aware of something unknown that continues continuously, and its result is a change in behaviour. Behavioural changes from the learning process produce new experiences (Djamaluddin and Wardana 2019) and the change in behaviour as a result of learning is known as learning outcomes. Learning outcomes are the achievement of an individual's knowledge after undergoing a learning process over time in the, affective, cognitive, and psychomotor domains, demonstrated by changes in individual behaviour independently (Mahananingtyas 2017; Nurrita 2018). Therefore, so that learning outcomes can be maximized and holistic for students, the learning process must be carried out by guiding and providing holistic skills and abilities. Holistic skills are crucial in the global era as they can be used to solve global issues (Miseliunaite et al., 2022) and specifically as a perspective in 4.0 learning 4.0 (Kolu and Nayar 2020). **Again:**

	For example: -The citations (Agnafia 2019; Danil 2021; Fitriyyah & Wulandari 2019) might all support the importance of critical thinking in biology learning, but if they all make the same point, one or two may suffice. -Similarly, the three citations for cooperative learning (Erdogan 2019; Leniati and Indarini 2021; Pratiwi 2015) could be reduced if they are not individually essential to your argument. Please ensure that every citation remaining in the paper is necessary and adds distinct value to your discussion.	Biology learning in the global era in Indonesia, especially in high school, has not been studied in depth regarding how effective a learning model is in enhancing the learning process (Azizah and Alberida 2021; Herman and Rahmat 2023; Imama and Rochmawati 2021), as well as its effectiveness in improving critical thinking skills and ethical attitudes. It is known that learning outcomes are an important part of measuring the extent of mastery of the material taught to an individual (Fitrianingtyas and Radia 2017), and depict what learners have achieved (Mahajan and Singh 2017). **Become:** Biology learning the global era in Indonesia, especially in high school, has not been studied in depth regarding how effective a learning model is in enhancing the learning process (Azizah & Alberida 2021; Herman & Rahmat 2023). Including the effectiveness of a learning model in enhancing students' critical thinking skills and ethical attitudes. It is known that learning outcomes are an important part of measuring the extent of mastery of the material taught to an individual (Fitrianingtyas & Radia 2017), Learning outcomes also reflect what students have achieved in their learning (Mahajan & Singh, 2017).
2	2) Format Citations According to APA 7th Edition: -Our journal requires all citations to follow APA 7th edition formatting. Currently, your paper uses a format like (Author Name and	**Answer (For Example):** **Again:** Biology education is closely linked to critical thinking skills, although Suharsono et al. (2017) state that learning outcomes do not differ significantly from critical thinking skills. However, At present, critical thinking skills are crucial in global life, especially in science education recognized by Kinoshita (2022) to have a broad impact on life. Therefore, achieving increased critical

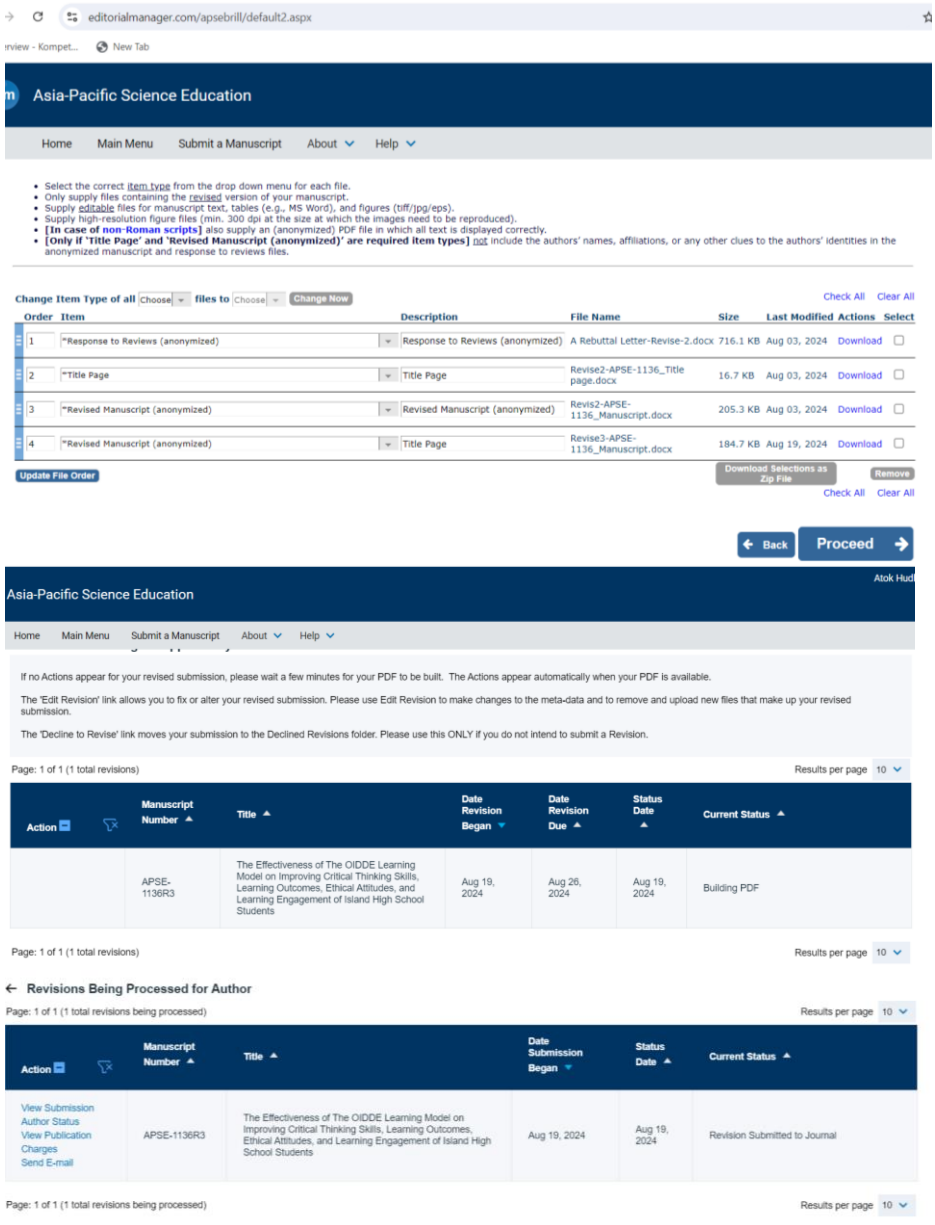
	Author Name Year). This should be revised to (Author Name & Author Name, Year). Please go through the manuscript and make these adjustments.	thinking skills in students must be sought by developing effective teaching (Kinoshita 2022; Setyowati, Sari, and Habibah 2018), through the development of teaching materials (Setyowati et al. 2018), and various learning models (Fuad et al. 2017). However, good learning outcomes and critical thinking skills are not meaningful if not balanced with the ethical attitudes of individuals. **Become:** Biology education is closely linked to critical thinking skills, although Suharsono et al. (2017) state that learning outcomes do not differ significantly from critical thinking skills. However, critical thinking skills are currently crucial in global life due to their broad impact in the global era. To achieve improvements in students' critical thinking skills, effective teaching development is necessary (Kinoshita, 2022; Setyowati et al., 2018).
3.	3) Revise Reference List to APA 7th Edition Format: -Along with formatting the in-text citations, please ensure that all references are correctly formatted according to APA 7th edition guidelines. Here are specific points to address: --Name Formatting: Currently, both first and last names are provided in the reference list. This should be corrected so that only the initials of the first names are used, e.g., "Smith, J.," rather than "John Smith." --Translation of Non-English Sources: For journals and papers published in Indonesian, please provide an English translation of the title	**Answer (For Example):** **Again:** Agnafia, Desi Nuzul. 2019. "Analisis Kemampuan Berpikir Kritis Siswa Dalam Pembelajaran Biologi." *Florea* 6(1):45–53. Agustina, Degi Alrinda, Farid Helmi Setyawan, and Sofyan Susanto. 2020. "Small Group Teaching and Learning: Method and Effect to Student' Learning Achievement." *Proceedings of the 2nd International Conference on Innovation in Education and Pedagogy (ICIEP 2020)* 619(Iciep 2020):28–32. doi: 10.2991/assehr.k.211219.006. Agustina, Hendra, and Zaenal Abidin. 2022. "Model Pembelajaran Yang Dapat Menumbuhkan Sikap Berpikir Kritis Pada Siswa." *Jurnal Ilmiah Wahana Pendidikan* 8(11):153–59. doi: https://doi.org/10.5281/zenodo.6830542. **Become:** Agnafia, D. N. (2019). Analisis Kemampuan Berpikir Kritis Siswa dalam Pembelajaran Biologi [Analysis of Students' Critical Thinking Abilities in Biology Learning]. *Florea*, *6*(1), 45–53. https://e-journal.unipma.ac.id/index.php/JF/article/view/4369/2130 Agustina, D. A., Setyawan, F. H., & Susanto, S. (2020). Small Group Teaching and Learning: Method and Effect to Student' Learning Achievement. *Proceedings of the 2nd International Conference on Innovation in Education and Pedagogy (ICIEP 2020)*, *619*(Iciep 2020), 28–32. https://doi.org/10.2991/assehr.k.211219.006

	and the journal name in square brackets after the original, if available. ---For example, if the original title is "Pembelajaran Biologi," and the journal name is "Jurnal Pendidikan," it should appear as "Pembelajaran Biologi [Biology Learning]," "Jurnal Pendidikan [Journal of Education]."	Agustina, H., & Abidin, Z. (2022). Model Pembelajaran Yang Dapat Menumbuhkan Sikap Berpikir Kritis Pada Siswa [Learning Model That Can Develop Critical Thinking Attitudes in Students]. *Jurnal Ilmiah Wahana Pendidikan* [Scientific Journal of Educational Opportunities], *8*(11), 153–159. https://doi.org/https://doi.org/10.5281/zenodo.6830542

15. Confirmation by the Editor in Chief APSE that the Article Manuscript is under Final Review by the Editor and Reviewer (Aug 19, 2024))



16. Monitoring the Process of Revision of Article Manuscripts by Authors Through OJS



17. The APSE Editor in Chief Requested Approval to Change the Article Title via E-Mail to:

***"Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Engagement among Island High School Students in Indonesia"* (APSE-1136R3). [Oct 18, 2024]**

APSE-1136R3: Please revise your manuscript

External

Inbox
Search for all messages with label Inbox
Remove label Inbox from this conversation

Sonya N Martin <em@editorialmanager.com> Oct 18, 2024, 1:22 AM

to me

Ref.: Your submission (APSE-1136R3)

Dear Mr. Hudha,

I am writing with reference to your article "Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Engagement among Island High School Students in Indonesia" (APSE-1136R3).

I hope this email finds you well. I have spent an extensive amount of time editing your manuscript, APSE-1136, focusing on grammar, spelling, formatting, and clarity. Due to page restrictions for the upcoming issue, I also needed to reduce the manuscript length. While I have taken care to avoid changing the content or intent of your work, I kindly ask you to review the edits carefully as, in some cases, the original intent was unclear, and the edits may have inadvertently altered your meaning.

To assist with your review, I have provided two versions of the paper:

APSE-1136 M1 (attached as a file to this email) – This version contains tracked changes where you can see every edit made.
APSE-1136 M2 Clean (in APSE Submission Folder)– In this version, all edits have been accepted to provide a clearer view of the final manuscript.

Please carefully review the changes and determine if you can accept or reject the edits where necessary. Please make edits to the M2 Clean version through the system using red colored font.

Action Items:

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Confidentiality of School Name: Please remove the name of the school in the manuscript to protect participant confidentiality.

Significance of Island High Schools: If the island school context is significant, please add a sentence or

two in the introduction or implications section explaining its importance. If this distinction is not critical, we will need to remove mention of the "island" aspect in the manuscript.

"About the Authors" Section: Please include brief biographical details for all authors in the "About the Authors" section. I have provided examples (including for my student and myself), which you should edit or remove as necessary.

Ethical Considerations: Since the study involves data collection from students, you must include a description of the ethical considerations followed in the research. This could include review board approval, as well as consent from parents, students, or relevant authorities. I have provided a sample statement, which you can edit as needed.

Thank you for your attention to these details.

You will find the submission in the 'Submissions Needing Revision' folder in your Author Main Menu. When submitting the revised article, please also include a detailed, point-by-point response to the review comments below. This should be uploaded as 'Response to Reviews'.

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Should you have any questions, please do not hesitate to contact me.

I look forward to receiving the revised article.

Yours sincerely,

Sonya N Martin, PhD
Editor-in-Chief
Asia-Pacific Science Education

Comments from the editor and reviewers:
One or more referees or the editor(s) have supplied additional documents in addition to the comments included in this letter. To access the file(s), please click on the link below. You can also access the files online via the 'View Attachments' action link for the manuscript.
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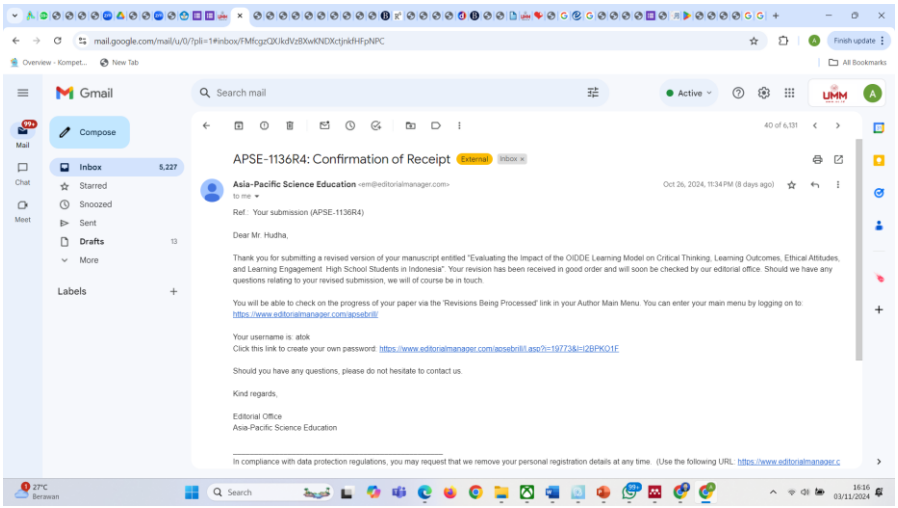
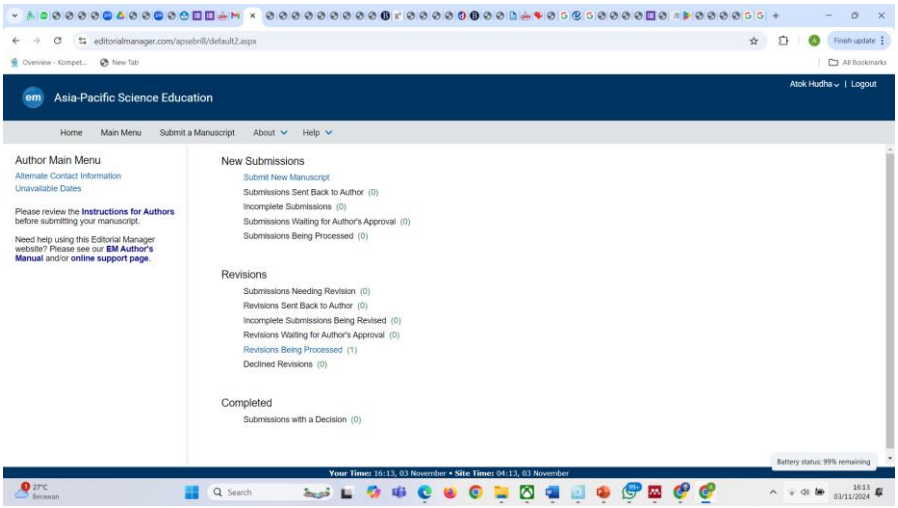
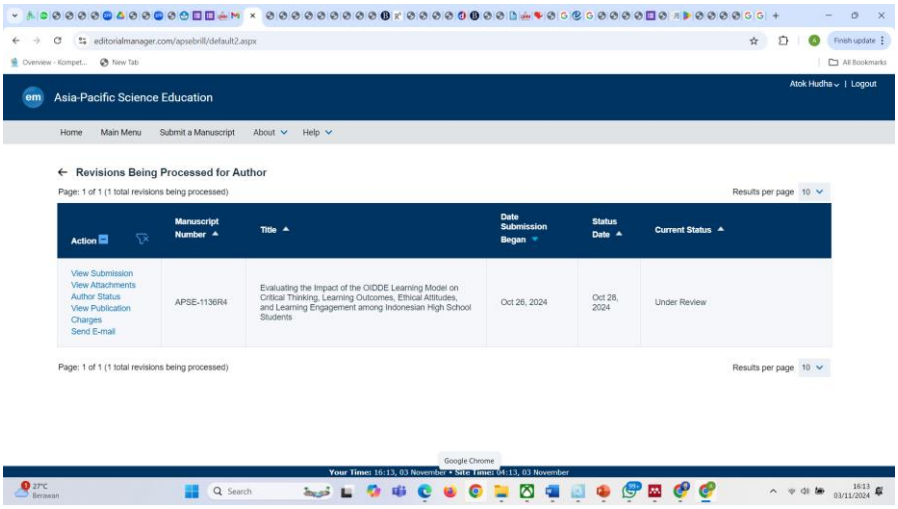
18. Submission the Fourth Revised Manuscript for review by editors and reviewers Via OJS (Oct 18, 2024)







A Rebuttal Letter: (The Fourth Revised)

Previous title:

"The Effectiveness of The OIDDE Learning Model on Improving Critical Thinking Skills, Learning Outcomes, Ethical Attitudes, and Learning Engagement of Island High School Students"

Subject: APSE-1136: Please revise your manuscript

Ref.: Your submission (APSE-1136)

Revised title by Dr. Sonya Martin:

Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Engagement among High School Students in Indonesia

Subject: APSE-1136_M2_Clean.docx

Revised title from me:

Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement High School Students in Indonesia

Subject: APSE-1136_M2_Clean.docx

Dear

Dr. Sonya Martin

I want to thank you very much for the email you sent. I have read and carefully considered all the suggestions and feedback you have provided, and I am trying to improve them as best as I can.

For the change in the title of the manuscript that you gave me, I would like to express my deepest thanks and I revised it by removing the word "island" and adding the word "Learning" to Engagement.

So the title you gave: **Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Engagement among Island High School Students in Indonesia.**

A few title changes from me: Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement High School Students in Indonesia.

So thank you for all your extraordinary help and cooperation.

Regards,

Atok Miftachul Hudha

No	Dr. Sonya Martin Note Comment	Revision Author
1.	**Copyright for Table 1:** Could you confirm whether you hold the copyright for Table 1? If so, please ensure that it is clearly indicated in the manuscript, confirming that it can be published in this journal. If the table is copyright-protected by someone else, we cannot include it in its current format. In that case, please either provide proof of permission to use it or adapt the table and attribute it accordingly.	**Previously:** The OIDDE learning model, which has been validated, proven reliable and practical (Hudha et al., 2016a), is now recognized as a copyrighted educational innovation. It was awarded copyright status by the Directorate General of Intellectual Property, Ministry of Law and Human Rights of the Republic of Indonesia (Number: EC00201701142) as a copyrighted work by Hudha (2016b). The syntax of the OIDDE learning model is outlined in Table 1. **Become:** The OIDDE learning model, which has been validated, and proven to be reliable

		and practical (Hudha et al., 2016a), is now recognized as an educational innovation protected by copyright. Has received copyright status by the Directorate General of Intellectual Property, Ministry of Law and Human Rights of the Republic of Indonesia (Number: EC00201701142) as a copyrighted work by Hudha (2016b). The first author holds this copyright, so readers can use the syntactic scheme of the OIDDE learning model published through this journal to apply the OIDDE learning model in their learning. The syntax of the OIDDE learning model is explained in Table 1. ***Documentary evidence:***  REPUBLIK INDONESIA KEMENTERIAN HUKUM DAN HAK ASASI MANUSIA SURAT PENCATATAN CIPTAAN Menteri Hukum dan Hak Asasi Manusia Republik Indonesia, berdasarkan Undang-Undang Nomor 28 Tahun 2014 tentang Hak Cipta yaitu Undang-Undang tentang perlindungan ciptaan di bidang ilmu pengetahuan, seni dan sastra (tidak melindungi hak kekayaan intelektual lainnya), dengan ini menerangkan bahwa hal-hal tersebut di bawah ini telah tercatat dalam Daftar Umum Ciptaan I. Nomor dan tanggal permohonan : EC00201701142, 8 Mei 2017 II. Pencipta Nama : Drs. Atok Miftachul Hudha, M.Pd Alamat : JL. Sarimun RT.003 RW.003 Kebarahan Beji, Kecamatan Junrejo, Batu, JAWA TIMUR, 65321 Kewarganegaraan : Indonesia III. Pemegang Hak Cipta Nama : UNIVERSITAS MUHAMMADIYAH MALANG Alamat : Jalan Raya Tlogomas No. 246 Malang , Malang, JAWA TIMUR, 65144 Kewarganegaraan : Indonesia IV. Jenis Ciptaan : Pamflet V. Judul Ciptaan : Skema Model Pembelajaran OIDDE VI. Tanggal dan tempat diumumkan untuk pertama kali di wilayah Indonesia atau di luar wilayah Indonesia : 13 Maret 2016, di Surabaya VII. Jangka waktu perlindungan : Berlaku selama 50 (lima puluh) tahun sejak Ciptaan tersebut pertama kali dilakukan Pengumuman. VIII. Nomor pencatatan : 02254 Pencatatan Ciptaan atau produk Hak Terkait dalam Daftar Umum Ciptaan bukan merupakan pengesahan atas isi, arti, maksud, atau bentuk dari Ciptaan atau produk Hak Terkait yang dicatat. Menteri tidak bertanggung jawab atas isi, arti, maksud, atau bentuk dari Ciptaan atau produk Hak Terkait yang terdaftar. (Pasal 72 dan Penjelasan Pasal 72 Undang-undang Nomor 28 Tahun 2014 Tentang Hak Cipta) a.n. MENTERI HUKUM DAN HAK ASASI MANUSIA REPUBLIK INDONESIA DIREKTUR JENDERAL KEKAYAAN INTELEKTUAL u.b. DIREKTUR HAK CIPTA DAN DESAIN INDUSTRI Dr. Dra. Erni Widhyastari, Apt., M.Si. NIP. 196003181991032001
2.	**Citations and References**: Kindly verify that all citations in the text are included in the reference list and that there are no references remaining that are no longer cited in the paper due to the edits.	**Answer:** The entire bibliography has been verified and references that are not cited are no longer listed.
3.	**Confidentiality of School Name:** Please remove the name of the school in the manuscript to protect participant confidentiality.	**Answer:** The name of the school in the manuscript has been deleted**.**

4.	**Significance of Island High Schools**: If the island school context is significant, please add a sentence or two in the introduction or implications section explaining its importance. If this distinction is not critical, we will need to remove mention of the "island" aspect in the manuscript.	**Answer:** Because the differences in school context are not crucial, I allowed deleting the "island" aspect in the manuscript.
5.	**"About the Authors" Section:** Please include brief biographical details for all authors in the "About the Authors" section. I have provided examples (including for my student and myself), which you should edit or remove as necessary.	**Answer:** **Atok Miftachul Hudha** is an associate professor and senior lecturer at the Department of Biology Education, Faculty of Teacher Training and Education, Muhammadiyah University of Malang, East Java, Indonesia. Atok earned a Bachelor's degree in Biology Education from the Department of Biology Education, Faculty of Teacher Training and Education, University of Muhammadiyah Malang, East Java, Indonesia and a Master's degree in Biology Education from the Malang State Postgraduate Institute for Teacher Training and Education, East Java, Indonesia. He also earned a doctorate in biology education from the postgraduate program at the State University of Malang, East Java, Indonesia. His research focuses on the application of learning models, bioethics teaching materials, and zoology related to biology learning and education. Until now he has taught courses that are the focus of his research. The research that became novel was the OIDDE learning model. **Handri Oktapiani** is a Master's in biology education. She obtained a bachelor's degree in biology education from the Biology Education Study Program, Faculty of Teacher Training and Education, Muhammadiyah University of Malang, East Java, Indonesia. A master's degree in biology education was obtained from the

		postgraduate biology education master's program at the University of Muhammadiyah Malang. Apart from being a teacher at a secondary school, she is also a volunteer master of teacher for the OIDDE learning model in the region in Eastern Indonesia. Research in the field of biology education has become the focus of his research. **Abdulkadir Rahardjanto** is a Professor in the Department of Biology Education, Faculty of Teacher Training and Education, University of Muhammadiyah Malang, East Java, Indonesia. Abdulkadir obtained a Bachelor's degree in Biology Education from Yogyakarta State University, Indonesia and a Master's degree in Environmental Studies from the Bandung Institute of Technology Postgraduate, West Java, Indonesia. doctorate in environmental studies obtained from the University of Indonesia. His research focuses on environmental science, environmental conservation, and societal dynamics related to biology learning and education. He is the Editor-in-Chief of the Journal of Educational Research and Development.
6.	Ethical Considerations: Since the study involves data collection from students, you must include a description of the ethical considerations followed in the research. This could include review board approval, as well as consent from parents, students, or relevant authorities. I have provided a sample statement, which you can edit as needed.	**Answer:** **Ethical Consideration** Approval to conduct this research was given by the principal of the school where the study was conducted. The data collected from this research was obtained with the permission of the biology subject teacher and students involved in this research. The identities of teachers and students are kept confidential.

Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement ~~among Island~~ High School Students in Indonesia

1. Introduction

Learning is an ongoing process of acquiring knowledge, which results in a change in behavior. These behavioral changes are shaped by new experiences gained through learning (Djamaluddin & Wardana, 2019)~~(Djamaluddin & Wardana, 2019)~~. The outcome of learning is often referred to as "learning outcomes," which encompass changes in behavior across the affective, cognitive, and psychomotor domains (Mahananingtyas, 2017;)(Nurrita, 2018) ~~(Mahananingtyas, 2017; Nurrita, 2018)~~. To maximize these outcomes, learning should be structured to provide holistic guidance and skills. In the global era, holistic skills are essential for addressing global challenges (Miseliunaite et al., 2022) ~~(Miseliunaite et al., 2022)~~.

In Indonesia, particularly in high schools, there is limited research on the effectiveness of various learning models in improving the learning process, especially in biology education ~~(~~(Azizah & Alberida, 2021)~~Azizah & Alberida, 2021~~; ~~(~~Herman & Rahmat, 2023)~~Herman & Rahmat, 2023~~. This includes evaluating how well these models enhance students' critical thinking skills and ethical attitudes. Learning outcomes serve as a key measure of students' mastery of the material ~~(~~(Fitrianingtyas & Radia, 2017)~~Fitrianingtyas & Radia, 2017~~, reflecting their overall achievement ~~(~~(Mahajan & Singh, 2017)~~Mahajan & Singh, 2017~~. Therefore, learning outcomes must be clear, learner-centered, and focused on the expected performance or understanding ~~(~~(García, 2021)~~García, 2021~~, especially in the context of biology education.

Biology education is closely linked to the development of critical thinking skills, even though some research suggests that learning outcomes do not always significantly reflect these skills (Suharsono et al., 2017)~~(Suharsono et al., 2017)~~. However, critical thinking is crucial in the global era because of its wide-ranging impacts. To improve students' critical thinking skills, effective teaching methods are required ~~(~~(Kinoshita, 2022)~~Kinoshita, 2022~~; ~~(~~Setyowati et al., 2018)~~Setyowati et al., 2018~~). The need to improve biology learning outcomes is particularly relevant in archipelagic regions, where primary and secondary students may face distinct challenges. Thus, investigating the effectiveness of the OIDDE learning model in enhancing high school biology learning outcomes is of great importance. Critical thinking skills are essential for addressing various problems, including environmental issues (Santi et al., 2018)~~(Santi et al., 2018)~~. Developing these skills requires diverse and engaging teaching methods (Hwang et al., 2023) ~~(Hwang et al., 2023)~~. Unfortunately, research shows that junior high school students in Indonesia's archipelago have relatively low critical thinking skills, likely due to traditional teaching methods that lack problem-solving opportunities and student-centered approaches (Susilawati et al., 2020)~~(Susilawati et al., 2020)~~.

Developing critical thinking skills is critical for helping students solve everyday problems (Syafitri et al., 2021) ~~(Syafitri et al., 2021)~~. However, research on enhancing critical thinking in biology through the OIDDE learning model is still scarce. Teachers employ various learning models to improve critical thinking, learning outcomes, and engagement, especially in biology. However, Indonesia's

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biology education faces many challenges, including didactic issues, curriculum constraints, and insufficient learning facilities (Khoiri et al., 2020)~~.(Khoiri et al., 2020).~~ Additionally, science teachers often lack proper training and resources, including laboratory equipment, which hinders effective biology instruction.

Several initiatives aim to improve science education in Indonesia, including teacher certification, curriculum innovation, and collaborative international research (Faisal & Martin, 2019)~~. (Faisal & Martin, 2019).~~ These initiatives can significantly impact biology learning, affecting learning outcomes, critical thinking skills, ethical attitudes, and student engagement. In education, there is often a focus on learning outcomes and critical skills, but aspects such as ethical attitudes and student engagement are frequently overlooked. This is especially true in archipelagic regions, where ethical attitudes and student engagement have not been sufficiently studied (Hudha et al., 2018)~~(Hudha et al., 2018)~~. In today's global era, ethical attitudes are crucial for shaping students' character and values, as well as for fostering a moral, tolerant, and well-behaved society (Tsoraya et al., 2023)~~.(Tsoraya et al., 2023).~~

Despite the importance of ethical attitudes, many high school biology teachers focus primarily on cognitive aspects of learning, neglecting the affective aspects like ethical attitudes (Chowdhury, 2016)~~. (Chowdhury, 2016).~~ The increasing instances of unethical behavior among students in Indonesia's archipelago underscore the need to emphasize ethical attitudes in education (Ardiana et al., 2022)~~(Ardiana et al., 2022)~~. Similarly, student engagement in biology learning requires further exploration. The OIDDE learning model offers a promising, innovative approach to address these educational challenges. This study aims to evaluate the effectiveness of the OIDDE learning model in improving critical thinking skills, learning outcomes, ethical attitudes, and learning engagement among high school students in the eastern archipelago of Indonesia.

2. The Syntax of the OIDDE Learning Model

The OIDDE learning model, which has been validated, proven reliable and practical (Hudha et al., 2016)~~(Hudha et al., 2016a)~~, is now recognized as a copyrighted educational innovation. It was awarded copyright status by the Directorate General of Intellectual Property, Ministry of Law and Human Rights of the Republic of Indonesia (Number: EC00201701142) as a copyrighted work by (Hudha, 2016)~~Hudha (2016b)~~. The first author holds this copyright, so readers can use the syntaxes scheme of the OIDDE learning model published through this journal to apply the OIDDE learning model in their learning. The syntax of the OIDDE learning model is outlined in Table 1.

Table 1.
Syntaxes of OIDDE Learning Model (adapted from ~~(~~Hudha et al., 2016)~~Hudha et al., 2016a).~~

Syntaxes	Teacher/Lecturer Activities	Students Activities

Phase 1: ***Orientation***	Prepare and direct students to learn about the material or subject to be studied.	Prepare and direct himself to learn about the material or subject matter that will be studied with the teacher.
	Presenting learning material is associated with strengthening values or character elements regarding the ethical problems of life (bioethics).	Receive material by listening, observing and taking notes independently and carefully.
	Presenting case stories from authentic facts, historical narratives, videos or documentaries that support the problems of the material being studied (for moral values, you can direct them to ethical problems)	Pay careful attention to case stories from authentic facts, historical narratives, videos or documentary films related to the problems presented by the teacher or lecturer.
Phase 2: ***Identify***	Directing and assigning individual students to identify findings of various (ethical) dilemmas from problems presented by teachers or lecturers through case stories, authentic facts, historical narratives, videos or documentary films related to the material being studied.	Identify dilemmas (directed towards ethical issues) in problematic presentations related to teaching material presented by teachers or lecturers through case stories, authentic facts, historical narratives, videos or documentary films.
	Ask students to randomly provide a brief explanation of the (ethical) dilemma that has been identified.	Select priority (ethical) dilemma issues as material for group discussion.
		Briefly explain to the teacher or lecturer the identified (ethical) dilemma (become a topic for class discussion).
Phase 3 ***Discussion***	Divide students into small heterogeneous groups of 4-5 people in each group.	Form heterogeneous discussion groups of 4-5 people per group.
	Directing students to deliberate to determine the	Deliberate to agree on priority discussion topics for the group

	topic of group discussion from the results of identifying each individual's (ethical) dilemma.	based on the results of identifying each individual's (ethical) dilemma.
	Direct all discussion groups to determine roles or positions that are appropriate to the discussion topic.	Agree on a role or position that suits the discussion topic.
	Become a facilitator for group discussions.	Carry out discussions democratically, honestly and ethically.
	Become a moderator for the presentation of the discussion results for each group.	Present together the results of the group discussion in front of the class and conduct questions and answers with other groups.
	Direct each discussion group to write down the results of their group discussion to be used as a basis for (ethical) decision making.	Compile the results of discussions to be used as a basis for (ethical) decision making.
Phase 4: ***Decision***	Direct each discussion group to determine (ethical) decision formulations from the results of their group discussions.	Determine the formulation of (ethical) decisions resulting from group discussions.
	Direct each student to formulate (ethical) decisions on their group discussion topics individually.	Formulate individual (ethical) decision formulations regarding (ethical) dilemmas based on the group discussion topic.
	Direct each student to write individually the formulation of their (ethical) decision based on the problems of the discussion topic.	Determine and write individual (ethical) decision formulations on sheets of paper that have been prepared by the teacher or lecturer.

Phase 5: ***Engage in behavior***	Encourage students to write honestly their form of (ethical) behavioral involvement regarding the discussion problems based on (ethical) decisions expressed verbally on the piece of paper provided.	Write honestly the form of behavioral (ethical) involvement in the problematic discussion based on the (ethical) decision stated verbally on the piece of paper provided.
	Inviting students to draw conclusions from learning results and class (group) discussions by providing motivation to become good and responsible academic people.	Draw conclusions from learning results and group discussions with teachers or lecturers in a good and responsible manner.

2.1 Research Questions

This study aims to evaluate the effectiveness of the OIDDE learning model for high school students in island regions through biology education. The specific research questions are as follows:

1. How does the OIDDE learning model enhance the biology learning outcomes of high school students in the islands?
2. How does the OIDDE learning model affect the development of critical thinking skills in high school students in the islands?
3. How does the OIDDE learning model influence the ethical behavior of high school students in the islands?
4. How does the OIDDE learning model contribute to increasing learning engagement among high school students in the islands?

3. Research Methodology

3.1 General Background

This study employs a quasi-experimental research design with a control group, utilizing a non-equivalent pre-test and post-test design. The experimental group was taught using the OIDDE learning model, while the control group followed conventional learning methods, as shown in Table 2.

Table 2

Research design table

Group	Pre-test	Treatment	Post-Test
E	O_1	X	O_2
C	O_3		O_4

The research was conducted with tenth-grade students at a High School, ~~in the West Nusa Tenggara Islands,~~ focusing on biology topics related to ecosystems. Students covered eight key topics during the study: ecosystem components, interactions within ecosystems, succession, types of ecosystems, ecological paradigms, food chains, biogeochemical cycles, and environmental changes. Classes were held once a week, with each session lasting 100 minutes.

The OIDDE learning model was applied to students in the experimental group, following the syntax stages outlined by ~~Hudha et al. (2017) and (~~Hudha et al., ~~(~~2018)~~Hudha et al. (2018),~~ as shown in Table 1. The control group, on the other hand, was taught using the conventional teaching methods typically employed by their teachers. This highlights the need for innovative teaching models to enhance biology education at the senior high school level. Research has consistently shown that innovative teaching approaches improve conceptual understanding more effectively than traditional methods (Artayasa et al., ~~I Putu., Susilo, H., & Indriwati,~~ 2017)~~(Artayasa, 2017)~~.

In the experimental group, the ecosystem content in the biology curriculum was delivered over three sessions following the OIDDE model. In contrast, students in the control group received the same content using the conventional teaching methods typically applied by their teacher. The details of the ecosystem material covered in these sessions are provided in Table 3.

Table 3

Implementation of Biology Learning Topics (Ecosystem Material) Using the OIDDE Learning Model Across Three Meetings

Syntax	Student Activities in 1st-2nd Meetings	Student Activities in 3rd Meeting
Orientation	Students analyze the material presented on ecosystem components and interactions within biomes across the Earth's surface.	Students analyze the material presented on biogeochemical cycles and current environmental changes occurring on the Earth's surface, engaging with great motivation.
Identify	Students identify interaction dilemmas by examining schematic patterns of ecosystem interactions in biomes. They focus on determining relationships between species (mutualism,	Students identify ecological dilemmas related to biogeochemical cycles (carbon, nitrogen, water, sulfur, and phosphorus cycles) and their connections to current environmental changes. These identification results are used for

	commensalism, parasitism, predation) and studying the emerging ecological paradigms.	group discussions on maintaining environmental balance.
Discussion	Students engage in group discussions to address the identified interaction dilemmas. They create a food web scheme to determine the trophic levels of organisms and explore the relationships of mutualism, commensalism, parasitism, and predation. They also study the associated ecological paradigms	Students participate in group discussions on ecological dilemmas related to biogeochemical cycles and environmental changes. They critically analyze the edaphic and atmospheric cycles within biogeochemical cycles, relating these to environmental changes and discussing potential solutions to maintain environmental balance.
Decision	Students, both in groups and individually, make critical decisions based on their discussions, focusing on: (1) interactions between ecosystem components and (2) the emerging ecological paradigms.	Students, both in groups and individually, determine ethical decisions based on their discussions. They critically analyze biogeochemical cycle issues and their impact on environmental changes, developing ethical perspectives on maintaining environmental stability.
Engage in behavior	Individual students reflect on and determine their ethical attitudes, committing to honest behaviors that contribute to the survival and sustainability of ecosystems.	Individual students reflect on their ethical responsibilities and commit to honest, ethical behaviors aimed at sustaining ecosystems. They focus on ensuring the continuity of biogeochemical cycles and mitigating behaviors that may negatively impact environmental change.

3.2 Research Sample

The population of this study consisted of 66 tenth-grade students from a high school, ~~located in the West Nusa Tenggara archipelago, Indonesia~~. From this population, the research sample was divided into two classes through random drawing. Class X-A, consisting of 33 students, served as the experimental group, while class X-B, also consisting of 33 students, served as the control group.

3.3 Instrument Development

This study examined four key variables: 1) Critical thinking skills – the ability to analyze arguments, draw conclusions based on reasoning, evaluate or assess information, and make decisions or solve problems. 2) Learning outcomes – the specific competencies or abilities acquired by students after participating in the learning process, encompassing cognitive, affective, and psychomotor domains. 3) Ethical attitudes – an individual's overall positive or negative response to ethical or unethical behavior, or adherence to rules and laws. 4) Learning engagement – an attitude reflecting cognitive involvement, active participation, and emotional commitment in all learning activities.

The instruments used in this research included: 1) Observation sheets for evaluating the implementation of both the OIDDE learning model and the conventional learning model. 2) Questionnaires assessing students' ethical attitudes toward ecosystems, administered both before and after the intervention. 3) Pre-test and post-test questions to measure learning outcomes, critical thinking skills, and ethical attitudes.

Before using the observation sheets and ethical attitude questionnaires, they were validated by expert validators, with all instruments deemed valid. Validation of the question items was conducted using the Pearson Correlation test, and the analysis was supported by SPSS 22.0 for Windows. The results of the validation showed that each question item was valid, as indicated by a p-value of less than 0.05. The reliability of the questions was tested using Cronbach's alpha, which yielded a value of 0.669, indicating that the question instrument was reliable ~~(Arikunto, 2006;~~ (Siregar, 2013)~~Siregar, 2015;, Sudjana, 2008).~~

For ethical attitudes, in addition to test-based measurements, non-test measurements were conducted using a questionnaire related to students' ethical attitudes toward ecosystems. The questionnaire consisted of 15 statements that students were required to respond to, reflecting their individual attitudes toward ecosystems. Ethical attitude data was collected using a four-point Likert scale to assess each item, with the following options: (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree (Syaifudin, 2012)~~.(Syaifudin, 2012).~~ A detailed description of the ethical attitude questionnaire is presented in Table 4.

Table 4
Questionnaire on High School Students' Ethical Attitudes Toward the Ecosystem

No	Aspects of Ethical Attitudes towards Ecosystems	Total Students			
		Strongly Disagree	Disagree	Agree	Strongly Agree
1.	Caring for ecosystems.				
2.	The role of humans in the ecosystem.				

3.	The impact of ecosystem destruction	
4.	Exploitation of ecosystems.	
5.	The environment is not solely for human use	
6.	Humans are the main actors in ecosystem preservation.	
7.	Humans as primary contributors to ecosystem damage.	
8.	Ethical behavior towards ecosystems.	
9.	Environmental ethics and the interests of life.	
10.	Impact of ecosystem destruction.	
11.	The importance of identifying methods for ecosystem management.	
12.	The relevance of ethical attitudes towards ecosystem care	
13.	The acceptability of actions that harm ecosystems	
14.	The importance of analyzing the concept of ethical attitudes regarding the environment.	
15.	Analyzing the impact of caring for the environment	

3.4 Learning Implementation Observation Sheet

The learning implementation observation sheet, used to measure learning engagement, was applied to both the experimental group (OIDDE learning model) and the control group (conventional learning model). The observation sheet focused on four main aspects, as outlined by (Weil & Joyce, (1978)~~Weil and Joyce (1978)~~ and (Joyce & Weil, (2003)~~Joyce and Weil (2003)~~: Implementation of the OIDDE learning model syntax; Implementation of social systems; Application of principles of reaction; and Implementation of support systems.

These four aspects were further developed into 22 measurable indicators, which were assessed using a Likert scale. The indicators were categorized as follows: seven indicators for model syntax, five for the social system, four for the principles of reaction, and six for the support system. All indicators were rated on a five-point Likert scale, with the following ratings: 1 = Very Bad, 2 = Not Good,

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Field Code Changed

3 = Fairly Good, 4 = Good, 5 = Very Good. The observation sheet for learning implementation is presented in Table 5.

Table 5
Learning Implementation Questionnaire for the Learning Engagement of Island High School Students in Biology and Ecosystem Material.

NO	Aspects of learning implementation	Scores				
		1	2	3	4	5
	A. Syntax Learning					
1.	The learning stages are organized in a clear and systematic manner.					
2.	The learning stages are logical and rational.					
3.	The learning stages clearly outline the activities for both lecturers and students.					
4.	The description of activities at each stage reflects the flow of interactions between lecturers and students.					
5.	Learning activities at each stage are oriented towards mastering ecosystem knowledge and environmental ethics.					
6.	Learning activities at each stage are focused on ethical decision-making.					
7.	Learning activities at each stage promote ethical attitudes among students.					
B	**Social System**					
1.	The learning activities encourage students to discover and construct ethical concepts.					
2.	The learning activities promote interaction between students.					
3.	The learning activities foster interaction between students and lecturers.					
4.	The learning activities reflect the embodiment of religious norms, honesty, politeness, and responsibility toward ecosystems.					
5.	The learning activities promote collaboration and mutual respect in discussions on ecosystem management.					
C	**Reaction Principle**					
1.	The teacher provides necessary learning resources such as textbooks and articles.					
2.	The teacher motivates students and sparks their interest in learning.					

3.	The teacher provides activities that stimulate curiosity, idea exploration, and scientific communication.	
4.	Students are given the opportunity to ask questions when they encounter difficulties in understanding concepts.	
D	**Support System (Nurturant Effect and Instructional Effect)**	
1.	The learning tools are aligned with the learning syntax.	
2.	The learning tools are designed to meet learning objectives that aim to improve conceptual understanding, critical thinking, ethical decision-making, and ethical behavior toward ecosystem problems.	
3.	The types of instructional effects (concept mastery, critical thinking, ethical decision-making, and ethical behavior) are clearly and logically stated in the learning stages.	
4.	The instructional effects (concept mastery, critical thinking, ethical decision-making, and ethical behavior) are aligned with the overall learning goals.	
5.	Accompanying impacts such as enhanced critical thinking skills are clearly and logically integrated into the learning stages.	
6.	Accompanying impacts in the form of ethical attitudes are aligned with the learning objectives.	

The scores obtained from Table 5 were then converted into learning implementation assessment categories based on the University of Muhammadiyah Malang Learning Assessment Standards ((Universitas Muhammadiyah Malang, (2020)~~Universitas Muhammadiyah Malang, n.d.)~~, as follows: 80.0 (Outstanding); 75.0-80.0 (Excellent); 70.0-74.9 (Very Good); 60.0-69.0 (Good); 55.0-59.9 (Fair); 40.0-54.0 (Pass); <40.0 (Fail).

3.5 Data Analysis

Data analysis was conducted using ANCOVA to assess the effectiveness of the OIDDE learning model compared to the conventional learning model in relation to learning outcomes, critical thinking skills, and ethical attitudes (based on pre-test and post-test results). Before performing the ANCOVA, normality was evaluated using the Kolmogorov-Smirnov test, and homogeneity was assessed with the Levene Test. All data analyses were carried out using SPSS for Windows, version 22.

4. Results

The research results provide insights into the impact of the OIDDE learning model on enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among students in both the experimental and control classes. The data analysis outcomes are detailed below.

4.1 Learning Outcomes

The differences in student learning outcomes between the experimental and control classes are shown in Table 6. The One-Way ANCOVA results presented in Table 6 indicate an F value of 27.643, with a p-value < 0.0001, demonstrating a significant difference in learning outcomes between the experimental and control classes, $F(1,37) = 27.643$, $p = 0.004$. This result suggests that the OIDDE learning model is effective and significantly improves learning outcomes for students in the experimental class compared to those in the control class.

Table 6

Results of One-Way ANCOVA on Biology Learning Outcomes of Island High School Students

Source	***df***	***F***	***Sig.***
learning Outcomes	1	9.434	.004
Class	1	27.643	.000
Error	37		

Next, the corrected mean analysis for each class, specifically comparing the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model), is shown in Table 7. The corrected average score for the experimental class (M = 77.350) was higher than that for the control class (M = 65.850), indicating that students in the experimental class achieved better learning outcomes. The final post-test scores and the improvement from pre-test to post-test were consistently higher for the experimental class. Therefore, the OIDDE learning model proves to be more effective in enhancing biology learning outcomes than conventional teaching methods.

Table 7

Mean Corrected Scores of Island High School Students' Learning Outcomes in Conventional vs. OIDDE Learning Models

Group	**Pre-test**	**Post-test**	**Difference**	**Corrected Mean**
Conventional	45.85	65.05	19.2	65.850
OIDDE	49.85	78.15	28.3	77.350

4.2 Critical Thinking Skills

The next section of data analysis focuses on the improvement of students' critical thinking skills for both experimental and control class students, as shown in Table 8. The calculated F difference in the OIDDE learning model treatment is 25.183, with a p-value < 0.0001, indicating a significant variation in critical thinking skills between the experimental and control classes, $F(1,37) = 25.183$, $p > 0.0001$.

Table 8

Analysis of Variance (ANCOVA) Results on Critical Thinking Skill Achievement of Island High School Students.

Source	*df*	*F*	*Sig.*
Critical Thinking	1	26.466	.000
Class	1	25.183	.000
Error	37		
Total	40		

Table 9 presents the average pre-test and post-test scores for both classes. According to the ANCOVA test results, the corrected mean score for critical thinking skills in the experimental class (M = 83.360) was higher than the corrected mean score in the control class (M = 74.490). This difference is evident in both the average post-test scores and the improvement from pre-test to post-test. Therefore, the OIDDE learning model positively influences the enhancement of students' critical thinking skills in the experimental class.

Table 9

Corrected Mean Scores for Critical Thinking Skills of Island High School Students

Group	*Pre-test*	*Post-test*	Difference	Enhancement	Corrected Mean
Conventional	67.20	74.85	7.65	11%	74.490
OIDDE	66.00	83.00	17	26%	83.360

Overall, the OIDDE learning model significantly improves students' critical thinking skills in the experimental class compared to the conventional learning model used in the control class. This finding suggests that applying the OIDDE learning model to biology learning, particularly ecosystem material, makes the learning process more conducive and meaningful than using conventional methods.

In line with ~~(~~Agustina & Abidin~~,~~ (2022)~~:~~ ~~Agustina and Abidin (2022), (~~Bayu et al.~~,~~ (2022)~~;Bayu et al. (2022), (~~Ningrum & Murti~~,~~ (2023)~~and Ningrum and Murti (2023)~~, who argue that improving critical thinking competency requires effective and innovative learning models, this research confirms that the OIDDE learning model effectively enhances students' critical thinking abilities. Additionally, as

highlighted by (Heard et al., (2020)Heard et al. (2020) and (Rodzalan et al., (2020)Rodzalan et al. (2020), sustaining improvements in critical thinking skills also requires attention to students' physical well-being, intellectual development, and continuous motivation.

4.3 Ethical Attitudes

The next research section presents an ANCOVA analysis of data on the ethical attitudes of students in both the experimental and control classes towards ecosystems after participating in biology lessons on ecosystem material, as shown in Table 10.

Table 10

Analysis of Variance (ANCOVA) Results on Ethical Attitudes of Island High School Students

Source	***df***	***F***	***Sig.***
Class	1	24.439	.000
Error	37		
Total	40		

Table 10 provides a summary of the ANCOVA test results, which were used to analyze the impact of the learning model on students' ethical attitudes. The results clearly show that there is a significant difference between the experimental and control classes in terms of ethical attitudes, with $F_{(1,37)} = 24.439$ and $p < 0.001$. This indicates that the OIDDE learning model is more effective in significantly enhancing the ethical attitudes of students in the experimental class compared to those in the control class, which followed a conventional learning model.

The increase in ethical attitudes through the OIDDE learning model is notable. This is because the OIDDE learning model's structure specifically fosters the development of attitudes, particularly in the fifth stage of its syntax: "Engage in behavior." This stage represents the culmination of the learning process, where students' ethical involvement becomes evident through their participation in problem-solving activities and dilemmas related to the teaching material.

Next, Table 11 compares the class averages for both the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model).

Table 11

Average Ethical Attitude Scores of Island High School Student

Group	*Pre-test*	*Post-test*	Difference	Enhancement	Corrected Mean
Conventional	67.00	74.85	7.85	12	74.612
OIDDE	66.20	83.00	21.80	25	83.233

Based on Table 11, the corrected mean for the experimental class (M = 83.233) was higher than that of the control class (M = 74.612). This confirms that the ethical attitudes of students in the experimental class, who engaged with the OIDDE learning model, were significantly better than those in the control class, who followed a conventional learning approach.

The significant increase in ethical attitudes in the experimental class highlights that learning ecosystem-related biology topics through the OIDDE learning model enhances students' ethical awareness and sense of responsibility toward the environment. These findings align with previous research by (Hudha et al., (2018)Hudha et al. (2018), which demonstrated that the OIDDE learning model effectively increases students' understanding of life ethics, ethical decision-making, and ethical attitudes.

Furthermore, (Ichsan et al., (2020)Ichsan et al. (2020) emphasized that 21st-century ecosystem education must be contextual and foster High Order Thinking Skills (HOTS) to effectively address environmental issues. In this regard, the OIDDE learning model is well-suited for fostering HOTS, as it encourages critical, creative, and analytical thinking applied to problem-solving in biology education. (Tasrif, (2022)Tasrif (2022) reinforced this idea by highlighting that HOTS includes the ability to think critically, creatively, and analytically to solve problems using information and data. The OIDDE learning model, by focusing on problem discovery, ethical decision-making, and behavioral involvement, supports the development of these higher-order thinking skills.

In addition to the pre-test and post-test measurements of ethical attitudes (as shown in Table 10 and Table 11), researchers also assessed students' ethical attitudes in both the experimental and control classes using a questionnaire. The results of this assessment are illustrated in Figure 1.

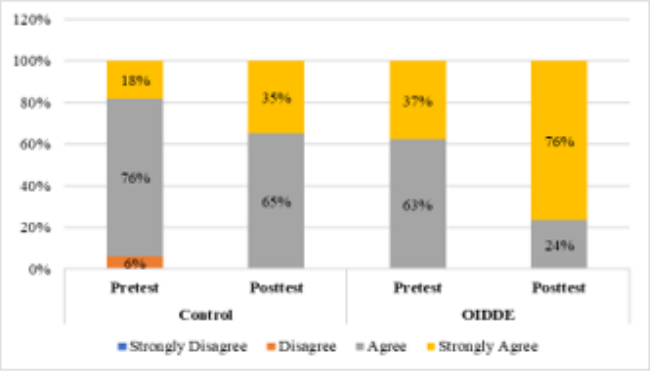

Figure 1 illustrates the results of the questionnaire assessing the ethical attitudes of X Island High School students before and after implementing the learning model in both the experimental and control groups.

The figure shows that students in the experimental group, who were taught using the OIDDE learning model, exhibited significantly stronger ethical attitudes toward ecosystem issues compared to students in the control group. In the pre-test for the experimental group, 37% of students strongly agreed with ethical statements regarding ecosystems, while in the post-test, this percentage increased to 76%. This reflects a 39% improvement in students' ethical attitudes after learning with the OIDDE model. Additionally, there was a notable decline in students expressing only agreement (from 63% in the pre-test to 24% in the post-test), indicating a positive shift from moderate agreement to strong agreement in ethical attitudes.
In contrast, the control group displayed more varied ethical attitudes toward ecosystem issues. In the pre-test, 6% of students disagreed, 76% agreed, and 18% strongly agreed with the ethical statements. By the post-test, there was a 17% increase in the number of students strongly agreeing, from 18% to 35%. This improvement was accompanied by a slight decrease in the percentage of students who agreed, dropping from 76% in the pre-test to 65% in the post-test. Overall, while there was some improvement in the control group, it was not as pronounced as in the experimental group.

The data from Figure 1 highlights one of the main advantages of the OIDDE learning model—it effectively motivates students to express ethical behavior independently, with integrity and honesty, particularly in relation to ecosystem issues. This is not commonly observed in other learning models. (Chairilsyah, (2016) As Chairilsyah (2016) notes, honesty is a critical aspect of daily life, and as (Cooper et al., (2023) Cooper et al. (2023) argue, honesty encourages individuals to behave ethically. Additionally, (Bonnie et al., (2022) Bonnie et al. (2022)

emphasize that honesty is closely related to well-being. Therefore, ethical attitudes, as reflected in honesty, play a fundamental role in students' lives and behavior.

In addition to the improvement in learning outcomes, critical thinking skills, and ethical attitudes, the study also measured student learning engagement for both the experimental and control classes. Learning engagement data was collected using observation sheets during biology lessons on ecosystem material. The findings show a clear difference between the two groups: students in the experimental class achieved a 'very good' level of engagement, while students in the control class were categorized as 'good,' as displayed in Table 12.

Table 12

Learning Engagement Levels of Island High School Students by Learning Model

Learning Model	Percentage	Category
Conventional	70%	Good
OIDDE	78%	Excellent

Table 12 shows that the learning engagement of students in the experimental class, who were taught using the OIDDE learning model, is categorized as 'very good' (excellent), whereas students in the control class, who followed the conventional learning model, are classified as 'good.' The increase in learning engagement for the experimental class was 78% (excellent), compared to only 70% (good) for the control class. This indicates that the OIDDE learning model had a greater impact on enhancing learning engagement among students in the experimental class compared to the conventional learning model used in the control class.

The results confirm that a learning model that is supportive, enjoyable, meaningful, student-centered, and includes an ethical dimension can significantly enhance student engagement. Therefore, it can be concluded that the OIDDE learning model is an effective approach for improving student engagement in biology education.

The research findings also revealed that students in the experimental class found learning biology more enjoyable with the OIDDE learning model, as demonstrated by their increased engagement. A teaching process that is supportive, enjoyable, meaningful, student-centered, and ethically grounded provides a richer learning experience for students, as supported by previous studies ((Bishop et al., 2014); (Emaliana, 2017); (Ali et al., 2020).

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What sets the OIDDE learning model apart from conventional and earlier models is its integration of the "decision" and "engage in behavior" stages. These stages are specifically designed to help students engage in ethical decision-making and develop ethical attitudes related to the material being studied.

In the decision stage, students are guided to make ethical decisions as a solution to the problems they encounter, with a focus on ethical reasoning. In the engage in behavior stage, students are encouraged to express their behaviors and attitudes based on the ethical decisions they have made during the learning process. This unique aspect of the OIDDE learning model ensures that students develop not only critical thinking and problem-solving skills but also ethical attitudes.

As a result, students in the experimental class reported positive experiences, stating that after learning ecosystem material using the OIDDE model, they felt highly motivated, found the learning environment conducive and enjoyable, and had increased learning awareness. Overall, the students appreciated the fresh and engaging approach offered by each component of the OIDDE model. It is not surprising, therefore, that many students expressed a desire for the OIDDE learning model to be applied not only in biology but also in other subjects.

5. Discussion

5.1 Effectiveness of the OIDDE Learning Model

The results indicate that the OIDDE learning model is highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement compared to the conventional learning model used in the control class. Students in the experimental class consistently outperformed those in the control class across all measured domains, demonstrating the value of the OIDDE model in fostering a more meaningful and engaging learning experience. This aligns with prior studies that emphasize the importance of innovative, problem-based, and contextual learning models in achieving significant educational outcomes ~~(As-Sa'idah et al., 2022;~~ (Hajeniati & Kaharuddin, 2022)~~Hajeniati & Kaharuddin, 2022)~~.

This research reinforces earlier findings, confirming that the OIDDE learning model improves the critical thinking skills of students, as well as their creative thinking abilities ~~(~~(Ma'rifatillah et al., 2019)~~Ma'rifatillah et al., 2019; Fatmawati et al., 2018)~~. The results are also consistent with studies that highlight the significance of ethical attitudes in biology education ~~((~~Kohli et al.~~,~~ (2015)~~Kohli et al., 2015~~; ~~(~~Chen & So~~,~~ (2017)~~Chen & So, 2017~~). Moreover, the OIDDE learning model's positive impact on ethical attitudes, which had been previously observed in prospective biology teachers, is confirmed here in the context of high school students ~~(~~(Hudha et al., 2018)~~Hudha et al., 2018)~~.

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The OIDDE learning model is well-suited to 21st-century educational demands, characterized by critical thinking, problem-solving, collaboration, creativity, and innovation ~~((~~(Aslamiah et al.~~,~~ 2021)~~Aslamiah et al., 2021~~; ~~(~~Wulandari, 2021)~~Wulandari, 2021~~). This model is highly effective in creating a constructive, student-centered learning environment, which is essential for developing students' cognitive and ethical competencies in modern education. The

integration of the model's syntax into science education fosters a conducive and innovative learning atmosphere, benefiting students academically and personally.

5.2 Enhancing Critical Thinking and Ethical Attitudes

The improvements in critical thinking skills and ethical attitudes among students in the experimental class highlight the effectiveness of the OIDDE learning model, particularly in the context of biology education. The model's problem-based approach encourages students to actively engage in solving ethical dilemmas related to ecosystem issues. This active involvement fosters critical thinking and enables students to make informed, ethical decisions, a skill that is vital for addressing 21st-century challenges ((Rahman et al., 2023)Rahman et al., 2023; (Haulia et al., 2022)Haulia et al., 2022).

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One of the key advantages of the OIDDE learning model is its capacity to create an active learning environment. The syntax of the model encourages students to engage in hands-on problem-solving, fostering both independent thinking and teamwork. This collaborative learning environment helps develop critical thinking and ethical attitudes, as students work together to address real-world issues. Small group discussions, in particular, encourage cooperation, which is essential for improving learning outcomes and engagement (Kvellestad et al., 2021)(Kvellestad et al., 2021).

5.3 The Role of Problem-Based Learning in Science Education

The OIDDE learning model's emphasis on problem-based learning aligns with research that demonstrates the importance of addressing contextual, real-world problems in education. By presenting students with issues related to ecosystems, the model promotes the development of critical thinking skills, ethical attitudes, and greater engagement in learning. The effectiveness of this approach is evident in the significant improvements observed in the experimental class, where students were more motivated, engaged, and capable of making ethical decisions compared to the control class ((Pozas et al., 2020)Pozas et al., 2020; (Bahri & Corebima, 2015)Bahri & Corebima, 2015).

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5.4 Strengths of the OIDDE Model Syntax

The sequential syntax of the OIDDE learning model, from orientation to decision-making and behavior engagement, plays a crucial role in its effectiveness. Each stage is designed to encourage students to think critically, collaborate, and engage in ethical decision-making. The syntax's flexibility allows teachers to incorporate real-world problems and contextual learning into their lessons, enhancing both

cognitive and affective learning outcomes. This step-by-step approach has proven to be effective in fostering deeper learning, ethical understanding, and student engagement in biology education.

The research uncovered several new findings related to the implementation of the OIDDE learning model. First, both teachers and students in island high schools were introduced to an innovative and effective learning model that fostered greater awareness of ethical dilemmas in biological issues. Second, students developed critical thinking skills and learned to engage in ethical decision-making through group discussions. These findings highlight the OIDDE model's potential for promoting student-centered learning and fostering a deeper understanding of complex environmental issues.

The OIDDE learning model has demonstrated its effectiveness in enhancing learning outcomes, critical thinking skills, ethical attitudes, and engagement among high school students. Based on the research findings, it is recommended that the OIDDE model be adopted in various subjects beyond biology to promote critical thinking, ethical behavior, and student engagement across disciplines. Additionally, further research should explore the application of the OIDDE model in different educational contexts and subject areas, focusing on the development of student integrity, ethical decision-making, and problem-solving skills.

6. Conclusion

The implementation of the OIDDE learning model has proven to be highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among high school students in the islands, especially in comparison to conventional learning models used in biology instruction. The experimental group showed significant improvements across all measured domains and provided overwhelmingly positive feedback. Students in the experimental class consistently expressed satisfaction with the OIDDE model, noting a pleasant and engaging learning atmosphere that fostered collaboration, critical thinking, and ethical decision-making.

Furthermore, students appreciated the novelty and interest sparked by each syntax of the OIDDE model, which encouraged them to explore more and suggested that the model could be applied successfully to other subjects like physics and chemistry. The model's ability to create an enjoyable and conducive learning environment has led students to advocate for its broader application beyond biology. Given these results, the OIDDE learning model presents a compelling option for fostering 21st-century learning skills. Its innovative approach should be considered for implementation across various educational levels and subjects to support the holistic development of students, particularly in critical thinking, ethical reasoning, and engagement.

7. Limitations and Recommendations

This study was conducted with students from a single high school, focusing solely on the subject of biology. As such, the results cannot be generalized across all educational settings or subjects. However, the findings provide a strong foundation for future research and implementation of the OIDDE model in different subject areas and educational contexts. Another limitation is that the OIDDE model is new to both students and teachers in the island school where the research was conducted. Despite this, the introduction of the model has successfully enriched the teachers' pedagogical repertoire and demonstrated its potential for broader application.

Based on the findings of this study, it is recommended that the OIDDE model should be adopted, and its use should be expanded. The OIDDE model is a promising, innovative learning model that should be considered for application across various educational levels and subjects, beyond just biology. Its structured approach to fostering critical thinking, ethical attitudes, and student engagement aligns with the demands of 21st-century learning. In addition, the OIDDE model should be referenced as a strategy for developing critical thinking skills and improving overall learning outcomes. It can serve as an effective learning framework for students in diverse educational contexts, helping to cultivate ethical behavior and enhance engagement at various levels of education. These recommendations highlight the value of the OIDDE model in modern education and suggest its potential to contribute to the ongoing development of innovative and student-centered learning strategies.

Ethical Consideration

Approval to conduct this research was given by the Principal of the High School at the research location. The data collected from this research was obtained with the necessary permission from the participants involved in this research and also the biology teacher at the school where the research took place. The identities of the participants were kept confidential. ~~Approval to conduct this study was granted by the XX Ethics Review Board. The data collected from this project were obtained with the necessary clearance from the participants involved in the study. The participants' identities have been kept anonymous.~~

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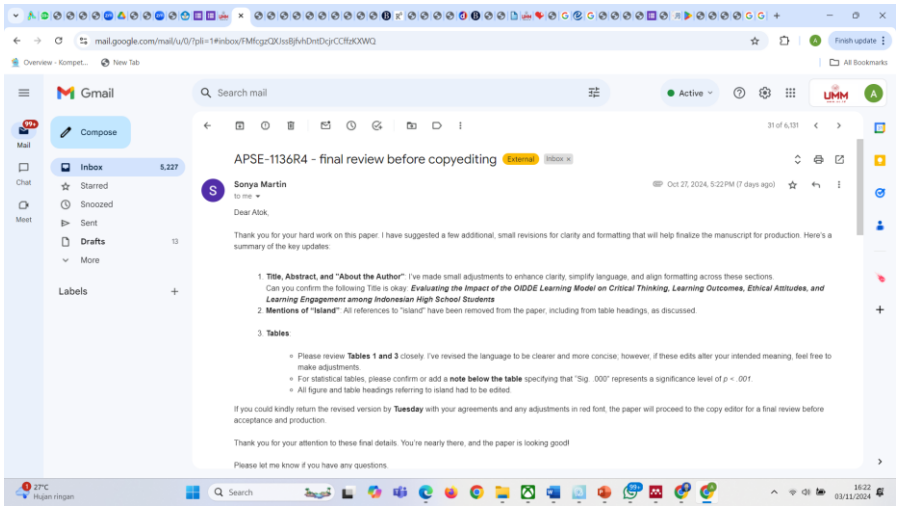

Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement among Indonesian High School Students

Abstract This study investigates the effectiveness of the OIDDE learning model in enhancing biology learning outcomes, critical thinking, ethical attitudes, and engagement among high school students in Indonesia. Employing a quasi-experimental design with pre- and post-tests, the research included 66 randomly sampled students, evenly divided into experimental and control groups. Data were gathered through validated observation sheets, ethical attitude questionnaires, and tests, with ANCOVA analysis conducted following normality and homogeneity tests. Results indicate significant improvements across all measured variables in the experimental group compared to the control group. The findings suggest that the OIDDE model is more effective than conventional methods in fostering comprehensive educational outcomes in biology, as its problem-based approach promotes active learning, ethical decision-making, and collaborative problem-solving, aligning well with the needs of 21st-century education. This study underscores the model's potential for broader application across various subjects to enhance critical thinking, ethical behaviour, and sustained student engagement.

Keywords critical thinking; ethical attitudes; learning engagement; learning model - OIDDE learning model

1. Introduction

Learning is an ongoing process of acquiring knowledge, which results in a change in behaviour. These behavioural changes are shaped by new experiences gained through learning (Djamaluddin & Wardana, 2019). The outcome of learning is often referred to as "learning outcomes," which encompass changes in behaviour across the affective, cognitive, and psychomotor domains (Mahananingtyas, 2017; Nurrita, 2018). To maximize these outcomes, learning should be structured to provide holistic guidance and skills. In the global era, holistic skills are essential for addressing global challenges (Miseliunaite et al., 2022).

In Indonesia, particularly in high schools, there is limited research on the effectiveness of various learning models in improving the learning process, especially in biology education (Azizah & Alberida, 2021; Herman & Rahmat, 2023). This includes evaluating how well these models enhance students' critical thinking skills and ethical attitudes. Learning outcomes serve as a key measure of students' mastery of the material (Fitrianingtyas & Radia, 2017), reflecting their overall achievement (Mahajan & Singh, 2017). Therefore, learning outcomes must be clear, learner-centered, and focused on the expected performance or understanding (García, 2021), especially in the context of biology education.

Biology education is closely linked to the development of critical thinking skills, even though some research suggests that learning outcomes do not always significantly reflect these skills (Suharsono et al., 2017). However, critical thinking is crucial in the global era because of its wide-ranging impacts. To improve students' critical thinking skills, effective teaching methods are required (Kinoshita, 2022; Setyowati et al., 2018)). The need to improve biology learning outcomes is particularly relevant in archipelagic regions, where primary and secondary students may face distinct challenges. Thus, investigating the effectiveness of the OIDDE learning model in enhancing high school biology learning outcomes is of great importance. Critical thinking skills are essential for addressing various problems, including environmental issues (Santi et al., 2018). Developing these skills requires diverse and engaging teaching methods (Hwang et al., 2023). Unfortunately, research shows that junior high school students in Indonesia's archipelago have relatively low critical thinking skills, likely due to traditional teaching methods that lack problem-solving opportunities and student-centered approaches (Susilawati et al., 2020).

Developing critical thinking skills is critical for helping students solve everyday problems (Syafitri et al., 2021). However, research on enhancing critical thinking in biology through the OIDDE learning model is still scarce. Teachers employ various learning models to improve critical thinking, learning outcomes, and engagement, especially in biology. However, Indonesia's biology education faces many challenges, including didactic issues, curriculum constraints, and insufficient learning facilities (Khoiri et al., 2020). Additionally, science teachers often lack proper training and resources, including laboratory equipment, which hinders effective biology instruction.

Several initiatives aim to improve science education in Indonesia, including teacher certification, curriculum innovation, and collaborative international research (Faisal & Martin, 2019). These initiatives can significantly impact biology learning, affecting learning outcomes, critical thinking skills, ethical attitudes, and student engagement. In education, there is often a focus on learning outcomes and critical skills, but aspects such as ethical attitudes and student engagement are frequently overlooked. This is especially true in archipelagic regions, where ethical attitudes and student engagement have not been sufficiently studied (Hudha et al., 2018). In today's global era, ethical attitudes are crucial for shaping students' character and values, as well as for fostering a moral, tolerant, and well-behaved society (Tsoraya et al., 2023).

Despite the importance of ethical attitudes, many high school biology teachers focus primarily on cognitive aspects of learning, neglecting the affective aspects like ethical attitudes (Chowdhury, 2016). The increasing instances of unethical behaviour among students in Indonesia's archipelago underscore the need to emphasize ethical attitudes in education (Ardiana et al., 2022). Similarly, student engagement in biology learning requires further exploration. The

OIDDE learning model offers a promising, innovative approach to address these educational challenges. This study aims to evaluate the effectiveness of the OIDDE learning model in improving critical thinking skills, learning outcomes, ethical attitudes, and learning engagement among high school students in the eastern archipelago of Indonesia.

2. The Syntax of the OIDDE Learning Model

The OIDDE learning model, developed and validated by Hudha et al. (2016), has demonstrated reliability and practical application in educational settings. Recognized as an innovative educational tool, it has been awarded copyright status by the Directorate General of Intellectual Property under the Ministry of Law and Human Rights of the Republic of Indonesia (Registration Number: EC00201701142). This copyright is held by the first author (Hudha, 2016). Readers are encouraged to apply the OIDDE learning model in their teaching by following the syntactic framework provided in this publication. The specific steps in the OIDDE model are detailed in Table 1.

Table 1.
Syntaxes of the OIDDE Learning Model (adapted from Hudha et al., 2016).

Syntax	Teacher Activities	Student Activities
Phase 1: Orientation	- Guide students in preparing to learn the material. - Present materials that incorporate values and ethical issues (bioethics). - Share case studies, historical narratives, videos, or documentaries to introduce ethical dilemmas.	- Prepare and engage with the material. - Listen, observe, and take notes. - Pay close attention to case studies and ethical issues presented.
Phase 2: Identify	- Assign students to identify ethical dilemmas within case stories, facts, and narratives. - Ask selected students to briefly explain identified dilemmas for class discussion.	- Identify ethical dilemmas in the material. - Select priority dilemmas for group discussion. - Explain identified dilemmas as part of a class discussion.
Phase 3: Discussion	- Divide students into small heterogeneous groups of 4-5 members. - Guide students to prioritize ethical dilemmas from individual findings as topics for group discussion. - Instruct each group to assign roles relevant to the chosen discussion topic. - Facilitate group discussions, ensuring they are	- Form groups of 4-5 members. - Deliberate within groups to select priority ethical dilemmas for discussion. - Assign appropriate roles for each group member. - Engage in discussions with a focus on democratic, honest, and ethical participation.

Syntax	Teacher Activities	Student Activities
	democratic, honest, and ethical. - Moderate as each group presents discussion results to the class, followed by a Q&A. - Direct groups to document discussion outcomes as a foundation for ethical decision-making.	- Present group discussion results to the class and participate in Q&A. - Document discussion outcomes for use in ethical decision-making.
Phase 4: Decision	- Guide each group to collaboratively formulate ethical decisions based on their discussions. - Instruct students to develop individual ethical decisions, reflecting on group discussion topics. - Direct each student to document their individual ethical decisions independently. - Provide prepared sheets for students to record their individual ethical decisions.	- Collaboratively formulate ethical decisions as a group based on group discussions. - Reflect individually on group topics to make personal ethical decisions. - Document individual ethical decisions on provided sheets.
Phase 5: Engage in Behaviour	- Encourage students to reflect on and document ethical behaviour related to the decisions made during discussions. - Facilitate class conclusions on learning outcomes and ethical responsibilities.	- Reflect on and document personal ethical behaviour in line with group decisions. - Participate in drawing class conclusions with integrity and responsibility.

2.1 Research Questions

This study aims to evaluate the effectiveness of the OIDDE learning model for high school students in island regions through biology education. The specific research questions are as follows:

1. How does the OIDDE learning model enhance the biology learning outcomes of high school students in the islands?
2. How does the OIDDE learning model affect the development of critical thinking skills in high school students in the islands?
3. How does the OIDDE learning model influence the ethical behaviour of high school students in the islands?
4. How does the OIDDE learning model contribute to increasing learning engagement among high school students in the islands?

3. Research Methodology

3.1 General Background

This study employs a quasi-experimental research design with a control group, utilizing a non-equivalent pre-test and post-test design. The experimental group was taught using the OIDDE learning model, while the control group followed conventional learning methods, as shown in Table 2.

Table 2

Research design

Group	Pre-test	Treatment (X)	Post-Test
E	O_1	X	O_2
C	O_3	—	O_4

Legend:

- E = Experimental Group
- C = Control Group
- O_1, O_3 = Pre-test measurements
- O_2, O_4 = Post-test measurements
- X = Treatment (OIDDE Learning Model

The research was conducted with tenth-grade students at a High School, focusing on biology topics related to ecosystems. Students covered eight key topics during the study: ecosystem components, interactions within ecosystems, succession, types of ecosystems, ecological paradigms, food chains, biogeochemical cycles, and environmental changes. Classes were held once a week, with each session lasting 100 minutes.

The OIDDE learning model was applied to students in the experimental group, following the syntax stages outlined by Hudha et al. (2018), as shown in Table 1. The control group, on the other hand, was taught using the conventional teaching methods typically employed by their teachers. This highlights the need for innovative teaching models to enhance biology education at the senior high school level. Research has consistently shown that innovative teaching approaches improve conceptual understanding more effectively than traditional methods (Artayasa et al., 2017).

In the experimental group, the ecosystem content in the biology curriculum was delivered over three sessions following the OIDDE model. In contrast, students in the control group received the same content using the conventional teaching methods typically applied by their teacher. The details of the ecosystem material covered in these sessions are provided in Table 3.

Table 3

Implementation of Biology Learning Topics on Ecosystems Using the OIDDE Learning Model Across Three Meetings

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Syntax	Student Activities in 1st-2nd Meetings	Student Activities in 3rd Meeting
Orientation	Students analyze material on ecosystem components and interactions within various biomes across the Earth's surface.	Students analyze biogeochemical cycles and current environmental changes, engaging with great motivation.
Identify	Students identify interaction dilemmas by examining ecosystem interactions in biomes, focusing on relationships (mutualism, commensalism, parasitism, predation) and emerging ecological paradigms.	Students identify ecological dilemmas related to biogeochemical cycles (carbon, nitrogen, water, sulfur, phosphorus) and their connection to environmental changes, using these insights for group discussions on environmental balance.
Discussion	In groups, students discuss the interaction dilemmas, create food web schemes to analyze trophic levels, and explore ecological relationships and paradigms.	Students participate in discussions on ecological dilemmas linked to biogeochemical cycles and environmental changes, analyzing edaphic and atmospheric cycles and discussing solutions for environmental balance..
Decision	Students make critical decisions individually and in groups, focusing on ecosystem interactions and emerging ecological paradigms.	Students make ethical decisions individually and in groups, based on their analysis of biogeochemical cycles and environmental impacts, developing perspectives on environmental stability.
Engage in Behaviour	Students individually reflect on their ethical attitudes and commit to honest behaviours that support ecosystem sustainability.	Students commit to ethical behaviours that support ecosystem sustainability, focusing on biogeochemical cycle continuity and minimizing negative impacts on the environment.

3.2 Research Sample

The study population consisted of 66 tenth-grade students, who were randomly assigned into two groups. Class X-A, with 33 students, served as the experimental group, and Class X-B, also with 33 students, served as the control group.

3.3 Instrument Development

This study examined four key variables: 1) Critical thinking skills – the ability to analyze arguments, draw conclusions based on reasoning, evaluate or assess information, and make decisions or solve problems. 2) Learning outcomes – the specific competencies or abilities acquired by students after participating in the learning process, encompassing cognitive, affective, and psychomotor domains. 3) Ethical attitudes – an individual's overall positive or negative response to ethical or unethical behaviour, or adherence to rules and laws. 4) Learning engagement – an attitude reflecting cognitive involvement, active participation, and emotional commitment in all learning activities.

The instruments used in this research included: 1) Observation sheets for evaluating the implementation of both the OIDDE learning model and the conventional learning model. 2) Questionnaires assessing students' ethical attitudes toward ecosystems, administered both before and after the intervention. 3) Pre-test and post-test questions to measure learning outcomes, critical thinking skills, and ethical attitudes.

Before using the observation sheets and ethical attitude questionnaires, they were validated by expert validators, with all instruments deemed valid. Validation of the question items was conducted using the Pearson Correlation test, and the analysis was supported by SPSS 22.0 for Windows. The results of the validation showed that each question item was valid, as indicated by a p-value of less than 0.05. The reliability of the questions was tested using Cronbach's alpha, which yielded a value of 0.669, indicating that the question instrument was reliable (Siregar, 2013).

For ethical attitudes, in addition to test-based measurements, non-test measurements were conducted using a questionnaire related to students' ethical attitudes toward ecosystems. The questionnaire consisted of 15 statements that students were required to respond to, reflecting their individual attitudes toward ecosystems. Ethical attitude data was collected using a four-point Likert scale to assess each item, with the following options: (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree (Syaifudin, 2012). A detailed description of the ethical attitude questionnaire is presented in Table 4.

Table 4

Questionnaire on High School Students' Ethical Attitudes Toward the Ecosystem

No	Aspects of Ethical Attitudes towards Ecosystems	Total Students			
		Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
1.	Caring for ecosystems				
2.	The role of humans in the ecosystem				
3.	The impact of ecosystem destruction				

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4.	Exploitation of ecosystems.	
5.	The environment is not solely for human use	
6.	Humans as primary agents of ecosystem preservation	
7.	Humans as primary contributors to ecosystem damage	
8.	Ethical behaviour towards ecosystems	
9.	Environmental ethics and the interests of life	
10.	Impact of ecosystem destruction	
11.	Importance of identifying methods for ecosystem management	
12.	Relevance of ethical attitudes towards ecosystem care	
13.	Acceptability of actions that harm ecosystems	
14.	Importance of analyzing ethical attitudes regarding the environment	
15.	Analyzing the impact of caring for the environment	

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3.4 Learning Implementation Observation Sheet

The learning implementation observation sheet, used to measure learning engagement, was applied to both the experimental group (OIDDE learning model) and the control group (conventional learning model). The observation sheet focused on four main aspects, as outlined by Weil and Joyce, (1978) and Joyce and Weil, (2003): Implementation of the OIDDE learning model syntax; Implementation of social systems; Application of principles of reaction; and Implementation of support systems.

These four aspects were further developed into 22 measurable indicators, which were assessed using a Likert scale. The indicators were categorized as follows: seven indicators for model syntax, five for the social system, four for the principles of reaction, and six for the support system. All indicators were rated on a five-point Likert scale, with the following ratings: 1 = Very

Bad, 2 = Not Good, 3 = Fairly Good, 4 = Good, 5 = Very Good. The observation sheet for learning implementation is presented in Table 5.

Table 5

Learning Implementation Questionnaire for High School Students' Engagement in Biology and Ecosystem Content

NO	Aspects of learning implementation	Scores				
		1	2	3	4	5
A. Syntax Learning						
1.	The learning stages are organized in a clear and systematic manner.					
2.	The learning stages are logical and rational.					
3.	The learning stages outline activities for both teachers and students.					
4.	Activities reflect the interaction flow between teachers and students.					
5.	Activities focus on mastering ecosystem knowledge and environmental ethics.					
6.	Activities emphasize ethical decision-making.					
7.	Activities promote ethical attitudes among students.					
B	**Social System**					
1.	Activities encourage students to discover and construct ethical concepts.					
2.	Activities promote student interaction.					
3.	Activities foster student-teacher interaction.					
4.	Activities embody religious norms, honesty, politeness, and ecosystem responsibility.					
5.	Activities promote collaboration and respect in ecosystem discussions.					
C	**Reaction Principle**					
1.	The teacher provides resources such as textbooks and articles.					
2.	The teacher motivates and engages students.					

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3.	Activities stimulate curiosity, idea exploration, and scientific communication.	
4.	Students can ask questions when facing concept difficulties..	
D	**Support System (Nurturant Effect and Instructional Effect)**	
1.	Learning tools align with the learning syntax.	
2.	Learning tools meet objectives to improve conceptual understanding, critical thinking, ethical decision-making, and ethical behaviour.	
3.	Instructional effects (concept mastery, critical thinking, ethical decision-making, and behaviour) are clearly and logically stated in the learning stages.	
4.	Instructional effects align with learning goals.	
5.	Accompanying impacts like improved critical thinking are integrated logically.	
6.	Ethical attitudes are aligned with learning objectives.	

The scores obtained from Table 5 were then converted into learning implementation assessment categories based on the University of Muhammadiyah Malang Learning Assessment Standards Universitas Muhammadiyah Malang, (2020), as follows: 80.0 (Outstanding); 75.0-80.0 (Excellent); 70.0-74.9 (Very Good); 60.0-69.0 (Good); 55.0-59.9 (Fair); 40.0-54.0 (Pass); <40.0 (Fail).

3.5 Data Analysis

Data analysis was conducted using ANCOVA to assess the effectiveness of the OIDDE learning model compared to the conventional learning model in relation to learning outcomes, critical thinking skills, and ethical attitudes (based on pre-test and post-test results). Before performing the ANCOVA, normality was evaluated using the Kolmogorov-Smirnov test, and homogeneity was assessed with the Levene Test. All data analyses were carried out using SPSS for Windows, version 22.

4. Results

The research results provide insights into the impact of the OIDDE learning model on enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among

students in both the experimental and control classes. The data analysis outcomes are detailed below.

4.1 Learning Outcomes

The differences in student learning outcomes between the experimental and control classes are shown in Table 6. The One-Way ANCOVA results presented in Table 6 indicate an F value of 27.643, with a p-value < 0.0001, demonstrating a significant difference in learning outcomes between the experimental and control classes, F (1,37) = 27.643, p = 0.004. This result suggests that the OIDDE learning model is effective and significantly improves learning outcomes for students in the experimental class compared to those in the control class.

Table 6

Results of One-Way ANCOVA on Biology Learning Outcomes of High School Students

Source	***df***	***F***	***Sig.***
Learning Outcomes	1	9.434	.004
Class	1	27.643	.000
Error	37		

Add a Note on Significance Levels: You might add a note below the table indicating that **Sig. .000** represents a significance level of $p < .001$.

Next, the corrected mean analysis for each class, specifically comparing the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model), is shown in Table 7. The corrected average score for the experimental class (M = 77.350) was higher than that for the control class (M = 65.850), indicating that students in the experimental class achieved better learning outcomes. The final post-test scores and the improvement from pre-test to post-test were consistently higher for the experimental class. Therefore, the OIDDE learning model proves to be more effective in enhancing biology learning outcomes than conventional teaching methods.

Table 7

Mean Corrected Scores of High School Students' Learning Outcomes in Conventional vs. OIDDE Learning Models

Group	**Pre-test**	**Post-test**	**Score Increase**	**Corrected Mean**
Conventional	45.85	65.05	19.20	65.850
OIDDE	49.85	78.15	28.30	77.350

4.2 Critical Thinking Skills

The next section of data analysis focuses on the improvement of students' critical thinking skills for both experimental and control class students, as shown in Table 8. The calculated F difference

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in the OIDDE learning model treatment is 25.183, with a p-value < 0.0001, indicating a significant variation in critical thinking skills between the experimental and control classes, F (1,37) = 25.183, p > 0.0001.

Table 8

Analysis of Variance (ANCOVA) Results on Critical Thinking Skill Achievement of High School

Add a

Source	*df*	*F*	*Sig.*
Critical Thinking	1	26.466	.000
Class	1	25.183	.000
Error	37		
Total	40		

Significance Note: Consider adding a note below the table to clarify that **Sig. .000** represents a significance level of *p < .001*.

Check Consistency of Decimal Places: If the rest of your tables use two decimal places, keep this format consistent across all tables.

Table 9 presents the average pre-test and post-test scores for both classes. According to the ANCOVA test results, the corrected mean score for critical thinking skills in the experimental class (M = 83.360) was higher than the corrected mean score in the control class (M = 74.490). This difference is evident in both the average post-test scores and the improvement from pre-test to post-test. Therefore, the OIDDE learning model positively influences the enhancement of students' critical thinking skills in the experimental class.

Table 9

Corrected Mean Scores for Critical Thinking Skills of High School Students

Group	*Pre-test*	*Post-test*	Score Increase	% Enhancement	Corrected Mean
Conventional	67.20	74.85	7.65	11%	74.490
OIDDE	66.00	83.00	17.00	26%	83.360

Overall, the OIDDE learning model significantly improves students' critical thinking skills in the experimental class compared to the conventional learning model used in the control class. This finding suggests that applying the OIDDE learning model to biology learning, particularly ecosystem material, makes the learning process more conducive and meaningful than using conventional methods.

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In line with Agustina and Abidin (2022); Bayu et al. (2022); Ningrum and Murti (2023), who argue that improving critical thinking competency requires effective and innovative learning models, this research confirms that the OIDDE learning model effectively enhances students' critical thinking abilities. Additionally, as highlighted by Heard et al. (2020) and Rodzalan et al. (2020), sustaining improvements in critical thinking skills also requires attention to students' physical well-being, intellectual development, and continuous motivation.

4.3 Ethical Attitudes

The next research section presents an ANCOVA analysis of data on the ethical attitudes of students in both the experimental and control classes towards ecosystems after participating in biology lessons on ecosystem material, as shown in Table 10.

Table 10

Analysis of Variance (ANCOVA) Results on Ethical Attitudes of High School Students

Source	***df***	***F***	***Sig.***
Class	1	24.439	.000
Error	37		
Total	40		

Clarify the Significance Level: Adding an asterisk or note below the table to specify what the significance level (.000) represents could be helpful, such as "*p < .001 indicates statistical significance."

Check Consistency of Decimal Places: If other tables include two decimal places, you may want to apply that here for consistency.

Table 10 provides a summary of the ANCOVA test results, which were used to analyze the impact of the learning model on students' ethical attitudes. The results clearly show that there is a significant difference between the experimental and control classes in terms of ethical attitudes, with F (1,37) = 24.439 and p < 0.001. This indicates that the OIDDE learning model is more effective in significantly enhancing the ethical attitudes of students in the experimental class compared to those in the control class, which followed a conventional learning model.

The increase in ethical attitudes through the OIDDE learning model is notable. This is because the OIDDE learning model's structure specifically fosters the development of attitudes, particularly in the fifth stage of its syntax: "Engage in behaviour." This stage represents the culmination of the learning process, where students' ethical involvement becomes evident through their participation in problem-solving activities and dilemmas related to the teaching material.

Next, Table 11 compares the class averages for both the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model).

Table 11

Average Ethical Attitude Scores of High School Student

Group	***Pre-test***	***Post-test***	**Score Increase**	**% Enhancement**	**Corrected Mean**
Conventional	67.00	74.85	7.85	12%	74.612

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OIDDE	66.2	83.0	21.80	25%	83.233

Based on Table 11, the corrected mean for the experimental class (M = 83.233) was higher than that of the control class (M = 74.612). This confirms that the ethical attitudes of students in the experimental class, who engaged with the OIDDE learning model, were significantly better than those in the control class, who followed a conventional learning approach.

The significant increase in ethical attitudes in the experimental class highlights that learning ecosystem-related biology topics through the OIDDE learning model enhances students' ethical awareness and sense of responsibility toward the environment. These findings align with previous research by Hudha et al. (2018), which demonstrated that the OIDDE learning model effectively increases students' understanding of life ethics, ethical decision-making, and ethical attitudes.

Furthermore, Ichsan et al. (2020) emphasized that 21st-century ecosystem education must be contextual and foster High Order Thinking Skills (HOTS) to effectively address environmental issues. In this regard, the OIDDE learning model is well-suited for fostering HOTS, as it encourages critical, creative, and analytical thinking applied to problem-solving in biology education. Tasrif (2022) reinforced this idea by highlighting that HOTS includes the ability to think critically, creatively, and analytically to solve problems using information and data. The OIDDE learning model, by focusing on problem discovery, ethical decision-making, and behavioural involvement, supports the development of these higher-order thinking skills.

In addition to the pre-test and post-test measurements of ethical attitudes (as shown in Table 10 and Table 11), researchers also assessed students' ethical attitudes in both the experimental and control classes using a questionnaire. The results of this assessment are illustrated in Figure 1.

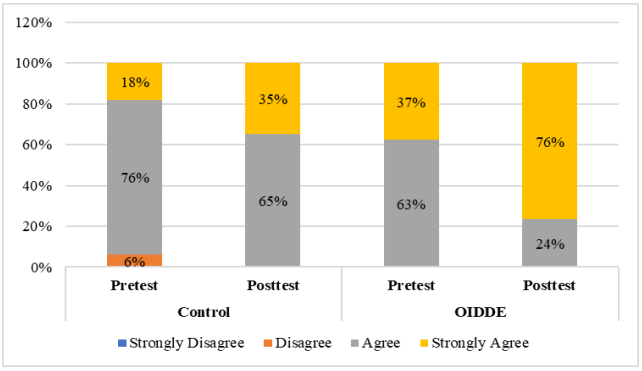

Figure 1 *Questionnaire Results on Students' Ethical Attitudes Before and After Implementing the Learning Model in the Experimental and Control Groups*.

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The figure shows that students in the experimental group, who were taught using the OIDDE learning model, exhibited significantly stronger ethical attitudes toward ecosystem issues compared to students in the control group. In the pre-test for the experimental group, 37% of students strongly agreed with ethical statements regarding ecosystems, while in the post-test, this percentage increased to 76%. This reflects a 39% improvement in students' ethical attitudes after learning with the OIDDE model. Additionally, there was a notable decline in students expressing only agreement (from 63% in the pre-test to 24% in the post-test), indicating a positive shift from moderate agreement to strong agreement in ethical attitudes.

In contrast, the control group displayed more varied ethical attitudes toward ecosystem issues. In the pre-test, 6% of students disagreed, 76% agreed, and 18% strongly agreed with the ethical statements. By the post-test, there was a 17% increase in the number of students strongly agreeing, from 18% to 35%. This improvement was accompanied by a slight decrease in the percentage of students who agreed, dropping from 76% in the pre-test to 65% in the post-test. Overall, while there was some improvement in the control group, it was not as pronounced as in the experimental group.

The data from Figure 1 highlights one of the main advantages of the OIDDE learning model—it effectively motivates students to express ethical behaviour independently, with integrity and honesty, particularly in relation to ecosystem issues. This is not commonly observed in other learning models. Chairilsyah, (2016) notes, honesty is a critical aspect of daily life, and as Cooper et al. (2023) argue, honesty encourages individuals to behave ethically. Additionally, Bonnie et al. (2022) emphasize that honesty is closely related to well-being. Therefore, ethical attitudes, as reflected in honesty, play a fundamental role in students' lives and behaviour.

In addition to the improvement in learning outcomes, critical thinking skills, and ethical attitudes, the study also measured student learning engagement for both the experimental and control classes. Learning engagement data was collected using observation sheets during biology lessons on ecosystem material. The findings show a clear difference between the two groups: students in the experimental class achieved a 'very good' level of engagement, while students in the control class were categorized as 'good,' as displayed in Table 12.

Table 12

Learning Engagement Levels of High School Students by Learning Model

Learning Model	Percentage	Category
Conventional	70%	Good
OIDDE	78%	Excellent

Table 12 shows that the learning engagement of students in the experimental class, who were taught using the OIDDE learning model, is categorized as 'very good' (excellent), whereas students in the control class, who followed the conventional learning model, are classified as 'good.' The increase in learning engagement for the experimental class was 78% (excellent), compared to only 70% (good) for the control class. This indicates that the OIDDE learning model had a greater impact on enhancing learning engagement among students in the experimental class compared to the conventional learning model used in the control class.

The results confirm that a learning model that is supportive, enjoyable, meaningful, student-centered, and includes an ethical dimension can significantly enhance student engagement. Therefore, it can be concluded that the OIDDE learning model is an effective approach for improving student engagement in biology education.

The research findings also revealed that students in the experimental class found learning biology more enjoyable with the OIDDE learning model, as demonstrated by their increased engagement. A teaching process that is supportive, enjoyable, meaningful, student-centered, and ethically grounded provides a richer learning experience for students, as supported by previous studies (Bishop et al., 2014; Emaliana, 2017; Ali et al., 2020).

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What sets the OIDDE learning model apart from conventional and earlier models is its integration of the "decision" and "engage in behaviour" stages. These stages are specifically designed to help students engage in ethical decision-making and develop ethical attitudes related to the material being studied.

In the decision stage, students are guided to make ethical decisions as a solution to the problems they encounter, with a focus on ethical reasoning. In the engage in behaviour stage, students are encouraged to express their behaviours and attitudes based on the ethical decisions they have made during the learning process. This unique aspect of the OIDDE learning model ensures that students develop not only critical thinking and problem-solving skills but also ethical attitudes.

As a result, students in the experimental class reported positive experiences, stating that after learning ecosystem material using the OIDDE model, they felt highly motivated, found the learning environment conducive and enjoyable, and had increased learning awareness. Overall, the students appreciated the fresh and engaging approach offered by each component of the OIDDE model. It is not surprising, therefore, that many students expressed a desire for the OIDDE learning model to be applied not only in biology but also in other subjects.

5. Discussion

5.1 Effectiveness of the OIDDE Learning Model

The results indicate that the OIDDE learning model is highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement compared to the conventional learning model used in the control class. Students in the experimental class consistently outperformed those in the control class across all measured domains, demonstrating the value of the OIDDE model in fostering a more meaningful and engaging learning experience. This aligns with prior studies that emphasize the importance of innovative, problem-based, and contextual learning models in achieving significant educational outcomes (Hajeniati & Kaharuddin, 2022).

This research reinforces earlier findings, confirming that the OIDDE learning model improves the critical thinking skills of students, as well as their creative thinking abilities (Ma'rifatillah et al., 2019). The results are also consistent with studies that highlight the significance of ethical attitudes in biology education by Kohli et al. (2015) and Chen and So (2017). The OIDDE learning model's positive impact on ethical attitudes, which had been previously observed in prospective biology teachers, is confirmed here in the context of high school students (Hudha et al., 2018).

The OIDDE learning model is well-suited to 21st-century educational demands, characterized by critical thinking, problem-solving, collaboration, creativity, and innovation (Aslamiah et al., 2021; Wulandari, 2021). This model is highly effective in creating a constructive, student-centered learning environment, which is essential for developing students' cognitive and ethical competencies in modern education. The integration of the model's syntax into science education fosters a conducive and innovative learning atmosphere, benefiting students academically and personally.

5.2 Enhancing Critical Thinking and Ethical Attitudes

The improvements in critical thinking skills and ethical attitudes among students in the experimental class highlight the effectiveness of the OIDDE learning model, particularly in the context of biology education. The model's problem-based approach encourages students to actively engage in solving ethical dilemmas related to ecosystem issues. This active involvement fosters critical thinking and enables students to make informed, ethical decisions, a skill that is vital for addressing 21st-century challenges (Rahman et al., 2023; Haulia et al., 2022).

One of the key advantages of the OIDDE learning model is its capacity to create an active learning environment. The syntax of the model encourages students to engage in hands-on problem-solving, fostering both independent thinking and teamwork. This collaborative learning environment helps develop critical thinking and ethical attitudes, as students work together to address real-world issues. Small group discussions, in particular, encourage cooperation, which is essential for improving learning outcomes and engagement (Kvellestad et al., 2021).

5.3 The Role of Problem-Based Learning in Science Education

The OIDDE learning model's emphasis on problem-based learning aligns with research that demonstrates the importance of addressing contextual, real-world problems in education. By presenting students with issues related to ecosystems, the model promotes the development of critical thinking skills, ethical attitudes, and greater engagement in learning. The effectiveness of this approach is evident in the significant improvements observed in the experimental class, where students were more motivated, engaged, and capable of making ethical decisions compared to the control class (Pozas et al., 2020; Bahri & Corebima, 2015).

5.4 Strengths of the OIDDE Model Syntax

The sequential syntax of the OIDDE learning model, from orientation to decision-making and behaviour engagement, plays a crucial role in its effectiveness. Each stage is designed to encourage students to think critically, collaborate, and engage in ethical decision-making. The syntax's flexibility allows teachers to incorporate real-world problems and contextual learning into their lessons, enhancing both cognitive and affective learning outcomes. This step-by-step approach has proven to be effective in fostering deeper learning, ethical understanding, and student engagement in biology education.

The research uncovered several new findings related to the implementation of the OIDDE learning model. First, both teachers and students in island high schools were introduced to an innovative and effective learning model that fostered greater awareness of ethical dilemmas in biological issues. Second, students developed critical thinking skills and learned to engage in ethical decision-making through group discussions. These findings highlight the OIDDE model's potential for promoting student-centered learning and fostering a deeper understanding of complex environmental issues.

The OIDDE learning model has demonstrated its effectiveness in enhancing learning outcomes, critical thinking skills, ethical attitudes, and engagement among high school students. Based on the research findings, it is recommended that the OIDDE model be adopted in various subjects beyond biology to promote critical thinking, ethical behaviour, and student engagement across disciplines. Additionally, further research should explore the application of the OIDDE

model in different educational contexts and subject areas, focusing on the development of student integrity, ethical decision-making, and problem-solving skills.

6. Conclusion

The implementation of the OIDDE learning model has proven to be highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among high school students in the islands, especially in comparison to conventional learning models used in biology instruction. The experimental group showed significant improvements across all measured domains and provided overwhelmingly positive feedback. Students in the experimental class consistently expressed satisfaction with the OIDDE model, noting a pleasant and engaging learning atmosphere that fostered collaboration, critical thinking, and ethical decision-making.

Furthermore, students appreciated the novelty and interest sparked by each syntax of the OIDDE model, which encouraged them to explore more and suggested that the model could be applied successfully to other subjects like physics and chemistry. The model's ability to create an enjoyable and conducive learning environment has led students to advocate for its broader application beyond biology. Given these results, the OIDDE learning model presents a compelling option for fostering 21st-century learning skills. Its innovative approach should be considered for implementation across various educational levels and subjects to support the holistic development of students, particularly in critical thinking, ethical reasoning, and engagement.

7. Limitations and Recommendations

This study was conducted with students from a single high school, focusing solely on the subject of biology. As such, the results cannot be generalized across all educational settings or subjects. However, the findings provide a strong foundation for future research and the implementation of the OIDDE model in different subject areas and educational contexts. Another limitation is that the OIDDE model was new to both students and teachers in the school where the research was conducted. Despite this, the introduction of the model has successfully enriched the teachers' pedagogical repertoire and demonstrated its potential for broader application.

Based on the findings of this study, it is recommended that the OIDDE model be adopted and its use expanded. The OIDDE model is a promising, innovative learning approach suitable for various educational levels and subjects, beyond just biology. Its structured approach to fostering critical thinking, ethical attitudes, and student engagement aligns well with the demands of 21st-century learning. Additionally, the OIDDE model should be referenced as a strategy for developing critical thinking skills and improving overall learning outcomes. It can serve as an effective learning framework for students in diverse educational contexts, helping to cultivate ethical behaviour and enhance engagement across different levels of education. These recommendations highlight the value of the OIDDE model in modern education and suggest its potential to contribute to the ongoing development of innovative, student-centered learning strategies.

Ethical Consideration

This study was conducted with oversight and approval from school administration, including the principal and relevant teachers, ensuring compliance with ethical standards for educational

research. Data collection was carried out with permission from both the participants and the biology teacher. The identities of all participants were kept confidential.

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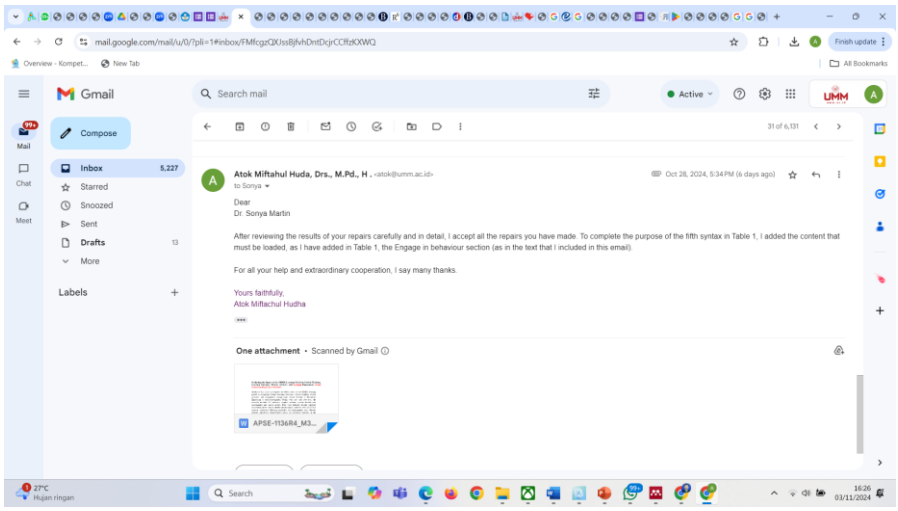

Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement among Indonesian High School Students

Abstract This study investigates the effectiveness of the OIDDE learning model in enhancing biology learning outcomes, critical thinking, ethical attitudes, and engagement among high school students in Indonesia. Employing a quasi-experimental design with pre- and post-tests, the research included 66 randomly sampled students, evenly divided into experimental and control groups. Data were gathered through validated observation sheets, ethical attitude questionnaires, and tests, with ANCOVA analysis conducted following normality and homogeneity tests. Results indicate significant improvements across all measured variables in the experimental group compared to the control group. The findings suggest that the OIDDE model is more effective than conventional methods in fostering comprehensive educational outcomes in biology, as its problem-based approach promotes active learning, ethical decision-making, and collaborative problem-solving, aligning well with the needs of 21st-century education. This study underscores the model's potential for

broader application across various subjects to enhance critical thinking, ethical behaviour, and sustained student engagement.

Keywords critical thinking; ethical attitudes; learning engagement; learning model - OIDDE learning model

1. Introduction

Learning is an ongoing process of acquiring knowledge, which results in a change in behaviour. These behavioural changes are shaped by new experiences gained through learning (Djamaluddin & Wardana, 2019). The outcome of learning is often referred to as "learning outcomes," which encompass changes in behaviour across the affective, cognitive, and psychomotor domains (Mahananingtyas, 2017; Nurrita, 2018). To maximize these outcomes, learning should be structured to provide holistic guidance and skills. In the global era, holistic skills are essential for addressing global challenges (Miseliunaite et al., 2022).

In Indonesia, particularly in high schools, there is limited research on the effectiveness of various learning models in improving the learning process, especially in biology education (Azizah & Alberida, 2021; Herman & Rahmat, 2023). This includes evaluating how well these models enhance students' critical thinking skills and ethical attitudes. Learning outcomes serve as a key measure of students' mastery of the material (Fitrianingtyas & Radia, 2017), reflecting their overall achievement (Mahajan & Singh, 2017). Therefore, learning outcomes must be clear, learner-centered, and focused on the expected performance or understanding (García, 2021), especially in the context of biology education.

Biology education is closely linked to the development of critical thinking skills, even though some research suggests that learning outcomes do not always significantly reflect these skills (Suharsono et al., 2017). However, critical thinking is crucial in the global era because of its wide-ranging impacts. To improve students' critical thinking skills, effective teaching methods are required (Kinoshita, 2022; Setyowati et al., 2018)). The need to improve biology learning outcomes is particularly relevant in archipelagic regions, where primary and secondary students may face distinct challenges. Thus, investigating the effectiveness of the OIDDE learning model in enhancing high school biology learning outcomes is of great importance. Critical thinking skills are essential for addressing various problems, including environmental issues (Santi et al., 2018). Developing these skills requires diverse and engaging teaching methods (Hwang et al., 2023). Unfortunately, research shows that junior high school students in Indonesia's archipelago have relatively low critical thinking skills, likely due to traditional teaching methods that lack problem-solving opportunities and student-centered approaches (Susilawati et al., 2020).

Developing critical thinking skills is critical for helping students solve everyday problems (Syafitri et al., 2021). However, research on enhancing critical thinking in biology through the OIDDE learning model is still scarce. Teachers employ various learning models to improve critical thinking, learning outcomes, and engagement, especially in biology. However, Indonesia's biology education faces many challenges, including didactic issues, curriculum constraints, and insufficient learning facilities (Khoiri et al., 2020). Additionally, science teachers often lack proper training and resources, including laboratory equipment, which hinders effective biology instruction.

Several initiatives aim to improve science education in Indonesia, including teacher certification, curriculum innovation, and collaborative international research (Faisal & Martin, 2019). These initiatives can significantly impact biology learning, affecting learning outcomes, critical thinking skills, ethical attitudes, and student engagement. In education, there is often a focus on learning outcomes and critical skills, but aspects such as ethical attitudes and student engagement are frequently overlooked. This is especially true in archipelagic regions, where ethical attitudes and student engagement have not been sufficiently studied (Hudha et al., 2018).

In today's global era, ethical attitudes are crucial for shaping students' character and values, as well as for fostering a moral, tolerant, and well-behaved society (Tsoraya et al., 2023).

Despite the importance of ethical attitudes, many high school biology teachers focus primarily on cognitive aspects of learning, neglecting the affective aspects like ethical attitudes (Chowdhury, 2016). The increasing instances of unethical behaviour among students in Indonesia's archipelago underscore the need to emphasize ethical attitudes in education (Ardiana et al., 2022). Similarly, student engagement in biology learning requires further exploration. The OIDDE learning model offers a promising, innovative approach to address these educational challenges. This study aims to evaluate the effectiveness of the OIDDE learning model in improving critical thinking skills, learning outcomes, ethical attitudes, and learning engagement among high school students in the eastern archipelago of Indonesia.

2. The Syntax of the OIDDE Learning Model

The OIDDE learning model, developed and validated by Hudha et al. (2016), has demonstrated reliability and practical application in educational settings. Recognized as an innovative educational tool, it has been awarded copyright status by the Directorate General of Intellectual Property under the Ministry of Law and Human Rights of the Republic of Indonesia (Registration Number: EC00201701142). This copyright is held by the first author (Hudha, 2016). Readers are encouraged to apply the OIDDE learning model in their teaching by following the syntactic framework provided in this publication. The specific steps in the OIDDE model are detailed in Table 1.

Table 1.
Syntaxes of the OIDDE Learning Model (adapted from Hudha et al., 2016).

Syntax	Teacher Activities	Student Activities
Phase 1: Orientation	- Guide students in preparing to learn the material. - Present materials that incorporate values and ethical issues (bioethics). - Share case studies, historical narratives, videos, or documentaries to introduce ethical dilemmas.	- Prepare and engage with the material. - Listen, observe, and take notes. - Pay close attention to case studies and ethical issues presented.
Phase 2: Identify	- Assign students to identify ethical dilemmas within case stories, facts, and narratives. - Ask selected students to briefly explain identified dilemmas for class discussion.	- Identify ethical dilemmas in the material. - Select priority dilemmas for group discussion. - Explain identified dilemmas as part of a class discussion.
Phase 3: Discussion	- Divide students into small heterogeneous groups of 4-5 members. - Guide students to prioritize ethical dilemmas from	- Form groups of 4-5 members. - Deliberate within groups to select priority ethical dilemmas for discussion.

Syntax	Teacher Activities	Student Activities
	individual findings as topics for group discussion. - Instruct each group to assign roles relevant to the chosen discussion topic. - Facilitate group discussions, ensuring they are democratic, honest, and ethical. - Moderate as each group presents discussion results to the class, followed by a Q&A. - Direct groups to document discussion outcomes as a foundation for ethical decision-making.	- Assign appropriate roles for each group member. - Engage in discussions with a focus on democratic, honest, and ethical participation. - Present group discussion results to the class and participate in Q&A. - Document discussion outcomes for use in ethical decision-making.
Phase 4: Decision	- Guide each group to collaboratively formulate ethical decisions based on their discussions. - Instruct students to develop individual ethical decisions, reflecting on group discussion topics. - Direct each student to document their individual ethical decisions independently. - Provide prepared sheets for students to record their individual ethical decisions.	- Collaboratively formulate ethical decisions as a group based on group discussions. - Reflect individually on group topics to make personal ethical decisions. - Document individual ethical decisions on provided sheets.
Phase 5: Engage in Behaviour	- Encourage students to reflect on and document ethical behaviour related to the decisions made during discussions. - Facilitate class conclusions on learning outcomes and ethical responsibilities.	- Reflect on and document personal ethical behaviour in line with group decisions. - Participate in drawing class conclusions with integrity and responsibility. - Declare your involvement in behaviour honestly and responsibly.

2.1 Research Questions

This study aims to evaluate the effectiveness of the OIDDE learning model for high school students in island regions through biology education. The specific research questions are as follows:

5. How does the OIDDE learning model enhance the biology learning outcomes of high school students in the islands?
6. How does the OIDDE learning model affect the development of critical thinking skills in high school students in the islands?
7. How does the OIDDE learning model influence the ethical behaviour of high school students in the islands?
8. How does the OIDDE learning model contribute to increasing learning engagement among high school students in the islands?

3. Research Methodology

3.1 General Background

This study employs a quasi-experimental research design with a control group, utilizing a non-equivalent pre-test and post-test design. The experimental group was taught using the OIDDE learning model, while the control group followed conventional learning methods, as shown in Table 2.

Table 2

Research design

Group	Pre-test	Treatment (X)	Post-Test
E	O_1	X	O_2
C	O_3	—	O_4

Legend:

- E = Experimental Group
- C = Control Group
- O_1, O_3 = Pre-test measurements
- O_2, O_4 = Post-test measurements
- X = Treatment (OIDDE Learning Model

The research was conducted with tenth-grade students at a High School, focusing on biology topics related to ecosystems. Students covered eight key topics during the study: ecosystem components, interactions within ecosystems, succession, types of ecosystems, ecological paradigms, food chains, biogeochemical cycles, and environmental changes. Classes were held once a week, with each session lasting 100 minutes.

The OIDDE learning model was applied to students in the experimental group, following the syntax stages outlined by Hudha et al. (2018), as shown in Table 1. The control group, on the other hand, was taught using the conventional teaching methods typically employed by their teachers. This highlights the need for innovative teaching models to enhance biology education at the senior high school level. Research has consistently shown that innovative teaching approaches improve conceptual understanding more effectively than traditional methods (Artayasa et al., 2017).

In the experimental group, the ecosystem content in the biology curriculum was delivered over three sessions following the OIDDE model. In contrast, students in the control group received

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the same content using the conventional teaching methods typically applied by their teacher. The details of the ecosystem material covered in these sessions are provided in Table 3.

Table 3

Implementation of Biology Learning Topics on Ecosystems Using the OIDDE Learning Model Across Three Meetings

Syntax	Student Activities in 1st-2nd Meetings	Student Activities in 3rd Meeting
Orientation	Students analyze material on ecosystem components and interactions within various biomes across the Earth's surface.	Students analyze biogeochemical cycles and current environmental changes, engaging with great motivation.
Identify	Students identify interaction dilemmas by examining ecosystem interactions in biomes, focusing on relationships (mutualism, commensalism, parasitism, predation) and emerging ecological paradigms.	Students identify ecological dilemmas related to biogeochemical cycles (carbon, nitrogen, water, sulfur, phosphorus) and their connection to environmental changes, using these insights for group discussions on environmental balance.
Discussion	In groups, students discuss the interaction dilemmas, create food web schemes to analyze trophic levels, and explore ecological relationships and paradigms.	Students participate in discussions on ecological dilemmas linked to biogeochemical cycles and environmental changes, analyzing edaphic and atmospheric cycles and discussing solutions for environmental balance..
Decision	Students make critical decisions individually and in groups, focusing on ecosystem interactions and emerging ecological paradigms.	Students make ethical decisions individually and in groups, based on their analysis of biogeochemical cycles and environmental impacts, developing perspectives on environmental stability.
Engage in Behaviour	Students individually reflect on their ethical attitudes and commit to honest behaviours that support ecosystem sustainability.	Students commit to ethical behaviours that support ecosystem sustainability, focusing on biogeochemical cycle continuity and minimizing negative impacts on the environment.

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3.2 Research Sample

The study population consisted of 66 tenth-grade students, who were randomly assigned into two groups. Class X-A, with 33 students, served as the experimental group, and Class X-B, also with 33 students, served as the control group.

3.4 Instrument Development

This study examined four key variables: 1) Critical thinking skills – the ability to analyze arguments, draw conclusions based on reasoning, evaluate or assess information, and make decisions or solve problems. 2) Learning outcomes – the specific competencies or abilities acquired by students after participating in the learning process, encompassing cognitive, affective, and psychomotor domains. 3) Ethical attitudes – an individual's overall positive or negative response to ethical or unethical behaviour, or adherence to rules and laws. 4) Learning engagement – an attitude reflecting cognitive involvement, active participation, and emotional commitment in all learning activities.

The instruments used in this research included: 1) Observation sheets for evaluating the implementation of both the OIDDE learning model and the conventional learning model. 2) Questionnaires assessing students' ethical attitudes toward ecosystems, administered both before and after the intervention. 3) Pre-test and post-test questions to measure learning outcomes, critical thinking skills, and ethical attitudes.

Before using the observation sheets and ethical attitude questionnaires, they were validated by expert validators, with all instruments deemed valid. Validation of the question items was conducted using the Pearson Correlation test, and the analysis was supported by SPSS 22.0 for Windows. The results of the validation showed that each question item was valid, as indicated by a p-value of less than 0.05. The reliability of the questions was tested using Cronbach's alpha, which yielded a value of 0.669, indicating that the question instrument was reliable (Siregar, 2013).

For ethical attitudes, in addition to test-based measurements, non-test measurements were conducted using a questionnaire related to students' ethical attitudes toward ecosystems. The questionnaire consisted of 15 statements that students were required to respond to, reflecting their individual attitudes toward ecosystems. Ethical attitude data was collected using a four-point Likert scale to assess each item, with the following options: (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree (Syaifudin, 2012). A detailed description of the ethical attitude questionnaire is presented in Table 4.

Table 4

Questionnaire on High School Students' Ethical Attitudes Toward the Ecosystem

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No	Aspects of Ethical Attitudes towards Ecosystems	Total Students			
		Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
1.	Caring for ecosystems				
2.	The role of humans in the ecosystem				

3.	The impact of ecosystem destruction	
4.	Exploitation of ecosystems.	
5.	The environment is not solely for human use	
6.	Humans as primary agents of ecosystem preservation	
7.	Humans as primary contributors to ecosystem damage	
8.	Ethical behaviour towards ecosystems	
9.	Environmental ethics and the interests of life	
10.	Impact of ecosystem destruction	
11.	Importance of identifying methods for ecosystem management	
12.	Relevance of ethical attitudes towards ecosystem care	
13.	Acceptability of actions that harm ecosystems	
14.	Importance of analyzing ethical attitudes regarding the environment	
15.	Analyzing the impact of caring for the environment	

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3.4 Learning Implementation Observation Sheet

The learning implementation observation sheet, used to measure learning engagement, was applied to both the experimental group (OIDDE learning model) and the control group (conventional learning model). The observation sheet focused on four main aspects, as outlined by Weil and Joyce, (1978) and Joyce and Weil, (2003): Implementation of the OIDDE learning model syntax; Implementation of social systems; Application of principles of reaction; and Implementation of support systems.

These four aspects were further developed into 22 measurable indicators, which were assessed using a Likert scale. The indicators were categorized as follows: seven indicators for model syntax, five for the social system, four for the principles of reaction, and six for the support

system. All indicators were rated on a five-point Likert scale, with the following ratings: 1 = Very Bad, 2 = Not Good, 3 = Fairly Good, 4 = Good, 5 = Very Good. The observation sheet for learning implementation is presented in Table 5.

Table 5

Learning Implementation Questionnaire for High School Students' Engagement in Biology and Ecosystem Content

NO	Aspects of learning implementation	Scores				
		1	2	3	4	5
A. Syntax Learning						
8.	The learning stages are organized in a clear and systematic manner.					
9.	The learning stages are logical and rational.					
10.	The learning stages outline activities for both teachers and students.					
11.	Activities reflect the interaction flow between teachers and students.					
12.	Activities focus on mastering ecosystem knowledge and environmental ethics.					
13.	Activities emphasize ethical decision-making.					
14.	Activities promote ethical attitudes among students.					
B	**Social System**					
1.	Activities encourage students to discover and construct ethical concepts.					
2.	Activities promote student interaction.					
3.	Activities foster student-teacher interaction.					
4.	Activities embody religious norms, honesty, politeness, and ecosystem responsibility.					
5.	Activities promote collaboration and respect in ecosystem discussions.					
C	**Reaction Principle**					
1.	The teacher provides resources such as textbooks and articles.					
2.	The teacher motivates and engages students.					

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3.	Activities stimulate curiosity, idea exploration, and scientific communication.	
4.	Students can ask questions when facing concept difficulties..	
D	**Support System (Nurturant Effect and Instructional Effect)**	
1.	Learning tools align with the learning syntax.	
2.	Learning tools meet objectives to improve conceptual understanding, critical thinking, ethical decision-making, and ethical behaviour.	
3.	Instructional effects (concept mastery, critical thinking, ethical decision-making, and behaviour) are clearly and logically stated in the learning stages.	
4.	Instructional effects align with learning goals.	
5.	Accompanying impacts like improved critical thinking are integrated logically.	
6.	Ethical attitudes are aligned with learning objectives.	

The scores obtained from Table 5 were then converted into learning implementation assessment categories based on the University of Muhammadiyah Malang Learning Assessment Standards Universitas Muhammadiyah Malang, (2020), as follows: 80.0 (Outstanding); 75.0-80.0 (Excellent); 70.0-74.9 (Very Good); 60.0-69.0 (Good); 55.0-59.9 (Fair); 40.0-54.0 (Pass); <40.0 (Fail).

3.5 Data Analysis

Data analysis was conducted using ANCOVA to assess the effectiveness of the OIDDE learning model compared to the conventional learning model in relation to learning outcomes, critical thinking skills, and ethical attitudes (based on pre-test and post-test results). Before performing the ANCOVA, normality was evaluated using the Kolmogorov-Smirnov test, and homogeneity was assessed with the Levene Test. All data analyses were carried out using SPSS for Windows, version 22.

4. Results

The research results provide insights into the impact of the OIDDE learning model on enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among students in both the experimental and control classes. The data analysis outcomes are detailed below.

4.1 Learning Outcomes

The differences in student learning outcomes between the experimental and control classes are shown in Table 6. The One-Way ANCOVA results presented in Table 6 indicate an F value of 27.643, with a p-value < 0.0001, demonstrating a significant difference in learning outcomes between the experimental and control classes, F (1,37) = 27.643, p = 0.004. This result suggests that the OIDDE learning model is effective and significantly improves learning outcomes for students in the experimental class compared to those in the control class.

Table 6

Results of One-Way ANCOVA on Biology Learning Outcomes of High School Students

Source	***df***	***F***	***Sig.***
Learning Outcomes	1	9.434	.004
Class	1	27.643	.000
Error	37		

Add a Note on Significance Levels: You might add a note below the table indicating that **Sig. .000** represents a significance level of $p < .001$.

Next, the corrected mean analysis for each class, specifically comparing the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model), is shown in Table 7. The corrected average score for the experimental class (M = 77.350) was higher than that for the control class (M = 65.850), indicating that students in the experimental class achieved better learning outcomes. The final post-test scores and the improvement from pre-test to post-test were consistently higher for the experimental class. Therefore, the OIDDE learning model proves to be more effective in enhancing biology learning outcomes than conventional teaching methods.

Table 7

Mean Corrected Scores of High School Students' Learning Outcomes in Conventional vs. OIDDE Learning Models

Group	**Pre-test**	**Post-test**	**Score Increase**	**Corrected Mean**
Conventional	45.85	65.05	19.20	65.850
OIDDE	49.85	78.15	28.30	77.350

4.2 Critical Thinking Skills

The next section of data analysis focuses on the improvement of students' critical thinking skills for both experimental and control class students, as shown in Table 8. The calculated F difference in the OIDDE learning model treatment is 25.183, with a p-value < 0.0001, indicating a significant variation in critical thinking skills between the experimental and control classes, F (1,37) = 25.183, p > 0.0001.

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Table 8

Analysis of Variance (ANCOVA) Results on Critical Thinking Skill Achievement of High School

Add a

Source	*df*	*F*	*Sig.*
Critical Thinking	1	26.466	.000
Class	1	25.183	.000
Error	37		
Total	40		

Significance Note: Consider adding a note below the table to clarify that **Sig. .000** represents a significance level of $p < .001$.

Check Consistency of Decimal Places: If the rest of your tables use two decimal places, keep this format consistent across all tables.

Table 9 presents the average pre-test and post-test scores for both classes. According to the ANCOVA test results, the corrected mean score for critical thinking skills in the experimental class (M = 83.360) was higher than the corrected mean score in the control class (M = 74.490). This difference is evident in both the average post-test scores and the improvement from pre-test to post-test. Therefore, the OIDDE learning model positively influences the enhancement of students' critical thinking skills in the experimental class.

Table 9

Corrected Mean Scores for Critical Thinking Skills of High School Students

Group	*Pre-test*	*Post-test*	Score Increase	% Enhancement	Corrected Mean
Conventional	67.20	74.85	7.65	11%	74.490
OIDDE	66.00	83.00	17.00	26%	83.360

Overall, the OIDDE learning model significantly improves students' critical thinking skills in the experimental class compared to the conventional learning model used in the control class. This finding suggests that applying the OIDDE learning model to biology learning, particularly ecosystem material, makes the learning process more conducive and meaningful than using conventional methods.

In line with Agustina and Abidin (2022); Bayu et al. (2022); Ningrum and Murti (2023), who argue that improving critical thinking competency requires effective and innovative learning models, this research confirms that the OIDDE learning model effectively enhances students' critical thinking abilities. Additionally, as highlighted by Heard et al. (2020) and Rodzalan et al.

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(2020), sustaining improvements in critical thinking skills also requires attention to students' physical well-being, intellectual development, and continuous motivation.

4.3 Ethical Attitudes

The next research section presents an ANCOVA analysis of data on the ethical attitudes of students in both the experimental and control classes towards ecosystems after participating in biology lessons on ecosystem material, as shown in Table 10.

Table 10

Analysis of Variance (ANCOVA) Results on Ethical Attitudes of High School Students

Source	*df*	*F*	*Sig.*
Class	1	24.439	.000
Error	37		
Total	40		

Clarify the Significance Level: Adding an asterisk or note below the table to specify what the significance level (.000) represents could be helpful, such as "*p < .001 indicates statistical significance."

Check Consistency of Decimal Places: If other tables include two decimal places, you may want to apply that here for consistency.

Table 10 provides a summary of the ANCOVA test results, which were used to analyze the impact of the learning model on students' ethical attitudes. The results clearly show that there is a significant difference between the experimental and control classes in terms of ethical attitudes, with F (1,37) = 24.439 and p < 0.001. This indicates that the OIDDE learning model is more effective in significantly enhancing the ethical attitudes of students in the experimental class compared to those in the control class, which followed a conventional learning model.

The increase in ethical attitudes through the OIDDE learning model is notable. This is because the OIDDE learning model's structure specifically fosters the development of attitudes, particularly in the fifth stage of its syntax: "Engage in behaviour." This stage represents the culmination of the learning process, where students' ethical involvement becomes evident through their participation in problem-solving activities and dilemmas related to the teaching material.

Next, Table 11 compares the class averages for both the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model).

Table 11

Average Ethical Attitude Scores of High School Student

Group	*Pre-test*	*Post-test*	Score Increase	% Enhancement	Corrected Mean
Conventional	67.00	74.85	7.85	12%	74.612
OIDDE	66.2	83.0	21.80	25%	83.233

Based on Table 11, the corrected mean for the experimental class (M = 83.233) was higher than that of the control class (M = 74.612). This confirms that the ethical attitudes of students in

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the experimental class, who engaged with the OIDDE learning model, were significantly better than those in the control class, who followed a conventional learning approach.

The significant increase in ethical attitudes in the experimental class highlights that learning ecosystem-related biology topics through the OIDDE learning model enhances students' ethical awareness and sense of responsibility toward the environment. These findings align with previous research by Hudha et al. (2018), which demonstrated that the OIDDE learning model effectively increases students' understanding of life ethics, ethical decision-making, and ethical attitudes.

Furthermore, Ichsan et al. (2020) emphasized that 21st-century ecosystem education must be contextual and foster High Order Thinking Skills (HOTS) to effectively address environmental issues. In this regard, the OIDDE learning model is well-suited for fostering HOTS, as it encourages critical, creative, and analytical thinking applied to problem-solving in biology education. Tasrif (2022) reinforced this idea by highlighting that HOTS includes the ability to think critically, creatively, and analytically to solve problems using information and data. The OIDDE learning model, by focusing on problem discovery, ethical decision-making, and behavioural involvement, supports the development of these higher-order thinking skills.

In addition to the pre-test and post-test measurements of ethical attitudes (as shown in Table 10 and Table 11), researchers also assessed students' ethical attitudes in both the experimental and control classes using a questionnaire. The results of this assessment are illustrated in Figure 1.

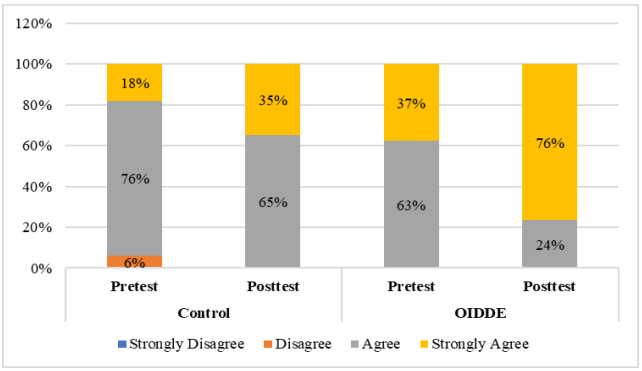

Figure 1 *Questionnaire Results on Students' Ethical Attitudes Before and After Implementing the Learning Model in the Experimental and Control Groups*.

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The figure shows that students in the experimental group, who were taught using the OIDDE learning model, exhibited significantly stronger ethical attitudes toward ecosystem issues compared to students in the control group. In the pre-test for the experimental group, 37% of students strongly agreed with ethical statements regarding ecosystems, while in the post-test, this percentage increased to 76%. This reflects a 39% improvement in students' ethical attitudes after learning with the OIDDE model. Additionally, there was a notable decline in students expressing only agreement (from 63% in the pre-test to 24% in the post-test), indicating a positive shift from moderate agreement to strong agreement in ethical attitudes.

In contrast, the control group displayed more varied ethical attitudes toward ecosystem issues. In the pre-test, 6% of students disagreed, 76% agreed, and 18% strongly agreed with the ethical statements. By the post-test, there was a 17% increase in the number of students strongly agreeing, from 18% to 35%. This improvement was accompanied by a slight decrease in the percentage of

students who agreed, dropping from 76% in the pre-test to 65% in the post-test. Overall, while there was some improvement in the control group, it was not as pronounced as in the experimental group.

The data from Figure 1 highlights one of the main advantages of the OIDDE learning model—it effectively motivates students to express ethical behaviour independently, with integrity and honesty, particularly in relation to ecosystem issues. This is not commonly observed in other learning models. Chairilsyah, (2016) notes, honesty is a critical aspect of daily life, and as Cooper et al. (2023) argue, honesty encourages individuals to behave ethically. Additionally, Bonnie et al. (2022) emphasize that honesty is closely related to well-being. Therefore, ethical attitudes, as reflected in honesty, play a fundamental role in students' lives and behaviour.

In addition to the improvement in learning outcomes, critical thinking skills, and ethical attitudes, the study also measured student learning engagement for both the experimental and control classes. Learning engagement data was collected using observation sheets during biology lessons on ecosystem material. The findings show a clear difference between the two groups: students in the experimental class achieved a 'very good' level of engagement, while students in the control class were categorized as 'good,' as displayed in Table 12.

Table 12

Learning Engagement Levels of High School Students by Learning Model

Learning Model	Percentage	Category
Conventional	70%	Good
OIDDE	78%	Excellent

Table 12 shows that the learning engagement of students in the experimental class, who were taught using the OIDDE learning model, is categorized as 'very good' (excellent), whereas students in the control class, who followed the conventional learning model, are classified as 'good.' The increase in learning engagement for the experimental class was 78% (excellent), compared to only 70% (good) for the control class. This indicates that the OIDDE learning model had a greater impact on enhancing learning engagement among students in the experimental class compared to the conventional learning model used in the control class.

The results confirm that a learning model that is supportive, enjoyable, meaningful, student-centered, and includes an ethical dimension can significantly enhance student engagement. Therefore, it can be concluded that the OIDDE learning model is an effective approach for improving student engagement in biology education.

The research findings also revealed that students in the experimental class found learning biology more enjoyable with the OIDDE learning model, as demonstrated by their increased engagement. A teaching process that is supportive, enjoyable, meaningful, student-centered, and ethically grounded provides a richer learning experience for students, as supported by previous studies (Bishop et al., 2014; Emaliana, 2017; Ali et al., 2020).

What sets the OIDDE learning model apart from conventional and earlier models is its integration of the "decision" and "engage in behaviour" stages. These stages are specifically designed to help students engage in ethical decision-making and develop ethical attitudes related to the material being studied.

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In the decision stage, students are guided to make ethical decisions as a solution to the problems they encounter, with a focus on ethical reasoning. In the engage in behaviour stage, students are encouraged to express their behaviours and attitudes based on the ethical decisions they have made during the learning process. This unique aspect of the OIDDE learning model ensures that students develop not only critical thinking and problem-solving skills but also ethical attitudes.

As a result, students in the experimental class reported positive experiences, stating that after learning ecosystem material using the OIDDE model, they felt highly motivated, found the learning environment conducive and enjoyable, and had increased learning awareness. Overall, the students appreciated the fresh and engaging approach offered by each component of the OIDDE model. It is not surprising, therefore, that many students expressed a desire for the OIDDE learning model to be applied not only in biology but also in other subjects.

5. Discussion

5.1 Effectiveness of the OIDDE Learning Model

The results indicate that the OIDDE learning model is highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement compared to the conventional learning model used in the control class. Students in the experimental class consistently outperformed those in the control class across all measured domains, demonstrating the value of the OIDDE model in fostering a more meaningful and engaging learning experience. This aligns with prior studies that emphasize the importance of innovative, problem-based, and contextual learning models in achieving significant educational outcomes (Hajeniati & Kaharuddin, 2022).

This research reinforces earlier findings, confirming that the OIDDE learning model improves the critical thinking skills of students, as well as their creative thinking abilities (Ma'rifatillah et al., 2019). The results are also consistent with studies that highlight the significance of ethical attitudes in biology education by Kohli et al. (2015) and Chen and So (2017). The OIDDE learning model's positive impact on ethical attitudes, which had been previously observed in prospective biology teachers, is confirmed here in the context of high school students (Hudha et al., 2018).

The OIDDE learning model is well-suited to 21st-century educational demands, characterized by critical thinking, problem-solving, collaboration, creativity, and innovation (Aslamiah et al., 2021; Wulandari, 2021). This model is highly effective in creating a constructive, student-centered learning environment, which is essential for developing students' cognitive and ethical competencies in modern education. The integration of the model's syntax into science education fosters a conducive and innovative learning atmosphere, benefiting students academically and personally.

5.2 Enhancing Critical Thinking and Ethical Attitudes

The improvements in critical thinking skills and ethical attitudes among students in the experimental class highlight the effectiveness of the OIDDE learning model, particularly in the context of biology education. The model's problem-based approach encourages students to actively engage in solving ethical dilemmas related to ecosystem issues. This active involvement

fosters critical thinking and enables students to make informed, ethical decisions, a skill that is vital for addressing 21st-century challenges (Rahman et al., 2023; Haulia et al., 2022).

One of the key advantages of the OIDDE learning model is its capacity to create an active learning environment. The syntax of the model encourages students to engage in hands-on problem-solving, fostering both independent thinking and teamwork. This collaborative learning environment helps develop critical thinking and ethical attitudes, as students work together to address real-world issues. Small group discussions, in particular, encourage cooperation, which is essential for improving learning outcomes and engagement (Kvellestad et al., 2021).

5.3 The Role of Problem-Based Learning in Science Education

The OIDDE learning model's emphasis on problem-based learning aligns with research that demonstrates the importance of addressing contextual, real-world problems in education. By presenting students with issues related to ecosystems, the model promotes the development of critical thinking skills, ethical attitudes, and greater engagement in learning. The effectiveness of this approach is evident in the significant improvements observed in the experimental class, where students were more motivated, engaged, and capable of making ethical decisions compared to the control class (Pozas et al., 2020; Bahri & Corebima, 2015).

5.4 Strengths of the OIDDE Model Syntax

The sequential syntax of the OIDDE learning model, from orientation to decision-making and behaviour engagement, plays a crucial role in its effectiveness. Each stage is designed to encourage students to think critically, collaborate, and engage in ethical decision-making. The syntax's flexibility allows teachers to incorporate real-world problems and contextual learning into their lessons, enhancing both cognitive and affective learning outcomes. This step-by-step approach has proven to be effective in fostering deeper learning, ethical understanding, and student engagement in biology education.

The research uncovered several new findings related to the implementation of the OIDDE learning model. First, both teachers and students in island high schools were introduced to an innovative and effective learning model that fostered greater awareness of ethical dilemmas in biological issues. Second, students developed critical thinking skills and learned to engage in ethical decision-making through group discussions. These findings highlight the OIDDE model's potential for promoting student-centered learning and fostering a deeper understanding of complex environmental issues.

The OIDDE learning model has demonstrated its effectiveness in enhancing learning outcomes, critical thinking skills, ethical attitudes, and engagement among high school students. Based on the research findings, it is recommended that the OIDDE model be adopted in various subjects beyond biology to promote critical thinking, ethical behaviour, and student engagement across disciplines. Additionally, further research should explore the application of the OIDDE model in different educational contexts and subject areas, focusing on the development of student integrity, ethical decision-making, and problem-solving skills.

6. Conclusion

The implementation of the OIDDE learning model has proven to be highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among high school students in the islands, especially in comparison to conventional learning models used in biology instruction. The experimental group showed significant improvements across all measured domains and provided overwhelmingly positive feedback. Students in the experimental class consistently expressed satisfaction with the OIDDE model, noting a pleasant and engaging learning atmosphere that fostered collaboration, critical thinking, and ethical decision-making.

Furthermore, students appreciated the novelty and interest sparked by each syntax of the OIDDE model, which encouraged them to explore more and suggested that the model could be applied successfully to other subjects like physics and chemistry. The model's ability to create an enjoyable and conducive learning environment has led students to advocate for its broader application beyond biology. Given these results, the OIDDE learning model presents a compelling option for fostering 21st-century learning skills. Its innovative approach should be considered for implementation across various educational levels and subjects to support the holistic development of students, particularly in critical thinking, ethical reasoning, and engagement.

7. Limitations and Recommendations

This study was conducted with students from a single high school, focusing solely on the subject of biology. As such, the results cannot be generalized across all educational settings or subjects. However, the findings provide a strong foundation for future research and the implementation of the OIDDE model in different subject areas and educational contexts. Another limitation is that the OIDDE model was new to both students and teachers in the school where the research was conducted. Despite this, the introduction of the model has successfully enriched the teachers' pedagogical repertoire and demonstrated its potential for broader application.

Based on the findings of this study, it is recommended that the OIDDE model be adopted and its use expanded. The OIDDE model is a promising, innovative learning approach suitable for various educational levels and subjects, beyond just biology. Its structured approach to fostering critical thinking, ethical attitudes, and student engagement aligns well with the demands of 21st-century learning. Additionally, the OIDDE model should be referenced as a strategy for developing critical thinking skills and improving overall learning outcomes. It can serve as an effective learning framework for students in diverse educational contexts, helping to cultivate ethical behaviour and enhance engagement across different levels of education. These recommendations highlight the value of the OIDDE model in modern education and suggest its potential to contribute to the ongoing development of innovative, student-centered learning strategies.

Ethical Consideration

This study was conducted with oversight and approval from school administration, including the principal and relevant teachers, ensuring compliance with ethical standards for educational research. Data collection was carried out with permission from both the participants and the biology teacher. The identities of all participants were kept confidential.

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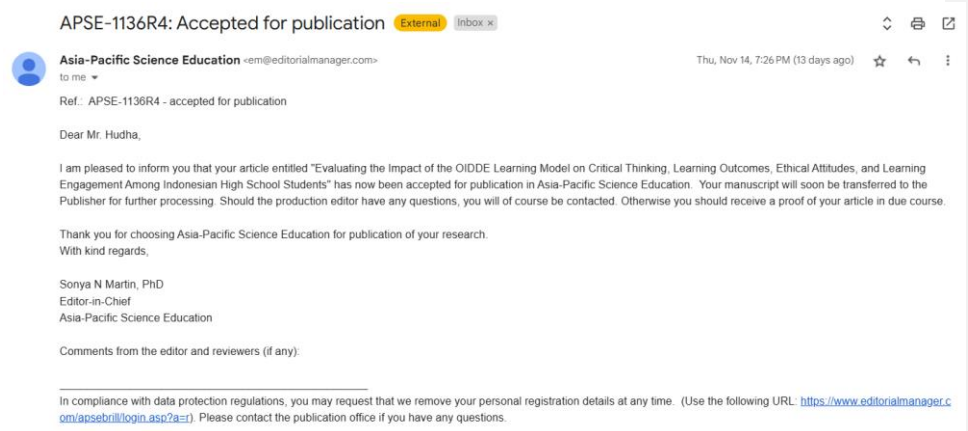

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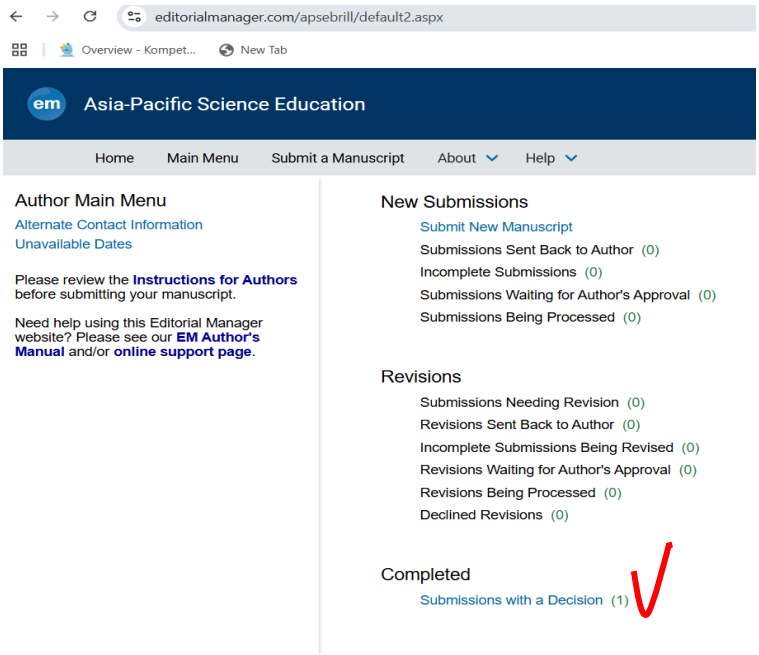

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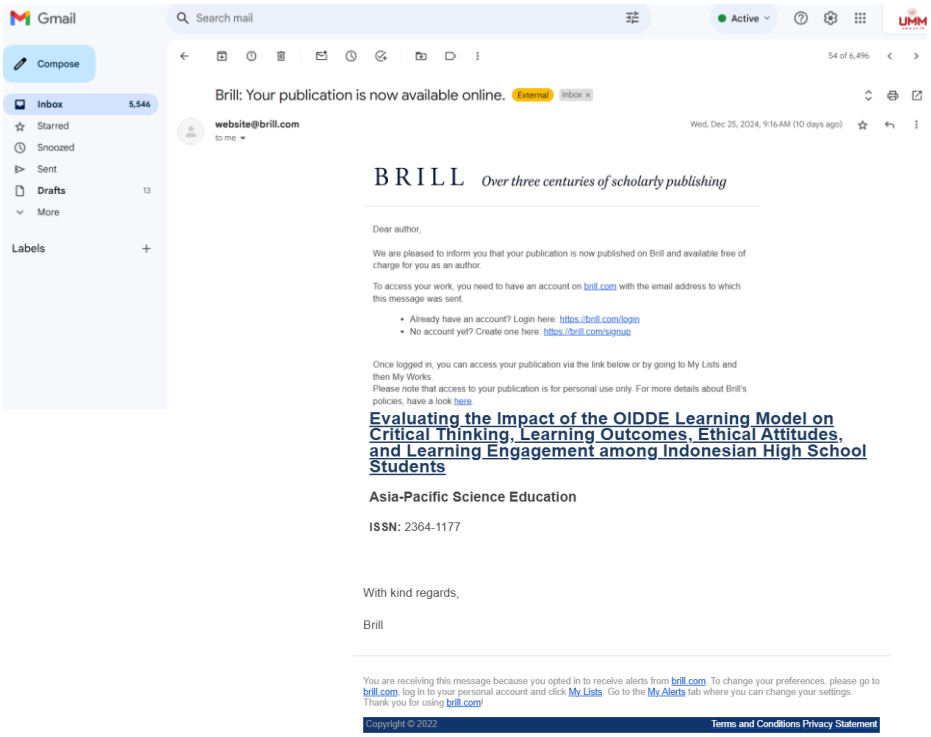

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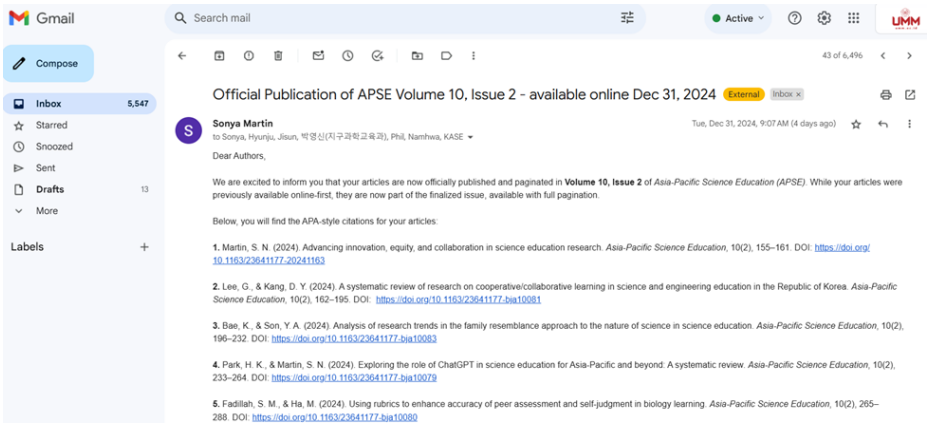

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1. Martin, S. N. (2024). Advancing innovation, equity, and collaboration in science education research. *Asia-Pacific Science Education*, 10(2), 155–161. DOI: https://doi.org/10.1163/23641177-20241163

2. Lee, G., & Kang, D. Y. (2024). A systematic review of research on cooperative/collaborative learning in science and engineering education in the Republic of Korea. *Asia-Pacific Science Education*, 10(2), 162–195. DOI: https://doi.org/10.1163/23641177-bja10081

3. Bae, K., & Son, Y. A. (2024). Analysis of research trends in the family resemblance approach to the nature of science in science education. *Asia-Pacific Science Education*, 10(2), 196–232. DOI: https://doi.org/10.1163/23641177-bja10083

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10. Alimin, M., Mun, J., & Lee, H. (2024). Investigating perceptions of the social responsibility of scientists and engineers: Comparison among South Korean, Malaysian, and Indonesian university students in STEM fields. *Asia-Pacific Science Education*, 10(2), 411–441. DOI: https://doi.org/10.1163/23641177-bja10088

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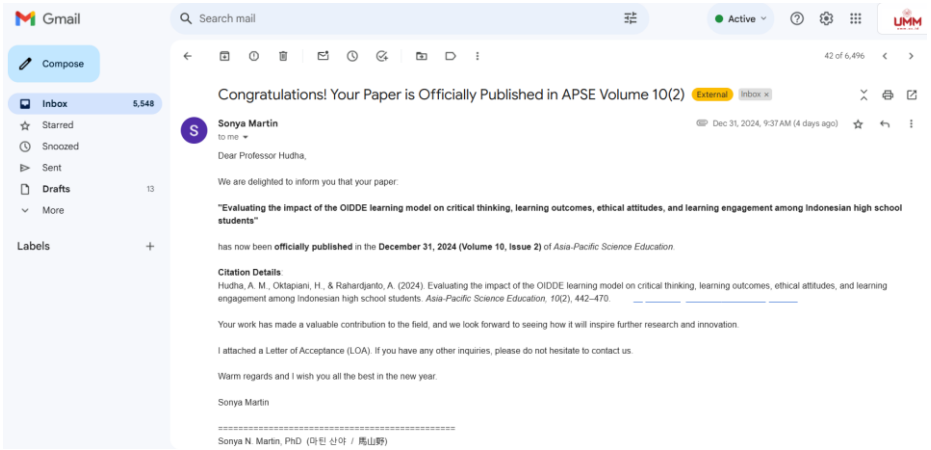

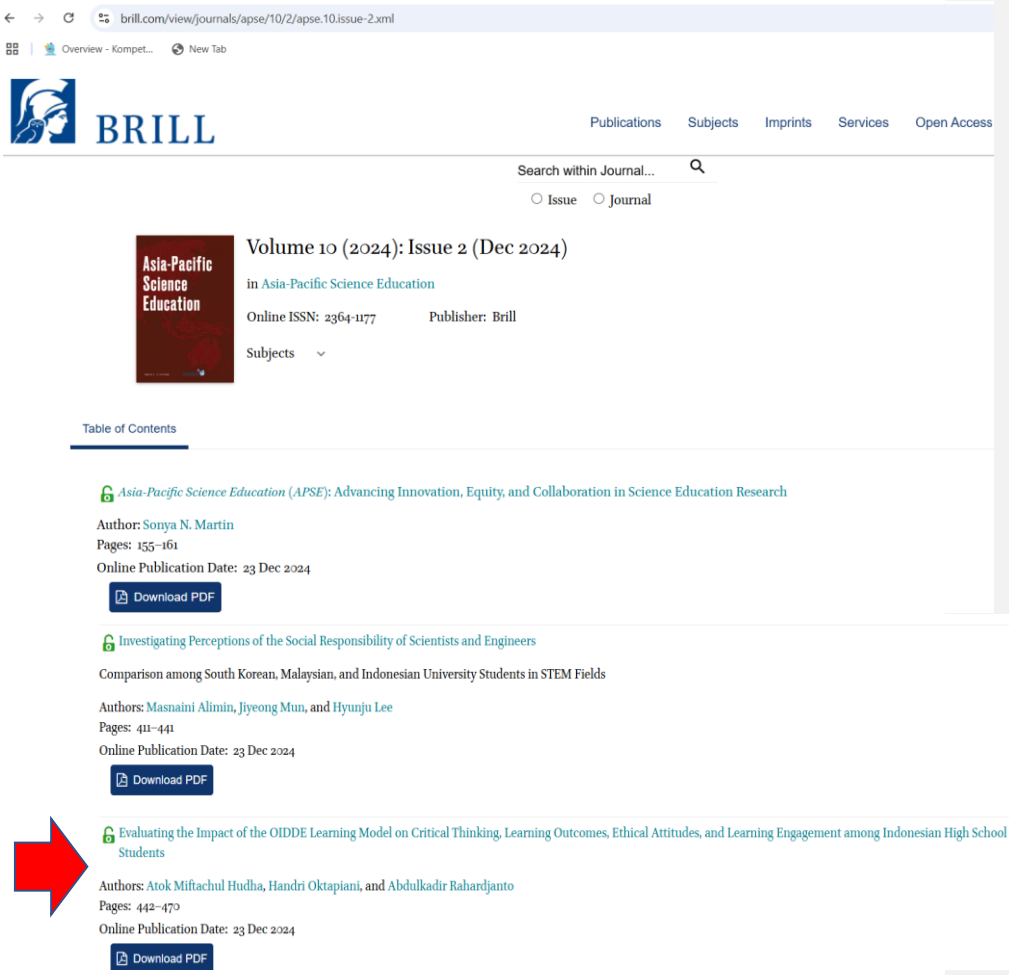
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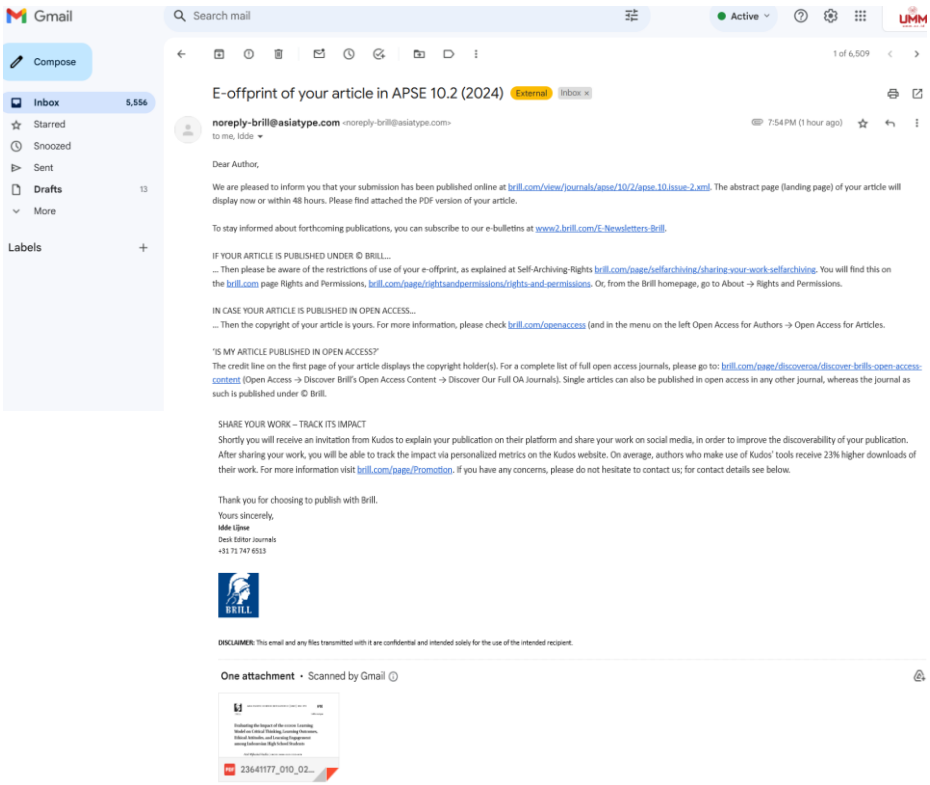

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Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement Among Indonesian High School Students

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Abstract This study investigated the effectiveness of the orientation, identify, discussion, decision, and engage in behavior (OIDDE) learning model in enhancing biology learning outcomes, critical thinking, ethical attitudes, and engagement among high school students in Indonesia. Employing a quasi-experimental design with pre- and post-tests, the research included 66 randomly sampled students, evenly divided into experimental and control groups. Data were gathered through validated observation sheets, ethical attitude questionnaires, and tests, with analysis of covariance (ANCOVA) analysis conducted following normality and homogeneity tests. Results indicated significant improvements across all measured variables in the experimental group compared to the control group. The findings suggest that the OIDDE model was more effective than conventional methods in fostering comprehensive educational outcomes in biology, as its problem-based approach promotes active learning, ethical decision-making, and collaborative problem-solving, aligning well with the needs of 21st-century education. This study underscores the model's potential for broader application across various subjects to enhance critical thinking, ethical behavior, and sustained student engagement.

Keywords critical thinking; ethical attitudes; learning engagement; biology education; OIDDE learning model

Ethical Consideration

This study was conducted with oversight and approval from school administration, including the principal and relevant teachers, ensuring compliance with ethical standards for educational research. Data collection was carried out with permission from both the participants and the biology teacher. The identities of all participants were kept confidential.

Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement Among Indonesian High School Students

Abstract This study investigated the effectiveness of the orientation, identify, discussion, decision, and engage in behaviour (OIDDE) learning model in enhancing biology learning outcomes, critical thinking, ethical attitudes, and engagement among high school students in Indonesia. Employing a quasi-experimental design with pre- and post-tests, the research included 66 randomly sampled students, evenly divided into experimental and control groups. Data were gathered through validated observation sheets, ethical attitude questionnaires, and tests, with analysis of covariance (ANCOVA) analysis conducted following normality and homogeneity tests. Results indicated significant improvements across all measured variables in the experimental group compared to the control group. The findings suggest that the OIDDE model was more effective than conventional methods in fostering comprehensive educational outcomes in biology, as its problem-based approach promotes active learning, ethical decision-making, and collaborative problem-solving, aligning well with the needs of 21st-century education. This study underscores the model's potential for broader application across various subjects to enhance critical thinking, ethical behaviour, and sustained student engagement.

Keywords critical thinking; ethical attitudes; learning engagement; biology education; OIDDE learning model

1. Introduction

Learning is an ongoing process of acquiring knowledge, which results in a change in behaviour. These behavioural changes are shaped by new experiences gained through learning (Djamaluddin & Wardana, 2019). The outcome of learning has often been referred to as "learning outcomes," which encompass changes in behaviour across the affective, cognitive, and psychomotor domains (Mahananingtyas, 2017; Nurrita, 2018). To maximize these outcomes, learning should be structured to provide holistic guidance and skills. In the global era, holistic skills are essential for addressing global challenges (Miseliunaite et al., 2022).

In Indonesia, particularly in high schools, there has been limited research on the effectiveness of various learning models in improving the learning process, especially in biology education (Azizah & Alberida, 2021; Herman & Rahmat, 2023). This includes evaluating how well these models enhance students' critical thinking skills and ethical attitudes. Learning outcomes serve as a key measure of students' mastery of the material (Fitrianingtyas & Radia, 2017), reflecting their overall achievement (Mahajan & Singh, 2017). Therefore, learning outcomes must be clear, learner centered, and focused on the expected performance or understanding (García, 2021), especially in the context of biology education.

Biology education is closely linked to the development of critical thinking skills, which are essential in today's globalized world due to their wide-ranging impacts. However, some research has suggested that learning outcomes in biology do not always significantly reflect these skills (Suharsono et al., 2017). This discrepancy underscores the need for effective teaching methods to cultivate critical thinking (Kinoshita, 2022; Setyowati et al., 2018).

In Indonesia's archipelagic regions, where students may face limited access to educational resources and infrastructure due to geographical isolation, improving biology learning outcomes is particularly relevant. These challenges can impact the quality of education and student engagement, especially in science subjects like biology, which often require hands-on learning and laboratory work.

The orientation, identify, discussion, decision, and engage in behaviour (OIDDE) learning model is specifically designed to enhance engagement and critical thinking through structured stages that foster active learning and decision-making. In resource-limited settings such as archipelagic regions, where traditional lecture-based methods may fail to fully engage students, the OIDDE model offers an alternative approach. By encouraging students to take an active role

in their learning, this model has the potential to improve biology learning outcomes despite logistical and infrastructural challenges. Therefore, investigating the effectiveness of the OIDDE model in enhancing high school biology learning outcomes is of great importance.

Moreover, critical thinking skills are essential for addressing complex problems, including environmental issues (Santi et al., 2018). Developing these skills requires diverse and engaging teaching methods (Hwang et al., 2023). Unfortunately, studies indicate that junior high school students in Indonesia's archipelagic regions have relatively low critical thinking skills, likely due to the prevalence of traditional teaching methods that lack problem-solving opportunities and student-centered approaches (Susilawati et al., 2020)

Developing critical thinking skills is vital for helping students solve everyday problems (Syafitri et al., 2021). However, research on enhancing critical thinking in biology through the OIDDE learning model has still been scarce. Teachers can employ various learning models to improve critical thinking, learning outcomes, and engagement, especially in biology. However, Indonesia's biology education faces many challenges, including didactic issues, curriculum constraints, and insufficient learning facilities (Khoiri et al., 2020). Additionally, science teachers often lack proper training and resources, including laboratory equipment, which hinders effective biology instruction.

Several initiatives have been aimed at improving science education in Indonesia, including teacher certification, curriculum innovation, and collaborative international research (Faisal & Martin, 2019). These initiatives can significantly impact biology learning, influencing not only learning outcomes and critical thinking skills but also ethical attitudes and student engagement. In education, there has often been a primary focus on learning outcomes and critical skills, while aspects such as ethical attitudes and student engagement have frequently been overlooked. This has been especially true in Indonesia's archipelagic regions, where unique geographic and cultural contexts create specific educational challenges, and where ethical attitudes and student engagement have not been sufficiently studied (Hudha et al., 2018).

In these isolated and diverse regions, ethical attitudes are particularly crucial for fostering social cohesion and mutual respect among students from varied cultural backgrounds. With limited access to external resources and diverse perspectives, these communities rely heavily on locally rooted values and interpersonal relationships. Developing ethical attitudes in education can thus promote tolerance and inclusivity, preparing students to contribute positively to their communities. Moreover, in today's global era, ethical attitudes play an essential role in shaping students' character and values, fostering a moral, tolerant, and well-behaved society (Tsoraya et al., 2023).

Despite the importance of ethical attitudes, many high school biology teachers focus primarily on cognitive aspects of learning, neglecting affective aspects such as ethical attitudes (Chowdhury, 2016). The increasing instances of unethical behaviour among students in Indonesia's archipelago have underscored the need to emphasize ethical attitudes in education (Ardiana et al., 2022). Similarly, student engagement in biology learning requires further exploration. The OIDDE learning model offers a promising, innovative approach to address these educational challenges. This study aims to evaluate the effectiveness of the OIDDE learning model in improving critical thinking skills, learning outcomes, ethical attitudes, and learning engagement among high school students in the eastern Indonesia.

2. The OIDDE Learning Model

The OIDDE learning model, developed and validated by Hudha et al. (2016), has demonstrated reliability and practical application in educational settings. Recognized as an innovative educational tool, it has been awarded copyright status by the Directorate General of Intellectual Property under the Ministry of Law and Human Rights of the Republic of Indonesia (Registration

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Table 1
Phases of the OIDDE Learning Model (adapted from Hudha et al., 2016).

Phase	Teacher activities	Student activities
Phase 1: Orientation	- Guide students in preparing to learn the material. - Present materials that incorporate values and ethical issues (bioethics). - Share case studies, historical narratives, videos, or documentaries to introduce ethical dilemmas.	- Prepare and engage with the material. - Listen, observe, and take notes. - Pay close attention to case studies and ethical issues presented.
Phase 2: Identify	- Assign students to identify ethical dilemmas within case studies, facts, and narratives. - Ask selected students to briefly explain identified dilemmas for class discussion.	- Identify ethical dilemmas in the material. - Select priority dilemmas for group discussion. - Explain identified dilemmas as part of a class discussion.
Phase 3: Discussion	- Divide students into small heterogeneous groups of 4-5 members. - Guide students to prioritize ethical dilemmas from individual findings as topics for group discussion. - Instruct each group to assign roles relevant to the chosen discussion topic. - Facilitate group discussions, ensuring they are democratic, honest, and ethical. - Moderate as each group presents discussion results to the class, followed by a Q&A. - Direct groups to document discussion outcomes as a foundation for ethical decision-making.	- Form groups of 4-5 members. - Deliberate within groups to select priority ethical dilemmas for discussion. - Assign appropriate roles for each group member. - Engage in discussions with a focus on democratic, honest, and ethical participation. - Present group discussion results to the class and participate in Q&A. - Document discussion outcomes for use in ethical decision-making.
Phase 4: Decision	- Guide each group to collaboratively formulate ethical decisions based on their discussions. - Instruct students to develop individual ethical decisions, reflecting on group discussion topics. - Direct each student to document their individual	- Collaboratively formulate ethical decisions as a group based on group discussions. - Reflect individually on group topics to make personal ethical decisions. - Document individual ethical decisions on provided sheets.

Phase	Teacher activities	Student activities
	ethical decisions independently. - Provide prepared sheets for students to record their individual ethical decisions.	
Phase 5: Engage in behaviour	- Encourage students to reflect on and document ethical behaviour related to the decisions made during discussions. - Facilitate class conclusions on learning outcomes and understanding ethical responsibilities.	- Reflect on and document personal ethical behaviour aligning with group decisions. - Participate in summarizing class conclusions with integrity and responsibility. - Honestly report your contributions and commitment to ethical behaviour.

2.1 Research Questions

This study was aimed at evaluating the effectiveness of the OIDDE learning model for high school students in island regions through biology education. The specific research questions were as follows:

9. How does the OIDDE learning model enhance the biology learning outcomes of high school students in the islands?
10. How does the OIDDE learning model affect the development of critical thinking skills in high school students in the islands?
11. How does the OIDDE learning model influence the ethical behaviour of high school students in the islands?
12. How does the OIDDE learning model contribute to increasing learning engagement among high school students in the islands?

3. Research Methodology

3.1 General Background

This study employed a quasi-experimental research design with a control group, utilizing a non-equivalent pre-test and post-test format. The experimental group was taught using the OIDDE learning model, while the control group followed conventional methods. The research was conducted with 10th-grade biology students at one high school, covering ecosystem topics. The study included three weekly sessions, each lasting 120 minutes, for a total of 360 minutes of instruction. The topics covered across these sessions included ecosystem components, interactions within ecosystems, the relationship between biotic and abiotic factors, levels of organization, and the flow of matter and energy within ecosystems.

The OIDDE learning model was applied to students in the experimental group, following the stages outlined by Hudha et al. (2018), as shown in Table 1. The control group, on the other hand, was taught using the conventional teaching methods typically employed by their teachers.

In the experimental group, the ecosystem content in the biology curriculum was delivered over three sessions following the OIDDE model. In contrast, students in the control group received

the same content using the conventional teaching methods typically applied by their teacher. The details of the ecosystem material covered in these sessions are provided in Table 2.

Table 2

Implementation of Biology Learning Topics on Ecosystems Using the OIDDE Learning Model Across Three Meetings

Phase	Student activities in first and second meetings	Student activities in third meeting
Orientation	Students analyzed material on ecosystem components and interactions within various biomes across the Earth's surface.	Students analyzed biogeochemical cycles and current environmental changes and engaged actively and positively.
Identify	Students identified interaction dilemmas by examining ecosystem interactions in biomes, focusing on relationships (mutualism, commensalism, parasitism, and predation) and emerging ecological paradigms.	Students identified ecological dilemmas related to biogeochemical cycles (carbon, nitrogen, water, sulfur, and phosphorus) and their connection to environmental changes, using these insights for group discussions on environmental balance.
Discussion	In groups, students discussed the interaction dilemmas, created food web schemes to analyze trophic levels, and explored ecological relationships and paradigms.	Students participated in discussions on ecological dilemmas linked to biogeochemical cycles and environmental changes, analyzing edaphic and atmospheric cycles and discussing solutions for environmental balance.
Decision	Students made critical decisions individually and in groups, focusing on ecosystem interactions and emerging ecological paradigms.	Students made ethical decisions individually and in groups based on their analysis of biogeochemical cycles and environmental impacts, developing perspectives on environmental stability.
Engage in Behaviour	Students individually reflected on their ethical attitudes and committed to honest behaviours that support ecosystem sustainability.	Students committed to ethical behaviours that support ecosystem sustainability, focusing on biogeochemical cycle continuity and minimizing negative impacts on the environment.

3.2 Research Sample

The study population consisted of 66 10th-grade students, who were randomly assigned into two groups. Class X-A, with 33 students, served as the experimental group, and Class X-B, also with 33 students, served as the control group.

3.5 Instrument Development

This study examined four key variables: (1) Critical thinking skills – the ability to analyze arguments, draw conclusions based on reasoning, evaluate or assess information, and make decisions or solve problems. (2) Learning outcomes – the specific competencies or abilities acquired by students after participating in the learning process, encompassing cognitive, affective, and psychomotor domains. (3) Ethical attitudes – an individual's overall positive or negative response to ethical or unethical behaviour, or adherence to rules and laws. (4) Learning engagement – an attitude reflecting cognitive involvement, active participation, and emotional commitment in all learning activities.

The instruments used in this research included (1) observation sheets for evaluating the implementation of both the OIDDE learning model and the conventional learning model; (2) questionnaires assessing students' ethical attitudes toward ecosystems, administered both before and after the intervention; and (3) pre-test and post-test questions to measure learning outcomes, critical thinking skills, and ethical attitudes.

Before using, the observation sheets and ethical attitude questionnaires were validated by expert validators, with all instruments deemed valid. Validation of the question items was conducted using the Pearson correlation test, and the analysis was supported by SPSS 22.0 for Windows. The results of the validation showed that each question item was valid, as indicated by a *p*-value of less than 0.05. The reliability of the questions was tested using Cronbach's alpha, which yielded a value of 0.669, indicating that the question instrument was reliable (Siregar, 2013).

For ethical attitudes, in addition to test-based measurements, non-test measurements were conducted using a questionnaire related to students' ethical attitudes toward ecosystems. The questionnaire consisted of 15 statements that students were asked to respond to, reflecting their individual attitudes toward ecosystems. Ethical attitude data was collected using a 4-point Likert scale to assess each item: (1) *strongly disagree*, (2) *disagree*, (3) *agree*, and (4) *strongly agree* (Syaifudin, 2012). A detailed description of the ethical attitude questionnaire is presented in Table 3.

Table 3

Questionnaire on High School Students' Ethical Attitudes Toward the Ecosystem

No	Questions	Answer			
		1	2	3	4
1	A caring attitude towards ecosystems will have an impact on the survival of ecosystems.				
2	Humans play a decisive role in the continued existence of ecosystems.				

3	I realize that the benefits of ecosystems are for humans and other ecosystems.	
4	Participating in ecosystem conservation efforts will have an impact on the balance of ecosystems.	
5	Destruction of ecosystems will affect both humans and the ecosystems themselves.	
6	Encouraging others to participate in ecosystem conservation is a caring attitude that should be practiced.	
7	Exploiting the ecosystems around us is a harmful action to ecosystem conservation.	
8	The environment is provided for all living beings, not just for humans.	
9	Humans, as part of the environment, are the main actors in environmental management, so they must always strive to maintain the sustainability, balance, and beauty of ecosystems.	
10	To maintain the balance of nature and prevent further damage, it is essential to cultivate human behaviour or ethics to always care for the environment.	
11	Environmental ethics not only fulfills human rights and duties towards the environment, but also limits behaviour and controls various human activities to ensure they remain within the boundaries of maintaining environmental balance.	
12	Destruction of ecosystems will have negative impacts on the surrounding environment.	
13	Identifying good ecosystem management practices is an ethical attitude that should be taken before deciding to manage natural environments.	
14	Deciding on the appropriate ethical stance to resolve ecosystem destruction issues is an action that should be taken after understanding the ethical problems in ecosystem conservation.	
15	Analyzing various concepts to create an argument for the ethical stance on ecosystem conservation is a wise and prudent step in ecosystem management.	

3.4 Learning Implementation Observation Sheet

The learning implementation observation sheet, used to measure learning engagement, was applied to both the experimental group and the control group. The observation sheet focused on four main aspects, as outlined by Weil and Joyce, (1978) and Joyce and Weil, (2003): implementation of the phases of the OIDDE learning model, implementation of social systems, application of principles of reaction, and implementation of support systems.

These four aspects were further developed into 22 measurable indicators, which were assessed using a Likert scale. The indicators were categorized as follows: seven indicators for model construction, five for the social system, four for the principles of reaction, and six for the support system. All indicators were rated on a 5-point Likert scale, with the following ratings: 1 = *very bad*, 2 = *not good*, 3a= *fairly good*, 4 = *good*, and 5 = *very good*. The observation sheet for learning implementation is presented in Table 4.

Table 4

Learning Implementation Questionnaire for High School Students' Engagement in Biology and Ecosystem Content

Number	Aspects of learning implementation	Scores				
		1	2	3	4	5
A. Learning states						
15.	The learning stages are organized in a clear and systematic manner.					
16.	The learning stages are logical and rational.					
17.	The learning stages outline activities for both teachers and students.					
18.	Activities reflect the interaction flow between teachers and students.					
19.	Activities focus on mastering ecosystem knowledge and environmental ethics.					
20.	Activities emphasize ethical decision-making.					
21.	Activities promote ethical attitudes among students.					
B	**Social system**					
1.	Activities encourage students to discover and construct ethical concepts.					
2.	Activities promote student interaction.					
3.	Activities foster student-teacher interaction.					
4.	Activities embody religious norms, honesty, politeness, and ecosystem responsibility.					
5.	Activities promote collaboration and respect in ecosystem discussions.					
C	**Reaction principle**					
1.	The teacher provides resources such as textbooks and articles.					
2.	The teacher motivates and engages students.					
3.	Activities stimulate curiosity, idea exploration, and scientific communication.					
4.	Students can ask questions when facing concept difficulties.					
D	**Support system (nurturant effect and instructional effect)**					

1.	Learning tools align with the learning phases.
2.	Learning tools meet objectives to improve conceptual understanding, critical thinking, ethical decision-making, and ethical behaviour.
3.	Instructional effects (concept mastery, critical thinking, ethical decision-making, and behaviour) are clearly and logically stated in the learning stages.
4.	Instructional effects align with learning goals.
5.	Accompanying impacts like improved critical thinking are integrated logically.
6.	Ethical attitudes are aligned with learning objectives.

The scores obtained from Table 4 were then converted into learning implementation assessment categories based on the University of Muhammadiyah Malang Learning Assessment Standards (Universitas Muhammadiyah Malang, 2020), as follows: 80.0 (outstanding), 75.0-80.0 (excellent), 70.0-74.9 (very good), 60.0-69.0 (good), 55.0-59.9 (fair), 40.0-54.0 (pass), and < 40.0 (fail).

3.5 Data Analysis

Data analysis was conducted using analysis of covariance (ANCOVA) to assess the effectiveness of the OIDDE learning model compared to the conventional learning model in relation to learning outcomes, critical thinking skills, and ethical attitudes (based on pre-test and post-test results). Before performing the ANCOVA, normality was evaluated using the Kolmogorov-Smirnov test, and homogeneity was assessed with the Levene test. All data analyses were carried out using SPSS for Windows, version 22.

4. Results

The research results provide insights into the impact of the OIDDE learning model on enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among students in both the experimental and control classes. The data analysis outcomes are detailed below.

4.1 Learning Outcomes

The differences in student learning outcomes between the experimental and control classes are shown in Table 6. The one-way ANCOVA results presented in Table 5 indicated an F value of 27.643, with a p-value < 0.0001, demonstrating a significant difference in learning outcomes between the experimental and control classes (F (1,37) = 27.643, p = 0.004). This result suggests that the OIDDE learning model was effective and significantly improved learning outcomes for students in the experimental class compared to those in the control class.

Table 5
Results of One-Way ANCOVA on Biology Learning Outcomes of High School Students

Source	***df***	***F***	***Sig.***
Learning outcomes	1	9.434	.004

Class	1	27.643	< .000
Error	37		

$p < .05$ indicates statistical significance, with $p < .001$ showing a higher level of significance.

Next, the corrected mean analysis for each class, specifically comparing the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model), is shown in Table 6. The corrected average score for the experimental class (M = 77.350) was higher than that for the control class (M = 65.850), indicating that students in the experimental class achieved better learning outcomes. The final post-test scores and the improvement from pre-test to post-test were consistently higher for the experimental class. These results indicated that the OIDDE learning model was more effective in enhancing biology learning outcomes than conventional teaching methods.

Table 6
Mean Corrected Scores of High School Students' Learning Outcomes in Conventional vs. OIDDE Learning Models

Group	Pre-test	Post-test	Score increase	Corrected mean
Conventional	45.85	65.05	19.20	65.850
OIDDE	49.85	78.15	28.30	77.350

4.2 Critical Thinking Skills

The next section of data analysis focused on the improvement of students' critical thinking skills for both experimental and control class students, as shown in Table 7. The calculated F difference in the OIDDE learning model treatment was 25.183, with a p-value < 0.0001, indicating a significant variation in critical thinking skills between the experimental and control classes ($F(1,37) = 25.183$, $p > 0.0001$).

Table 7
ANCOVA Results on Critical Thinking Skill Achievement of High School Students

Source	*df*	*F*	*Sig.*
Critical Thinking	1	26.466	< .000
Class	1	25.183	< .000
Error	37		
Total	40		

*p < .001 indicates statistical *p < .001 indicates statistical significance

Table 8 presents the average pre-test and post-test scores for both classes. According to the ANCOVA test results, the corrected mean score for critical thinking skills in the experimental class (M = 83.360) was higher than the corrected mean score in the control class (M = 74.490). This difference was evident in both the average post-test scores and the improvement from pre-test to post-test. Therefore, the OIDDE learning model positively influenced the enhancement of students' critical thinking skills in the experimental class.

Table 8
Corrected Mean Scores for Critical Thinking Skills of High School Students

Group	Pre-test	Post-test	Score increase	% enhancement	Corrected mean
Conventional	67.20	74.85	7.65	11%	74.490
OIDDE	66.00	83.00	17.00	26%	83.360

Overall, the OIDDE learning model significantly improved students' critical thinking skills in the experimental class compared to the conventional learning model used in the control class. This finding suggests that applying the OIDDE model to biology learning, especially in ecosystem studies, creates a more conducive learning environment for developing higher-order thinking skills. The structured stages of the OIDDE model—orientation, identify, discussion, decision, and engage in behaviour—encourage active participation and deeper engagement with the content, making the learning process more interactive, student-centered, and meaningful compared to traditional methods

In line with Agustina and Abidin (2022), Bayu et al. (2022), and Ningrum and Murti (2023), who argued that improving critical thinking competency requires effective and innovative learning models, this research shows that the OIDDE model can significantly enhance students' critical thinking abilities. Additionally, as highlighted by Heard et al. (2020) and Rodzalan et al. (2020), sustaining improvements in critical thinking skills requires attention to various factors, including students' physical well-being, intellectual development, and continuous motivation. The OIDDE model indirectly supports these aspects by fostering an engaging, interactive learning environment that encourages active learning and intellectual curiosity. This holistic approach aligns with the need for a learning model that not only enhances cognitive skills but also motivates and sustains students' interest and engagement

4.3 Ethical Attitudes

The next research section presents an ANCOVA analysis of data on the ethical attitudes of students in both the experimental and control classes toward ecosystems after participating in biology lessons on ecosystem material, as shown in Table 9.

Table 9

ANCOVA Results on Ethical Attitudes of High School Students

Source	***df***	***F***	***Sig.***
Class	1	24.439	< .000
Error	37		
Total	40		

*p < .001 indicates statistical significance

Table 9 provides a summary of the ANCOVA test results, which were used to analyze the impact of the learning model on students' ethical attitudes. The results clearly showed that there was a significant difference between the experimental and control classes in terms of ethical attitudes, with F (1,37) = 24.439 and p < 0.001. This indicates that the OIDDE learning model was more effective in significantly enhancing the ethical attitudes of students in the experimental class than it was in the control class, which followed a conventional learning model.

The increase in ethical attitudes through the OIDDE learning model is notable. This is because the OIDDE learning model's structure specifically fosters the development of attitudes, particularly in its fifth stage: "Engage in behaviour." This stage represents the culmination of the learning process, where students' ethical involvement becomes evident through their participation in problem-solving activities and dilemmas related to the teaching material.

Next, the class averages for both the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model) are compared (Table 10).

Table 10

Average Ethical Attitude Scores of High School Student

Group	*Pre-test*	*Post-test*	Score increase	% Enhancement	Corrected mean
Conventional	67.00	74.85	7.85	12%	74.612
OIDDE	66.2	83.0	21.80	25%	83.233

Table 11 shows that the corrected mean for the experimental class (M = 83.233) was higher than that of the control class (M = 74.612), showing that the ethical attitudes of students in the experimental class, who engaged with the OIDDE learning model, were significantly better than those in the control class, who followed a conventional learning approach.

The significant increase in ethical attitudes in the experimental class highlights that learning ecosystem-related biology topics through the OIDDE learning model may have enhanced students' ethical awareness and sense of responsibility toward the environment. These findings align with previous research by Hudha et al. (2018), which demonstrated that the OIDDE learning model effectively increases students' understanding of life ethics, ethical decision-making, and ethical attitudes.

Ichsan et al. (2020) further emphasized that 21st-century ecosystem education must be contextual and foster higher-order thinking skills to effectively address environmental issues. In this regard, the OIDDE learning model is well suited for fostering foster higher-order thinking skills, as it encourages critical, creative, and analytical thinking applied to problem-solving in biology education. Tasrif (2022) reinforced this idea by highlighting that fostering higher-order thinking skills includes the ability to think critically, creatively, and analytically to solve problems using information and data. The OIDDE learning model, by focusing on problem discovery, ethical decision-making, and behavioural involvement, supports the development of these higher-order thinking skills.

In addition to the pre-test and post-test measurements of ethical attitudes (as shown in Tables 10 and 11), researchers also assessed students' ethical attitudes in both the experimental and control classes using a questionnaire. The results of this assessment are illustrated in Figure 1.

Figure 1

Questionnaire Results on Students' Ethical Attitudes Before and After Implementing the Learning Model in the Experimental and Control Groups

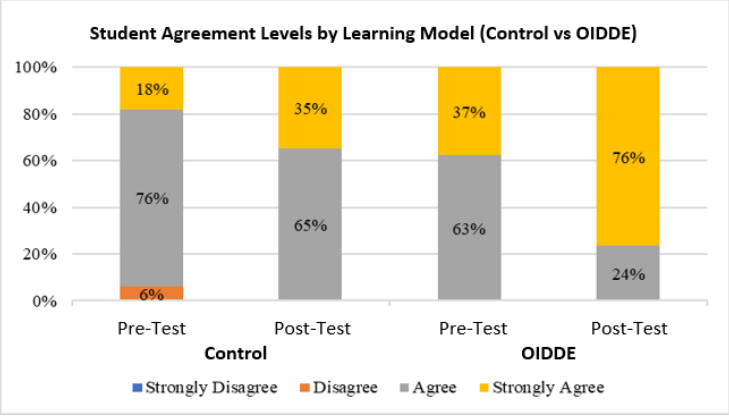

Figure 1 shows that students in the experimental group, who were taught using the OIDDE learning model, exhibited significantly stronger ethical attitudes toward ecosystem issues compared to students in the control group. In the pre-test for the experimental group, 37% of students strongly agreed with ethical statements regarding ecosystems, while in the post-test, this percentage increased to 76%. This reflects a 39% improvement in students' ethical attitudes after learning with the OIDDE model. Additionally, there was a notable decline in students expressing only agreement (from 63% in the pre-test to 24% in the post-test), indicating a positive shift from moderate agreement to strong agreement in ethical attitudes.

In contrast, the control group displayed more varied ethical attitudes toward ecosystem issues. In the pre-test, 6% of students disagreed, 76% agreed, and 18% strongly agreed with the ethical statements. By the post-test, there was a 17% increase in the number of students strongly agreeing, from 18% to 35%. This improvement was accompanied by a slight decrease in the percentage of students who agreed, dropping from 76% in the pre-test to 65% in the post-test. Overall, while there was some improvement in the control group, it was not as pronounced as in the experimental group.

The data shown in Figure 1 highlight one of the main advantages of the OIDDE learning model: It effectively motivated students to express ethical behaviour independently, with integrity and honesty, particularly in relation to ecosystem issues. This is not commonly observed in other learning models. Chairilsyah (2016) noted that honesty is a critical aspect of daily life, and as Cooper et al. (2023) argued, honesty encourages individuals to behave ethically. Additionally, Bonnie et al. (2022) emphasized that honesty is closely related to well-being. Therefore, ethical attitudes, as reflected in honesty, play a fundamental role in students' lives and behaviour.

In addition to improvements in learning outcomes, critical thinking skills, and ethical attitudes, the study also measured student learning engagement for both the experimental and control classes. Learning engagement data was collected using observation sheets during biology lessons on ecosystem material. As noted earlier, engagement levels were then categorized based on the University of Muhammadiyah Malang Learning Assessment Standards (Universitas Muhammadiyah Malang, 2020). According to these standards, scores are classified as follows: ≥ 80.0 (outstanding), 75.0–79.9 (excellent), 70.0–74.9 (very good), 60.0–69.9 (good), 55.0–59.9 (fair), 40.0–54.9 (pass), and < 40.0 (fail).

Table 12

Learning Engagement Levels of High School Students by Learning Model

Learning Model	Percentage	Category
Conventional	70%	Good
OIDDE	78%	Excellent

As shown in Table 12, students in the experimental class, who were taught using the OIDDE learning model, achieved an engagement score of 78%, which falls into the 'excellent' category. In contrast, students in the control class, who followed the conventional learning model, scored 70%, placing them in the 'very good' category. While the difference between the two percentages is 8%, this suggests that the OIDDE model may contribute to a higher level of student engagement. However, further research with a larger sample size and additional engagement metrics would be beneficial to confirm these findings.

5. Discussion

5.1 Effectiveness of the OIDDE Learning Model

The results indicated that the OIDDE learning model was highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement compared to the conventional learning model used in the control class. Students in the experimental class consistently outperformed those in the control class across all measured domains, demonstrating the value of the OIDDE model in fostering a more meaningful and engaging learning experience. This aligns with prior studies that have emphasized the importance of innovative, problem-based, and contextual learning models in achieving significant educational outcomes (Hajeniati & Kaharuddin, 2022).

This research reinforces earlier findings that have indicated that the OIDDE learning model improves the critical thinking skills of students and their creative thinking abilities (Ma'rifatillah et al., 2019). The results are also consistent with studies that have highlighted the significance of ethical attitudes in biology education (Kohli et al., 2015; Chen and So, 2017). The OIDDE learning model's positive impact on ethical attitudes, which had been previously observed in prospective biology teachers, has also been shown here in the context of high school students (Hudha et al., 2018).

The OIDDE learning model is well-suited to 21st-century educational demands, characterized by critical thinking, problem-solving, collaboration, creativity, and innovation (Aslamiah et al., 2021; Wulandari, 2021). This model can be highly effective in creating a constructive, student-centered learning environment, which is essential for developing students' cognitive and ethical competencies in modern education. The integration of the model's stages into science education can foster a conducive and innovative learning atmosphere, benefiting students academically and personally.

5.2 Enhancing Critical Thinking and Ethical Attitudes

The improvements in critical thinking skills and ethical attitudes among students in the experimental class highlight the effectiveness of the OIDDE learning model, particularly in the context of biology education. The model's problem-based approach encourages students to actively engage in solving ethical dilemmas related to ecosystem issues. This active involvement fosters critical thinking and enables students to make informed, ethical decisions, a skill that is vital for addressing 21st-century challenges (Rahman et al., 2023; Haulia et al., 2022).

One of the key advantages of the OIDDE learning model is its capacity to create an active learning environment. The stages of the model encourage students to engage in hands-on problem-solving, fostering both independent thinking and teamwork. This collaborative learning environment helps develop critical thinking and ethical attitudes, as students work together to address real-world issues. Small group discussions, in particular, encourage cooperation, which is essential for improving learning outcomes and engagement (Kvellestad et al., 2021).

5.3 The Role of Problem-Based Learning in Science Education

The OIDDE learning model's emphasis on problem-based learning aligns with research that has demonstrated the importance of addressing contextual, real-world problems in education. By presenting students with issues related to ecosystems, the model promotes the development of

critical thinking skills, ethical attitudes, and greater engagement in learning. The effectiveness of this approach was evident in the significant improvements observed in the experimental class, where students were more motivated, engaged, and capable of making ethical decisions compared to the control class (Pozas et al., 2020; Bahri & Corebima, 2015).

5.4 Strengths of the OIDDE Model

The sequential stages of the OIDDE learning model, from orientation to decision-making and behaviour engagement, play a crucial role in its effectiveness. Each stage was designed to encourage students to think critically, collaborate, and engage in ethical decision-making. The flexibility of these stages allows teachers to incorporate real-world problems and contextual learning into their lessons, enhancing both cognitive and affective learning outcomes. This step-by-step approach has proven to be effective in fostering deeper learning, ethical understanding, and student engagement in biology education.

The research uncovered several new findings related to the implementation of the OIDDE learning model. First, both teachers and students in island high schools were introduced to an innovative and effective learning model that fostered greater awareness of ethical dilemmas in biological issues. Second, students developed critical thinking skills and learned to engage in ethical decision-making through group discussions. These findings highlight the OIDDE model's potential for promoting student-centered learning and fostering a deeper understanding of complex environmental issues.

The OIDDE learning model has been demonstrated to be effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and engagement among high school students. Based on the research findings, we recommend that the OIDDE model be adopted in various subjects beyond biology to promote critical thinking, ethical behaviour, and student engagement across disciplines. Additionally, further research should explore the application of the OIDDE model in different educational contexts and subject areas, focusing on the development of student integrity, ethical decision-making, and problem-solving skills.

6. Conclusion

This study demonstrated the effectiveness of the OIDDE learning model in enhancing various educational outcomes, including learning achievement, critical thinking, ethical attitudes, and student engagement in high school biology education. Students in the experimental group, who were instructed using the OIDDE model, demonstrated significantly higher performance across these domains compared to their peers in the control group who were taught with conventional methods. These findings underscore the potential of the OIDDE model to address the demands of 21st-century education by promoting skills such as critical thinking, problem-solving, ethical reasoning, and active learning.

The OIDDE model's structured, problem-based stages were particularly effective in developing students' critical thinking and ethical attitudes. As noted in the discussion, the model's ability to engage students with real-world environmental issues and ethical dilemmas not only enhanced their cognitive skills but also fostered a sense of responsibility and ethical awareness—qualities essential for addressing global challenges in the modern world. These results support prior research on the benefits of problem-based learning for fostering ethical and analytical competencies, especially in complex, context-dependent subjects like biology.

In addition to cognitive benefits, the model's impact on ethical attitudes highlights the importance of integrating ethical reasoning and behaviour into science education. The "Engage in behaviour" stage of the OIDDE model was particularly effective in this regard, encouraging students to participate actively in ethical discussions and decision-making related to ecosystem issues. This stage aligns with research advocating for educational models that go beyond content mastery, aiming to cultivate students' holistic development, including ethical and social responsibilities.

The study demonstrated that the OIDDE model creates a more engaging and collaborative learning environment. Students taught under this model reported higher engagement levels, possibly due to the model's emphasis on interactive, student-centered learning. This aligns with the discussion's emphasis on the importance of active, cooperative learning environments for enhancing student motivation and participation.

Overall, the OIDDE learning model has shown its effectiveness in improving learning outcomes, fostering critical thinking, and developing ethical attitudes in biology education. Future research should explore the OIDDE model's applicability across other subjects and educational settings to examine its broader impact on student engagement, ethical development, and critical thinking across disciplines. Expanding the use of this model may contribute to the cultivation of ethically minded, critically thinking individuals prepared to tackle complex societal and environmental challenges.

7. Limitations and Recommendations

This study was conducted with students from a single high school, focusing specifically on biology education. Consequently, the findings may not be fully generalizable to other subjects or educational settings. However, the positive outcomes observed here provide a valuable foundation for future research exploring the implementation of the OIDDE model across different subject areas and diverse educational contexts.

Another limitation is that the OIDDE model was new to both students and teachers at the research site. As with any new educational model, there was an adjustment period that may have influenced the initial impact. Future studies might consider longer implementation timelines to better assess the sustained effects of the OIDDE model in familiar classroom settings.

Based on the findings of this study, we recommend expanding the adoption of the OIDDE model in various educational levels and subjects beyond biology. The model's structured approach, which fosters critical thinking, ethical attitudes, and student engagement, aligns well with the competencies required in 21st-century education. Educators and policymakers may find the OIDDE model to be a valuable strategy for enhancing student engagement and learning outcomes across disciplines.

Additionally, the OIDDE model can serve as an effective framework for cultivating critical thinking skills and promoting ethical behaviour, both essential qualities for modern learners. By integrating this model into diverse educational contexts, educators can support the holistic development of students, encouraging deeper engagement and ethical awareness. These recommendations underscore the value of the OIDDE model in advancing innovative, student-centered learning strategies that prepare students for complex, real-world challenges.

Ethical Consideration

This study was conducted with oversight and approval from school administration, including the principal and relevant teachers, ensuring compliance with ethical standards for educational research. Data collection was carried out with permission from both the participants and the biology teacher. The identities of all participants were kept confidential.

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Evaluating the Impact of the OIDDE Learning Model on Critical Thinking, Learning Outcomes, Ethical Attitudes, and Learning Engagement among Indonesian High School Students

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Abstract

This study investigated the effectiveness of the orientation, identify, discussion, decision, and engage in behavior (OIDDE) learning model in enhancing biology learning outcomes, critical thinking, ethical attitudes, and engagement among high school students in Indonesia. Employing a quasi-experimental design with pre- and post-tests,

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the research included 66 randomly sampled students, evenly divided into experimental and control groups. Data were gathered through validated observation sheets, ethical attitude questionnaires, and tests, with analysis of covariance (ANCOVA) analysis conducted following normality and homogeneity tests. Results indicated significant improvements across all measured variables in the experimental group compared to the control group. The findings suggest that the OIDDE model was more effective than conventional methods in fostering comprehensive educational outcomes in biology, as its problem-based approach promotes active learning, ethical decision-making, and collaborative problem-solving, aligning well with the needs of 21st-century education. This study underscores the model's potential for broader application across various subjects to enhance critical thinking, ethical behavior, and sustained student engagement.

Keywords

critical thinking – ethical attitudes – learning engagement – biology education – OIDDE learning model

1 Introduction

Learning is an ongoing process of acquiring knowledge, which results in a change in behavior. These behavioral changes are shaped by new experiences gained through learning (Djamaluddin & Wardana, 2019). The outcome of learning has often been referred to as "learning outcomes," which encompass changes in behavior across the affective, cognitive, and psychomotor domains (Mahananingtyas, 2017; Nurrita, 2018). To maximize these outcomes, learning should be structured to provide holistic guidance and skills. In the global era, holistic skills are essential for addressing global challenges (Miseliunaite et al., 2022).

In Indonesia, particularly in high schools, there has been limited research on the effectiveness of various learning models in improving the learning process, especially in biology education (Azizah & Alberida, 2021; Herman & Rahmat, 2023). This includes evaluating how well these models enhance students' critical thinking skills and ethical attitudes. Learning outcomes serve as a key measure of students' mastery of the material (Fitrianingtyas & Radia, 2017), reflecting their overall achievement (Mahajan & Singh, 2017). Therefore, learning outcomes must be clear, learner centered, and focused on the expected performance or understanding (García, 2021), especially in the context of biology education.

Biology education is closely linked to the development of critical thinking skills, which are essential in today's globalized world due to their wide-ranging impacts. However, some research has suggested that learning outcomes in biology do not always significantly reflect these skills (Suharsono et al., 2017). This discrepancy underscores the need for effective teaching methods to cultivate critical thinking (Kinoshita, 2022; Setyowati et al., 2018).

In Indonesia's archipelagic regions, where students may face limited access to educational resources and infrastructure due to geographical isolation, improving biology learning outcomes is particularly relevant. These challenges can impact the quality of education and student engagement, especially in science subjects like biology, which often require hands-on learning and laboratory work.

The orientation, identify, discussion, decision, and engage in behavior (OIDDE) learning model is specifically designed to enhance engagement and critical thinking through structured stages that foster active learning and decision-making. In resource-limited settings such as archipelagic regions, where traditional lecture-based methods may fail to fully engage students, the OIDDE model offers an alternative approach. By encouraging students to take an active role in their learning, this model has the potential to improve biology learning outcomes despite logistical and infrastructural challenges. Therefore, investigating the effectiveness of the OIDDE model in enhancing high school biology learning outcomes is of great importance.

Moreover, critical thinking skills are essential for addressing complex problems, including environmental issues (Santi et al., 2018). Developing these skills requires diverse and engaging teaching methods (Hwang et al., 2023). Unfortunately, studies indicate that junior high school students in Indonesia's archipelagic regions have relatively low critical thinking skills, likely due to the prevalence of traditional teaching methods that lack problem-solving opportunities and student-centered approaches (Susilawati et al., 2020).

Developing critical thinking skills is vital for helping students solve everyday problems (Syafitri et al., 2021). However, research on enhancing critical thinking in biology through the OIDDE learning model has still been scarce. Teachers can employ various learning models to improve critical thinking, learning outcomes, and engagement, especially in biology. However, Indonesia's biology education faces many challenges, including didactic issues, curriculum constraints, and insufficient learning facilities (Khoiri et al., 2020). Additionally, science teachers often lack proper training and resources, including laboratory equipment, which hinders effective biology instruction.

Several initiatives have been aimed at improving science education in Indonesia, including teacher certification, curriculum innovation, and collaborative international research (Faisal & Martin, 2019). These initiatives can

significantly impact biology learning, influencing not only learning outcomes and critical thinking skills but also ethical attitudes and student engagement. In education, there has often been a primary focus on learning outcomes and critical skills, while aspects such as ethical attitudes and student engagement have frequently been overlooked. This has been especially true in Indonesia's archipelagic regions, where unique geographic and cultural contexts create specific educational challenges, and where ethical attitudes and student engagement have not been sufficiently studied (Hudha et al., 2018).

In these isolated and diverse regions, ethical attitudes are particularly crucial for fostering social cohesion and mutual respect among students from varied cultural backgrounds. With limited access to external resources and diverse perspectives, these communities rely heavily on locally rooted values and interpersonal relationships. Developing ethical attitudes in education can thus promote tolerance and inclusivity, preparing students to contribute positively to their communities. Moreover, in today's global era, ethical attitudes play an essential role in shaping students' character and values, fostering a moral, tolerant, and well-behaved society (Tsoraya et al., 2023).

Despite the importance of ethical attitudes, many high school biology teachers focus primarily on cognitive aspects of learning, neglecting affective aspects such as ethical attitudes (Chowdhury, 2016). The increasing instances of unethical behavior among students in Indonesia's archipelago have underscored the need to emphasize ethical attitudes in education (Ardiana et al., 2022). Similarly, student engagement in biology learning requires further exploration. The OIDDE learning model offers a promising, innovative approach to address these educational challenges. This study aims to evaluate the effectiveness of the OIDDE learning model in improving critical thinking skills, learning outcomes, ethical attitudes, and learning engagement among high school students in the eastern Indonesia.

2 The OIDDE Learning Model

The OIDDE learning model, developed and validated by Hudha et al. (2016), has demonstrated reliability and practical application in educational settings. Recognized as an innovative educational tool, it has been awarded copyright status by the Directorate General of Intellectual Property under the Ministry of Law and Human Rights of the Republic of Indonesia (Registration Number: EC00201701142). This copyright is held by the first author (Hudha, 2016). Readers are encouraged to apply the OIDDE learning model in their teaching by following the syntactic framework provided in this publication. The specific steps in the OIDDE model are detailed in Table 1.

TABLE 1 Phases of the OIDDE learning model

Phase	Teacher activities	Student activities
Phase 1: Orientation	– Guide students in preparing to learn the material. – Present materials that incorporate values and ethical issues (bioethics). – Share case studies, historical narratives, videos, or documentaries to introduce ethical dilemmas.	– Prepare and engage with the material. – Listen, observe, and take notes. – Pay close attention to case studies and ethical issues presented.
Phase 2: Identify	– Assign students to identify ethical dilemmas within case studies, facts, and narratives. – Ask selected students to briefly explain identified dilemmas for class discussion.	– Identify ethical dilemmas in the material. – Select priority dilemmas for group discussion. – Explain identified dilemmas as part of a class discussion.
Phase 3: Discussion	– Divide students into small heterogeneous groups of 4–5 members. – Guide students to prioritize ethical dilemmas from individual findings as topics for group discussion. – Instruct each group to assign roles relevant to the chosen discussion topic. – Facilitate group discussions, ensuring they are democratic, honest, and ethical. – Moderate as each group presents discussion results to the class, followed by a Q&A. – Direct groups to document discussion outcomes as a foundation for ethical decision-making.	– Form groups of 4–5 members. – Deliberate within groups to select priority ethical dilemmas for discussion. – Assign appropriate roles for each group member. – Engage in discussions with a focus on democratic, honest, and ethical participation. – Present group discussion results to the class and participate in Q&A. – Document discussion outcomes for use in ethical decision-making.

TABLE 1 Phases of the OIDDE learning model (*cont.*)

Phase	Teacher activities	Student activities
Phase 4: Decision	– Guide each group to collaboratively formulate ethical decisions based on their discussions. – Instruct students to develop individual ethical decisions, reflecting on group discussion topics. – Direct each student to document their individual ethical decisions independently. – Provide prepared sheets for students to record their individual ethical decisions.	– Collaboratively formulate ethical decisions as a group based on group discussions. – Reflect individually on group topics to make personal ethical decisions. – Document individual ethical decisions on provided sheets.
Phase 5: Engage in behavior	– Encourage students to reflect on and document ethical behavior related to the decisions made during discussions. – Facilitate class conclusions on learning outcomes and understanding ethical responsibilities.	– Reflect on and document personal ethical behavior aligning with group decisions. – Participate in summarizing class conclusions with integrity and responsibility. – Honestly report your contributions and commitment to ethical behavior.

ADAPTED FROM HUDHA ET AL., 2016

2.1 *Research Questions*

This study was aimed at evaluating the effectiveness of the OIDDE learning model for high school students in island regions through biology education. The specific research questions were as follows:

1. How does the OIDDE learning model enhance the biology learning outcomes of high school students in the islands?
2. How does the OIDDE learning model affect the development of critical thinking skills in high school students in the islands?

3. How does the OIDDE learning model influence the ethical behavior of high school students in the islands?
4. How does the OIDDE learning model contribute to increasing learning engagement among high school students in the islands?

3 Research Methodology

3.1 *General Background*

This study employed a quasi-experimental research design with a control group, utilizing a non-equivalent pre-test and post-test format. The experimental group was taught using the OIDDE learning model, while the control group followed conventional methods. The research was conducted with 10th-grade biology students at one high school, covering ecosystem topics. The study included three weekly sessions, each lasting 120 minutes, for a total of 360 minutes of instruction. The topics covered across these sessions included ecosystem components, interactions within ecosystems, the relationship between biotic and abiotic factors, levels of organization, and the flow of matter and energy within ecosystems.

The OIDDE learning model was applied to students in the experimental group, following the stages outlined by Hudha et al. (2018), as shown in Table 1.

TABLE 2 Implementation of biology learning topics on ecosystems using the OIDDE learning model across three meetings

Phase	Student activities in first and second meetings	Student activities in third meeting
Orientation	Students analyzed material on ecosystem components and interactions within various biomes across the Earth's surface.	Students analyzed biogeochemical cycles and current environmental changes and engaged actively and positively.
Identify	Students identified interaction dilemmas by examining ecosystem interactions in biomes, focusing on relationships (mutualism, commensalism, parasitism, and predation)	Students identified ecological dilemmas related to biogeochemical cycles (carbon, nitrogen, water, sulfur, and phosphorus) and their connection to environmental

TABLE 2 Implementation of biology learning topics (*cont.*)

Phase	Student activities in first and second meetings	Student activities in third meeting
	and emerging ecological paradigms.	changes, using these insights for group discussions on environmental balance.
Discussion	In groups, students discussed the interaction dilemmas, created food web schemes to analyze trophic levels, and explored ecological relationships and paradigms.	Students participated in discussions on ecological dilemmas linked to biogeochemical cycles and environmental changes, analyzing edaphic and atmospheric cycles and discussing solutions for environmental balance.
Decision	Students made critical decisions individually and in groups, focusing on ecosystem interactions and emerging ecological paradigms.	Students made ethical decisions individually and in groups based on their analysis of biogeochemical cycles and environmental impacts, developing perspectives on environmental stability.
Engage in Behavior	Students individually reflected on their ethical attitudes and committed to honest behaviors that support ecosystem sustainability.	Students committed to ethical behaviors that support ecosystem sustainability, focusing on biogeochemical cycle continuity and minimizing negative impacts on the environment.

The control group, on the other hand, was taught using the conventional teaching methods typically employed by their teachers.

In the experimental group, the ecosystem content in the biology curriculum was delivered over three sessions following the OIDDE model. In contrast, students in the control group received the same content using the conventional teaching methods typically applied by their teacher. The details of the ecosystem material covered in these sessions are provided in Table 2.

3.2 *Research Sample*

The study population consisted of 66 10th-grade students, who were randomly assigned into two groups. Class X-A, with 33 students, served as the experimental group, and Class X-B, also with 33 students, served as the control group.

3.3 *Instrument Development*

This study examined four key variables: (1) Critical thinking skills – the ability to analyze arguments, draw conclusions based on reasoning, evaluate or assess information, and make decisions or solve problems. (2) Learning outcomes – the specific competencies or abilities acquired by students after participating in the learning process, encompassing cognitive, affective, and psychomotor domains. (3) Ethical attitudes – an individual's overall positive or negative response to ethical or unethical behavior, or adherence to rules and laws. (4) Learning engagement – an attitude reflecting cognitive involvement, active participation, and emotional commitment in all learning activities.

The instruments used in this research included (1) observation sheets for evaluating the implementation of both the OIDDE learning model and the conventional learning model; (2) questionnaires assessing students' ethical attitudes toward ecosystems, administered both before and after the intervention; and (3) pre-test and post-test questions to measure learning outcomes, critical thinking skills, and ethical attitudes.

Before using, the observation sheets and ethical attitude questionnaires were validated by expert validators, with all instruments deemed valid. Validation of the question items was conducted using the Pearson correlation test, and the analysis was supported by SPSS 22.0 for Windows. The results of the validation showed that each question item was valid, as indicated by a p-value of less than 0.05. The reliability of the questions was tested using Cronbach's alpha, which yielded a value of 0.669, indicating that the question instrument was reliable (Siregar, 2013).

For ethical attitudes, in addition to test-based measurements, non-test measurements were conducted using a questionnaire related to students' ethical attitudes toward ecosystems. The questionnaire consisted of 15 statements that students were asked to respond to, reflecting their individual attitudes toward ecosystems. Ethical attitude data was collected using a 4-point Likert scale to assess each item: (1) *strongly disagree*, (2) *disagree*, (3) *agree*, and (4) *strongly agree* (Syaifudin, 2012). A detailed description of the ethical attitude questionnaire is presented in Table 3.

TABLE 3 Questionnaire on high school students' ethical attitudes toward the ecosystem

No	Questions	Answer			
		1	2	3	4
1	A caring attitude towards ecosystems will have an impact on the survival of ecosystems.				
2	Humans play a decisive role in the continued existence of ecosystems.				
3	I realize that the benefits of ecosystems are for humans and other ecosystems.				
4	Participating in ecosystem conservation efforts will have an impact on the balance of ecosystems.				
5	Destruction of ecosystems will affect both humans and the ecosystems themselves.				
6	Encouraging others to participate in ecosystem conservation is a caring attitude that should be practiced.				
7	Exploiting the ecosystems around us is a harmful action to ecosystem conservation.				
8	The environment is provided for all living beings, not just for humans.				
9	Humans, as part of the environment, are the main actors in environmental management, so they must always strive to maintain the sustainability, balance, and beauty of ecosystems.				
10	To maintain the balance of nature and prevent further damage, it is essential to cultivate human behavior or ethics to always care for the environment.				
11	Environmental ethics not only fulfills human rights and duties towards the environment, but also limits behavior and controls various human activities to ensure they remain within the boundaries of maintaining environmental balance.				
12	Destruction of ecosystems will have negative impacts on the surrounding environment.				
13	Identifying good ecosystem management practices is an ethical attitude that should be taken before deciding to manage natural environments.				

TABLE 3 Questionnaire on high school students' ethical attitudes (*cont.*)

No	Questions	Answer			
		1	2	3	4
14	Deciding on the appropriate ethical stance to resolve ecosystem destruction issues is an action that should be taken after understanding the ethical problems in ecosystem conservation.				
15	Analyzing various concepts to create an argument for the ethical stance on ecosystem conservation is a wise and prudent step in ecosystem management.				

3.4 *Learning Implementation Observation Sheet*

The learning implementation observation sheet, used to measure learning engagement, was applied to both the experimental group and the control group. The observation sheet focused on four main aspects, as outlined by Weil and Joyce, (1978) and Joyce and Weil, (2003): implementation of the phases of the OIDDE learning model, implementation of social systems, application of principles of reaction, and implementation of support systems.

These four aspects were further developed into 22 measurable indicators, which were assessed using a Likert scale. The indicators were categorized as follows: seven indicators for model construction, five for the social system, four for the principles of reaction, and six for the support system. All indicators were rated on a 5-point Likert scale, with the following ratings: 1 = *very bad*, 2 = *not good*, 3a = *fairly good*, 4 = *good*, and 5 = *very good*. The observation sheet for learning implementation is presented in Table 4.

The scores obtained from Table 4 were then converted into learning implementation assessment categories based on the University of Muhammadiyah Malang Learning Assessment Standards (Universitas Muhammadiyah Malang, 2020), as follows: 80.0 (outstanding), 75.0–80.0 (excellent), 70.0–74.9 (very good), 60.0–69.0 (good), 55.0–59.9 (fair), 40.0–54.0 (pass), and < 40.0 (fail).

3.5 *Data Analysis*

Data analysis was conducted using analysis of covariance (ANCOVA) to assess the effectiveness of the OIDDE learning model compared to the conventional learning model in relation to learning outcomes, critical thinking skills, and

TABLE 4 Learning implementation questionnaire for high school students' engagement in biology and ecosystem content

Number	Aspects of learning implementation	Scores				
		1	2	3	4	5
A	**Learning states**					
1.	The learning stages are organized in a clear and systematic manner.					
2.	The learning stages are logical and rational.					
3.	The learning stages outline activities for both teachers and students.					
4.	Activities reflect the interaction flow between teachers and students.					
5.	Activities focus on mastering ecosystem knowledge and environmental ethics.					
6.	Activities emphasize ethical decision-making.					
7.	Activities promote ethical attitudes among students.					
B	**Social system**					
1.	Activities encourage students to discover and construct ethical concepts.					
2.	Activities promote student interaction.					
3.	Activities foster student-teacher interaction.					
4.	Activities embody religious norms, honesty, politeness, and ecosystem responsibility.					
5.	Activities promote collaboration and respect in ecosystem discussions.					
C	**Reaction principle**					
1.	The teacher provides resources such as textbooks and articles.					
2.	The teacher motivates and engages students.					
3.	Activities stimulate curiosity, idea exploration, and scientific communication.					
4.	Students can ask questions when facing concept difficulties.					

TABLE 4 Learning implementation questionnaire (*cont.*)

Number	Aspects of learning implementation	Scores				
		1	2	3	4	5
D	**Support system (nurturant effect and instructional effect)**					
1.	Learning tools align with the learning phases.					
2.	Learning tools meet objectives to improve conceptual understanding, critical thinking, ethical decision-making, and ethical behavior.					
3.	Instructional effects (concept mastery, critical thinking, ethical decision-making, and behavior) are clearly and logically stated in the learning stages.					
4.	Instructional effects align with learning goals.					
5.	Accompanying impacts like improved critical thinking are integrated logically.					
6.	Ethical attitudes are aligned with learning objectives.					

ethical attitudes (based on pre-test and post-test results). Before performing the ANCOVA, normality was evaluated using the Kolmogorov-Smirnov test, and homogeneity was assessed with the Levene test. All data analyses were carried out using SPSS for Windows, version 22.

4 Results

The research results provide insights into the impact of the OIDDE learning model on enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement among students in both the experimental and control classes. The data analysis outcomes are detailed below.

4.1 *Learning Outcomes*

The differences in student learning outcomes between the experimental and control classes are shown in Table 6. The one-way ANCOVA results presented in Table 5 indicated an F value of 27.643, with a p-value < 0.0001, demonstrating a significant difference in learning outcomes between the experimental and control classes ($F(1,37) = 27.643$, $p = 0.004$). This result suggests that the OIDDE

TABLE 5 Results of one-way ANCOVA on biology learning outcomes of high school students

Source	*df*	*F*	*Sig.*
Learning outcomes	1	9.434	.004
Class	1	27.643	< .000
Error	37		

$p < .05$ indicates statistical significance, with $p < .001$ showing a higher level of significance

TABLE 6 Mean corrected scores of high school students' learning outcomes in conventional vs. OIDDE learning models

Group	Pre-test	Post-test	Score increase	Corrected mean
Conventional	45.85	65.05	19.20	65.850
OIDDE	49.85	78.15	28.30	77.350

learning model was effective and significantly improved learning outcomes for students in the experimental class compared to those in the control class.

Next, the corrected mean analysis for each class, specifically comparing the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model), is shown in Table 6. The corrected average score for the experimental class ($M = 77.350$) was higher than that for the control class ($M = 65.850$), indicating that students in the experimental class achieved better learning outcomes. The final post-test scores and the improvement from pre-test to post-test were consistently higher for the experimental class. These results indicated that the OIDDE learning model was more effective in enhancing biology learning outcomes than conventional teaching methods.

4.2 *Critical Thinking Skills*

The next section of data analysis focused on the improvement of students' critical thinking skills for both experimental and control class students, as shown in Table 7. The calculated F difference in the OIDDE learning model treatment was 25.183, with a p-value < 0.0001, indicating a significant variation in critical thinking skills between the experimental and control classes ($F(1,37) = 25.183$, $p > 0.0001$).

Table 8 presents the average pre-test and post-test scores for both classes. According to the ANCOVA test results, the corrected mean score for critical

TABLE 7 ANCOVA results on critical thinking skill achievement of high school students

Source	*df*	*F*	*Sig.*
Critical Thinking	1	26.466	< .000
Class	1	25.183	< .000
Error	37		
Total	40		

*$p < .001$ indicates statistical significance

TABLE 8 Corrected mean scores for critical thinking skills of high school students

Group	Pre-test	Post-test	Score increase	% Enhancement	Corrected mean
Conventional	67.20	74.85	7.65	11%	74.490
OIDDE	66.00	83.00	17.00	26%	83.360

thinking skills in the experimental class ($M = 83.360$) was higher than the corrected mean score in the control class ($M = 74.490$). This difference was evident in both the average post-test scores and the improvement from pre-test to post-test. Therefore, the OIDDE learning model positively influenced the enhancement of students' critical thinking skills in the experimental class.

Overall, the OIDDE learning model significantly improved students' critical thinking skills in the experimental class compared to the conventional learning model used in the control class. This finding suggests that applying the OIDDE model to biology learning, especially in ecosystem studies, creates a more conducive learning environment for developing higher-order thinking skills. The structured stages of the OIDDE model – orientation, identify, discussion, decision, and engage in behavior – encourage active participation and deeper engagement with the content, making the learning process more interactive, student-centered, and meaningful compared to traditional methods.

In line with Agustina and Abidin (2022), Bayu et al. (2022), and Ningrum and Murti (2023), who argued that improving critical thinking competency requires effective and innovative learning models, this research shows that the OIDDE model can significantly enhance students' critical thinking abilities. Additionally, as highlighted by Heard et al. (2020) and Rodzalan et al. (2020), sustaining improvements in critical thinking skills requires attention to various factors, including students' physical well-being, intellectual development, and

continuous motivation. The OIDDE model indirectly supports these aspects by fostering an engaging, interactive learning environment that encourages active learning and intellectual curiosity. This holistic approach aligns with the need for a learning model that not only enhances cognitive skills but also motivates and sustains students' interest and engagement.

4.3 *Ethical Attitudes*

The next research section presents an ANCOVA analysis of data on the ethical attitudes of students in both the experimental and control classes toward ecosystems after participating in biology lessons on ecosystem material, as shown in Table 9.

Table 9 provides a summary of the ANCOVA test results, which were used to analyze the impact of the learning model on students' ethical attitudes. The results clearly showed that there was a significant difference between the experimental and control classes in terms of ethical attitudes, with $F(1,37) = 24.439$ and $p < 0.001$. This indicates that the OIDDE learning model was more effective in significantly enhancing the ethical attitudes of students in the experimental class than it was in the control class, which followed a conventional learning model.

The increase in ethical attitudes through the OIDDE learning model is notable. This is because the OIDDE learning model's structure specifically fosters the development of attitudes, particularly in its fifth stage: "Engage in behavior." This stage represents the culmination of the learning process, where students' ethical involvement becomes evident through their participation in problem-solving activities and dilemmas related to the teaching material.

Next, the class averages for both the experimental class (using the OIDDE learning model) and the control class (using the conventional learning model) are compared (Table 10).

Table 11 shows that the corrected mean for the experimental class ($M = 83.233$) was higher than that of the control class ($M = 74.612$), showing that the ethical attitudes of students in the experimental class, who engaged with the OIDDE learning model, were significantly better than those in the control class, who followed a conventional learning approach.

The significant increase in ethical attitudes in the experimental class highlights that learning ecosystem-related biology topics through the OIDDE learning model may have enhanced students' ethical awareness and sense of responsibility toward the environment. These findings align with previous research by Hudha et al. (2018), which demonstrated that the OIDDE learning model effectively increases students' understanding of life ethics, ethical decision-making, and ethical attitudes.

TABLE 9 ANCOVA results on ethical attitudes of high school students

Source	*df*	*F*	*Sig.*
Class	1	24.439	< .000
Error	37		
Total	40		

*$p < .001$ indicates statistical significance

TABLE 10 Average ethical attitude scores of high school student

Group	*Pre-test*	*Post-test*	Score increase	% Enhancement	Corrected mean
Conventional	67.00	74.85	7.85	12%	74.612
OIDDE	66.2	83.0	21.80	25%	83.233

TABLE 11 Learning engagement levels of high school students by learning model

Learning model	Percentage	Category
Conventional	70%	Good
OIDDE	78%	Excellent

Ichsan et al. (2020) further emphasized that 21st-century ecosystem education must be contextual and foster higher-order thinking skills to effectively address environmental issues. In this regard, the OIDDE learning model is well suited for fostering foster higher-order thinking skills, as it encourages critical, creative, and analytical thinking applied to problem-solving in biology education. Tasrif (2022) reinforced this idea by highlighting that fostering higher-order thinking skills includes the ability to think critically, creatively, and analytically to solve problems using information and data. The OIDDE learning model, by focusing on problem discovery, ethical decision-making, and behavioral involvement, supports the development of these higher-order thinking skills.

In addition to the pre-test and post-test measurements of ethical attitudes (as shown in Tables 10 and 11), researchers also assessed students' ethical

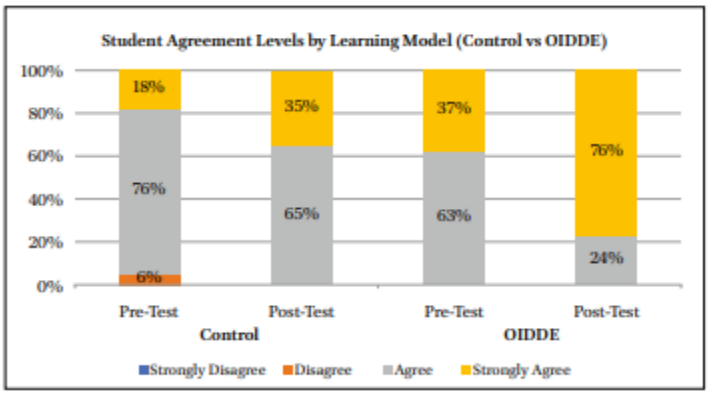

FIGURE 1 Questionnaire results on students' ethical attitudes before and after implementing the learning model in the experimental and control groups

attitudes in both the experimental and control classes using a questionnaire. The results of this assessment are illustrated in Figure 1.

Figure 1 shows that students in the experimental group, who were taught using the OIDDE learning model, exhibited significantly stronger ethical attitudes toward ecosystem issues compared to students in the control group. In the pre-test for the experimental group, 37% of students strongly agreed with ethical statements regarding ecosystems, while in the post-test, this percentage increased to 76%. This reflects a 39% improvement in students' ethical attitudes after learning with the OIDDE model. Additionally, there was a notable decline in students expressing only agreement (from 63% in the pre-test to 24% in the post-test), indicating a positive shift from moderate agreement to strong agreement in ethical attitudes.

In contrast, the control group displayed more varied ethical attitudes toward ecosystem issues. In the pre-test, 6% of students disagreed, 76% agreed, and 18% strongly agreed with the ethical statements. By the post-test, there was a 17% increase in the number of students strongly agreeing, from 18% to 35%. This improvement was accompanied by a slight decrease in the percentage of students who agreed, dropping from 76% in the pre-test to 65% in the post-test. Overall, while there was some improvement in the control group, it was not as pronounced as in the experimental group.

The data shown in Figure 1 highlight one of the main advantages of the OIDDE learning model: It effectively motivated students to express ethical behavior independently, with integrity and honesty, particularly in relation to

ecosystem issues. This is not commonly observed in other learning models. Chairilsyah (2016) noted that honesty is a critical aspect of daily life, and as Cooper et al. (2023) argued, honesty encourages individuals to behave ethically. Additionally, Bonnie et al. (2022) emphasized that honesty is closely related to well-being. Therefore, ethical attitudes, as reflected in honesty, play a fundamental role in students' lives and behavior.

In addition to improvements in learning outcomes, critical thinking skills, and ethical attitudes, the study also measured student learning engagement for both the experimental and control classes. Learning engagement data was collected using observation sheets during biology lessons on ecosystem material. As noted earlier, engagement levels were then categorized based on the University of Muhammadiyah Malang Learning Assessment Standards (Universitas Muhammadiyah Malang, 2020). According to these standards, scores are classified as follows: ≥ 80.0 (outstanding), 75.0–79.9 (excellent), 70.0–74.9 (very good), 60.0–69.9 (good), 55.0–59.9 (fair), 40.0–54.9 (pass), and < 40.0 (fail).

As shown in Table 11, students in the experimental class, who were taught using the OIDDE learning model, achieved an engagement score of 78%, which falls into the 'excellent' category. In contrast, students in the control class, who followed the conventional learning model, scored 70%, placing them in the 'very good' category. While the difference between the two percentages is 8%, this suggests that the OIDDE model may contribute to a higher level of student engagement. However, further research with a larger sample size and additional engagement metrics would be beneficial to confirm these findings.

5 Discussion

5.1 *Effectiveness of the OIDDE Learning Model*

This model is particularly valuable in Indonesia's archipelagic regions, where logistical challenges and limited resources can hinder the effectiveness of traditional, lecture-based teaching methods. By providing a structured, student-centered approach, the OIDDE model offers a feasible and impactful solution to enhance student engagement and critical thinking in resource-constrained environments. The results indicated that the OIDDE learning model was highly effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and learning engagement compared to the conventional learning model used in the control class. Students in the experimental class consistently outperformed those in the control class across all measured domains, demonstrating the value of the OIDDE model in fostering

a more meaningful and engaging learning experience. This aligns with prior studies that have emphasized the importance of innovative, problem-based, and contextual learning models in achieving significant educational outcomes (Hajeniati & Kaharuddin, 2022).

This research reinforces earlier findings that have indicated that the OIDDE learning model improves the critical thinking skills of students and their creative thinking abilities (Ma'rifatillah et al., 2019). The results are also consistent with studies that have highlighted the significance of ethical attitudes in biology education (Kohli et al., 2015; Chen and So, 2017). The OIDDE learning model's positive impact on ethical attitudes, which had been previously observed in prospective biology teachers, has also been shown here in the context of high school students (Hudha et al., 2018).

The OIDDE learning model is well-suited to 21st-century educational demands, characterized by critical thinking, problem-solving, collaboration, creativity, and innovation (Aslamiah et al., 2021; Wulandari, 2021). This model can be highly effective in creating a constructive, student-centered learning environment, which is essential for developing students' cognitive and ethical competencies in modern education. The integration of the model's stages into science education can foster a conducive and innovative learning atmosphere, benefiting students academically and personally.

5.2 *Enhancing Critical Thinking and Ethical Attitudes*

The development of ethical attitudes is especially crucial in these culturally diverse and geographically isolated communities, where fostering social cohesion and mutual respect among students from varied backgrounds is essential. The OIDDE model's emphasis on ethical reasoning aligns with these community needs, supporting students in becoming responsible and ethically aware citizens. The improvements in critical thinking skills and ethical attitudes among students in the experimental class highlight the effectiveness of the OIDDE learning model, particularly in the context of biology education. The model's problem-based approach encourages students to actively engage in solving ethical dilemmas related to ecosystem issues. This active involvement fosters critical thinking and enables students to make informed, ethical decisions, a skill that is vital for addressing 21st-century challenges (Rahman et al., 2023; Haulia et al., 2022).

One of the key advantages of the OIDDE learning model is its capacity to create an active learning environment. The stages of the model encourage students to engage in hands-on problem-solving, fostering both independent thinking and teamwork. This collaborative learning environment helps develop critical thinking and ethical attitudes, as students work together to

address real-world issues. Small group discussions, in particular, encourage cooperation, which is essential for improving learning outcomes and engagement (Kvellestad et al., 2021).

5.3 *The Role of Problem-Based Learning in Science Education*

The OIDDE learning model's emphasis on problem-based learning aligns with research that has demonstrated the importance of addressing contextual, real-world problems in education. By presenting students with issues related to ecosystems, the model promotes the development of critical thinking skills, ethical attitudes, and greater engagement in learning. The effectiveness of this approach was evident in the significant improvements observed in the experimental class, where students were more motivated, engaged, and capable of making ethical decisions compared to the control class (Pozas et al., 2020; Bahri & Corebima, 2015).

5.4 *Strengths of the OIDDE Model*

The sequential stages of the OIDDE learning model, from orientation to decision-making and behavior engagement, play a crucial role in its effectiveness. Each stage was designed to encourage students to think critically, collaborate, and engage in ethical decision-making. The flexibility of these stages allows teachers to incorporate real-world problems and contextual learning into their lessons, enhancing both cognitive and affective learning outcomes. This step-by-step approach has proven to be effective in fostering deeper learning, ethical understanding, and student engagement in biology education.

The research uncovered several new findings related to the implementation of the OIDDE learning model. First, both teachers and students in island high schools were introduced to an innovative and effective learning model that fostered greater awareness of ethical dilemmas in biological issues. Second, students developed critical thinking skills and learned to engage in ethical decision-making through group discussions. These findings highlight the OIDDE model's potential for promoting student-centered learning and fostering a deeper understanding of complex environmental issues.

The OIDDE learning model has been demonstrated to be effective in enhancing learning outcomes, critical thinking skills, ethical attitudes, and engagement among high school students. Based on the research findings, we recommend that the OIDDE model be adopted in various subjects beyond biology to promote critical thinking, ethical behavior, and student engagement across disciplines. Additionally, further research should explore the application of the OIDDE model in different educational contexts and subject areas, focusing on the development of student integrity, ethical decision-making, and problem-solving skills.

6 Conclusion

This study demonstrated the effectiveness of the OIDDE learning model in enhancing various educational outcomes, including learning achievement, critical thinking, ethical attitudes, and student engagement, within the specific context of high school biology education in Indonesia's archipelagic regions. Students in the experimental group, who were instructed using the OIDDE model, demonstrated significantly higher performance across these domains compared to their peers in the control group who were taught with conventional methods. These findings underscore the potential of the OIDDE model to address the demands of 21st-century education by promoting skills such as critical thinking, problem-solving, ethical reasoning, and active learning.

The OIDDE model's structured, problem-based stages were particularly effective in developing students' critical thinking and ethical attitudes. Given the geographical and logistical constraints faced by schools in isolated regions, where traditional teaching methods often fail to engage students fully, the OIDDE model offers a valuable alternative. By enabling students to interact with real-world environmental issues and ethical dilemmas, the model not only enhanced cognitive skills but also fostered a sense of responsibility and ethical awareness. These qualities are crucial for preparing students to confront complex global and local challenges, aligning with the broader goals of holistic education.

In addition to cognitive benefits, the model's impact on ethical attitudes highlights the importance of integrating ethical reasoning and behavior into science education. The "Engage in behavior" stage of the OIDDE model was particularly effective in this regard, encouraging students to participate actively in ethical discussions and decision-making related to ecosystem issues. This stage aligns with research advocating for educational models that go beyond content mastery, aiming to cultivate students' holistic development, including ethical and social responsibilities.

The findings also revealed that the OIDDE model fosters a more engaging and collaborative learning environment, which is beneficial in settings where students may otherwise have limited exposure to interactive learning. Students taught under the OIDDE model reported higher levels of engagement, likely due to the model's emphasis on student-centered, active learning strategies that increase motivation and cooperation. This aligns with the study's emphasis on creating inclusive, supportive learning environments that are critical for fostering student engagement and success in regions facing educational resource limitations.

Overall, the OIDDE learning model has shown its effectiveness in improving learning outcomes, fostering critical thinking, and developing ethical attitudes

in biology education. Future research should explore the OIDDE model's applicability across other subjects and educational settings to examine its broader impact on student engagement, ethical development, and critical thinking across disciplines. Expanding the use of this model may contribute to the cultivation of ethically minded, critically thinking individuals prepared to tackle complex societal and environmental challenges.

7 Limitations and Recommendations

This study was conducted with students from a single high school in Indonesia's archipelagic region, focusing specifically on biology education. Consequently, the findings may not be fully generalizable to other subjects, educational settings, or geographic regions. Consequently, the findings may not be fully generalizable to other subjects or educational settings. However, the positive outcomes observed here provide a valuable foundation for future research exploring the implementation of the OIDDE model across different subject areas and diverse educational contexts.

Another limitation is that the OIDDE model was new to both students and teachers at the research site. As with any new educational model, there was an adjustment period that may have influenced the initial impact. Future studies might consider longer implementation timelines to allow students and teachers to become more familiar with the model, enabling a more accurate assessment of its sustained impact. Such studies could also explore adaptations of the model to better fit resource-limited settings, ensuring its accessibility and relevance in regions with fewer educational resources.

Based on the findings of this study, we recommend expanding the adoption of the OIDDE model in various educational levels and subjects beyond biology. The model's structured approach, which fosters critical thinking, ethical attitudes, and student engagement, aligns well with the competencies required in 21st-century education. In contexts where traditional, lecture-based teaching methods prevail, the OIDDE model provides a student-centered alternative that encourages holistic development – an approach particularly relevant in Indonesia's archipelagic regions where students may face limited access to diverse learning opportunities.

Additionally, the OIDDE model can serve as an effective framework for cultivating critical thinking skills and promoting ethical behavior, both essential qualities for modern learners. By integrating this model into diverse educational contexts, educators can support the holistic development of

students, encouraging deeper engagement and ethical awareness. These recommendations underscore the value of the OIDDE model in advancing innovative, student-centered learning strategies that prepare students for complex, real-world challenges.

Future research should focus on exploring the applicability of the OIDDE model in other subject areas and regional contexts, particularly those with similar geographic and resource-based challenges. By doing so, the model's potential to advance innovative, student-centered learning strategies can be more fully understood, enabling educators to cultivate ethically aware, critically thinking students prepared to address complex societal and environmental issues.

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Ethical Consideration

This study was conducted with oversight and approval from school administration, including the principal and relevant teachers, ensuring compliance with ethical standards for educational research. Data collection was carried out with permission from both the participants and the biology teacher. The identities of all participants were kept confidential.

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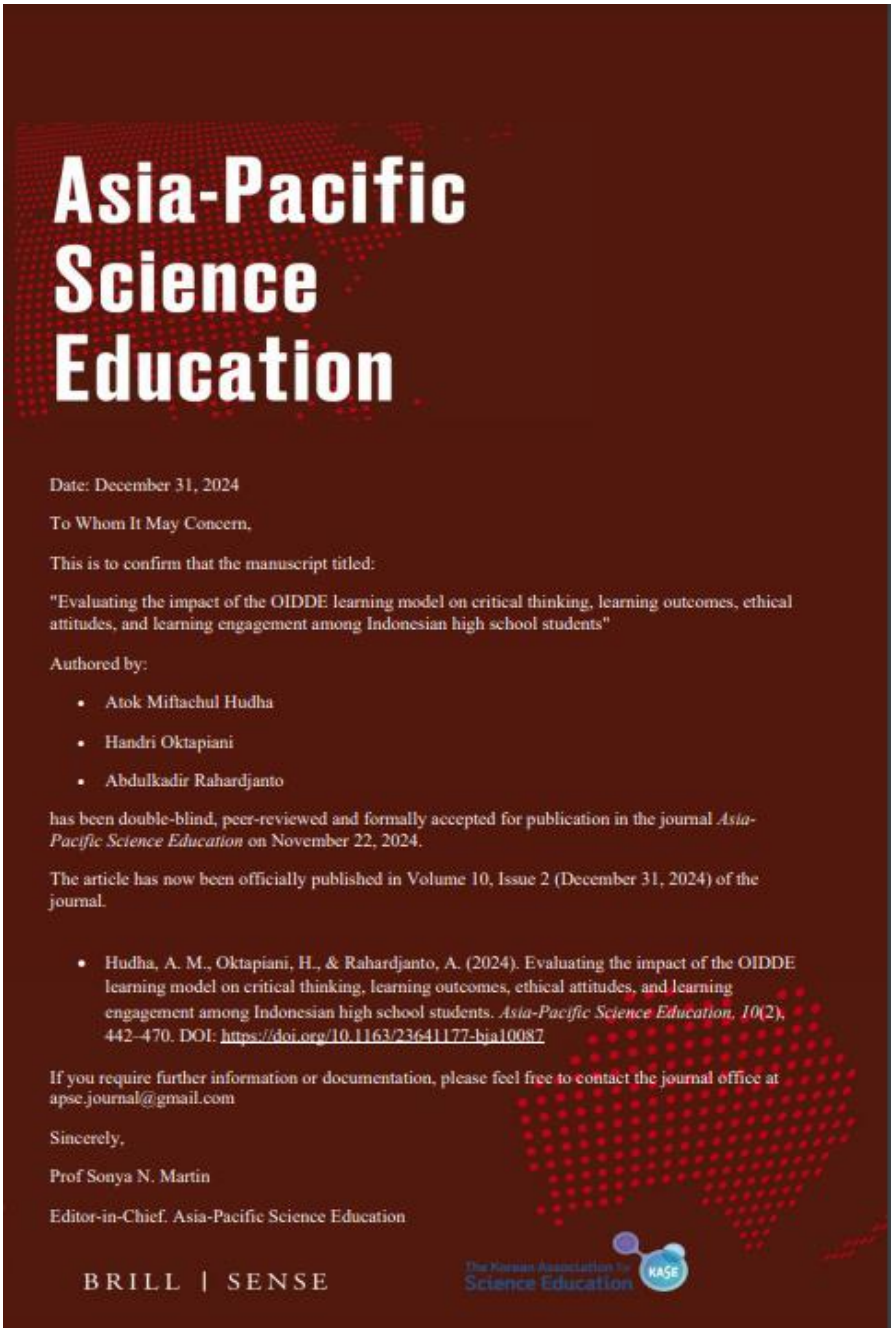
26. ***Letter of Acceptence*** **(LoA)**



Asia-Pacific Science Education

Date: December 31, 2024

To Whom It May Concern,

This is to confirm that the manuscript titled:

"Evaluating the impact of the OIDDE learning model on critical thinking, learning outcomes, ethical attitudes, and learning engagement among Indonesian high school students"

Authored by:

- Atok Miftachul Hudha
- Handri Oktapiani
- Abdulkadir Rahardjanto

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Sincerely,

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