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Development of Anecopbl Model to Improve Critical Thinking and Collaboration Skills of Elementary School Students

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ABSTRACT
This study aims to develop anecopbl learning model to improve critical thinking and collaboration skills of elementary school students. This type of research is development research. The development model used in this study is the ADDIE model through 5 stages, namely, (1) analysis stage (2) design stage; (3) development stage (4) implementation stage,; (5) evaluation stage. The data obtained in the validation of model assessment instruments by experts are in the form of underlying theories, objectives, syntax, and social systems. The results of the conversion of validation assessments on the underlying theoretical aspects have an average value of 10 with very good categories. While the conversion results of the validation assessment on the objective aspect have an average of 8.5, with a very good category. The results of the conversion validation assessment on syntax and social systems by experts have an average value of 18.5 so that it has a very good category. The effectiveness of the anecopbl model was shown by an average test result of n-gain of 0.77 in the effective category. These results suggest that the use of models can improve students' critical thinking skills. Based on the effect size test between the control group and anecopbl showed a result of 2.90 showing that learning using the model that has been done is very effective and has a major effect in improving critical thinking skills. The results of the collaboration assessment showed that more than half of all respondents agreed that they had the same goals, shared duties and responsibilities, and that there was cooperation between groups. So that the anecopbl model is feasible, effective, and practical to be used to improve critical thinking and collaboration skills of elementary students.

Keywords: *anecopbl, critical thinking, collaboration*

INTRODUCTION

A 21st century education is one that is able to integrate a variety of environments to support real-world and relevant learning for children and deal with global issues in their lives (Palmer, 2013). 21st century education must be able to connect not only with technological devices, in relationships with society, the world of work but also be able to provide broad access to its environment so as to foster awareness and concern for the environment in an effort to realise sustainability. The development of the world in the 21st century, characterised by the use of information and communication technology, raises concerns for educators about what skills they already have to deal with these developments (Kudari, 2016; OECD, 2018). This is a question of what knowledge and skills our children need to survive in the face of challenging development. Therefore, children must gain more knowledge about different fields of study to live a successful life in this fast-paced world. At the same time, they must achieve some important skills, which will help them survive in a rapidly changing world (Rahman, 2019). This is the duty of a teacher to teach the knowledge and skills needed (Kuloglu, A., Karabekmez, 2022).

Many empirical investigations show that in this century every job requires fast information so that computers can replace manual and cognitive tasks. Therefore, a new paradigm is needed to encourage learners with innovative and critical thinking.Indonesia in 2018 ranked 71st out of 79 participating countries for science skills. The assessment conducted by PISA basically emphasises the skills needed in the 21st century, especially in planning for the future, namely critical thinking, creative, research-based, initiative, informative, systematic thinking, communicative, and reflection (OECD, 2018).

Critical thinking is defined as logical reflective thinking that is focussed on assisting in making judgements or making decisions when faced with a problem and is one of the higher-level thinking that should be central to learning development because it makes humans have life skills, creativity, and innovation to face complex real-life problems (Paul, R., & Elder, 2008; Prayogi, S., Yuanita, 2018). Critical thinking helps students develop and strengthen their thinking skills (Moust, J., Bouhuijs, P., & Schmidt, 2019). To think critically, one needs a rational mind with good reasoning, as well as the ability to follow logical rules, and scientific reasoning as the best foundation for making decisions (Razak, A.A., Ramdan, M.R., Mahjom, N., Zabit, 2022). A person who senses critical thinking skills will have careful consideration to gather various evidence/information before making decisions or establishing positions (Saputro S.D, Tukiran, 2022). Critical thinking can be used to distinguish points of view from positive and negative aspects so that it can filter incoming influences and adapt to the conditions and culture of its nation. Critical thinking ability is a way of thinking for humans to respond to others by analysing facts to form judgements so that this ability needs to be trained and developed. (Günay, C., Doloc-Mihu, A., Gluick, T., and Moore, 2019) and can be learnt (Holmes Natasha G., Wieman Carl E., 2015). Currently, humans are required to have the ability to think critically to be able to answer various global challenges. (Rijal, M., Mastuti, A.G., Safitri, D., Bachtiar, S., and Samputri, 2021; Sutiani, A., Situmorang, M., and Silalahi, 2021). Therefore, students are not only required to be able to complete assignments or get good grades but students are also required to have critical thinking skills in the learning process. Students with critical thinking skills can decide what is right and wrong and stay away from negative influences due to globalisation. (Warsah, I., Morganna, R., Uyun, M., Hamengkubuwono, H., and Afandi, 2021).

A student-centered learning approach is necessary to improve critical thinking skills such as the ability to analyze, understand, evaluate, summarize, and generate new information. Critical thinking skills can be developed but require a process to develop them (Günay, C., Doloc-Mihu, A., Gluick, T., and Moore, 2019). Although it requires a process, if trained, individuals with high critical thinking skills will tend to be able to manage their behavior to do good and avoid embarrassing behavior, have a strong character and good self-management. (Eggen, P., & Kauchak, 2012). They can also filter the information received and take measurable action to respond (Paul, R., Binker, 2012). (Paul, R., Binker, A. J., Martin, D., Vetrano, C., & Kreklau, 1989). This skill is also a demand for future competencies that need to be immediately empowered to students through learning and problem-solving efforts. (Croucher, S. M., Kelly, S., Rahmani, D., Burkey, M., Subanaliev, T., Galy-Badenas, F., Lando, A. L., Chibita & Nyiransabimana, V., Turdubaeva, E., Eskiçorapçı, N., & Jackson, 2020).

The study to determine the level of critical thinking ability was conducted on 72 students from 4 different schools can be shown in Figure 1 below.

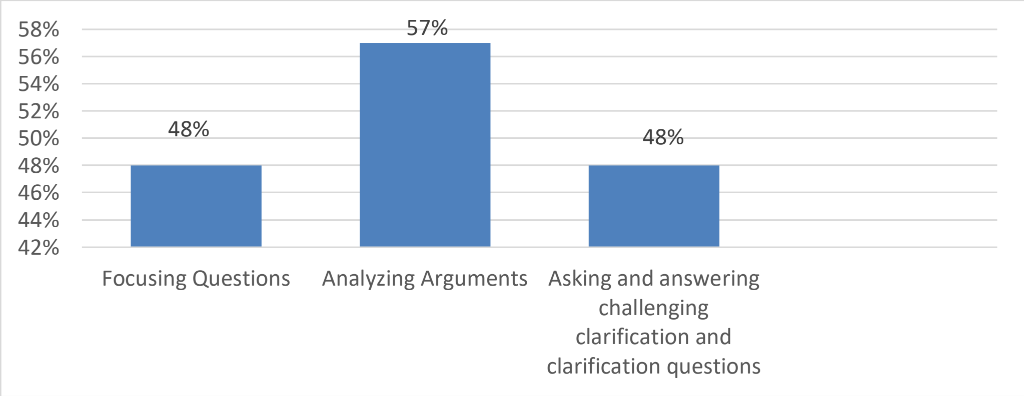

Figure 1. Graph of critical thinking skills of primary school students

The data shows that students' critical thinking skills are still low in the indicators of focusing questions (48%), analysing arguments (57%), asking and answering clarifying questions and challenging questions (48%). Students' critical thinking is still low in analyzing arguments and focusing on questions that may occur due to a lack of observation, experience, reasoning or communication (Ulger, 2018). Students who are accustomed to learning to observe, share experiences, reason and communicate will be able to easily interpret, analyze, synthesize, infer, evaluate information, explain, and organize themselves (Wale, B. D., & Bishaw, 2020). Another activity that can be influential in improving critical thinking skills is problem-solving activities by calculating various possibilities and scenarios to make the right decisions (Erikson, M. G., & Erikson, 2019). In terms of school management, critical thinking practice becomes a problem where not all schools provide facilities that support learning activities. (Chusni, M.M., Saputro, S., Suranto, Rahardjo, 2020). For such cases, teachers should also reform the learning process more effectively and implement an ideal learning model to improve those critical thinking skills.

Collaboration is a skill required in the 21st century in addition to critical thinking. According to Trilling & Fadel, learners reflect collaboration skills if three components can be fulfilled, namely: 1) demonstrating the ability to work effectively and appreciate the differences that exist in the group; 2) being able to accept other people's opinions for the same goal; 3) responsibility and contribution of each group member. (Trilling, B & Fadel, 2009). Students' collaboration skills are needed in science learning because science lessons are not only learning about knowledge of facts, principles, but also learning in the process of discovery. Science learning is a collection of facts, concepts, and discovery processes (Pratiwi, 2015). Interaction activities during the learning process in groups are not fully implemented properly so that collaboration skills are neglected and have an impact on the low collaboration skills of students (Jalmo, Fitriyani, & Yolida, 2019.

Empowerment of 21st century skills should be integrated in learning (Arranz, J. M., & García-Serrano, 2020)21st century skills include critical thinking and collaboration. These abilities are also followed by an attitude of empathy and care, especially for the environment. So far, the level of environmental literacy in Indonesia is cumulative and still needs to be improved (Maulidya, F., Mudzakir, A., Sanjaya, 2014).. Therefore, learning needs to facilitate students to develop environmental literacy skills. Environmental literacy can be applied in the learning process or integrated into learning materials. (Nurhayati, Hernani, 2019).. One of the existing learning methods in promoting environmental literacy is collaborative learning.

E-learning or known as online learning is a form of using internet technology in learning that has shown good results in science education (Nuić, I. Glažar, 2020). Online learning is likely to continue to grow and become commonplace in learning (Osborne, 2013). Several meta-analyses have found that learning outcomes are to some extent improved by combined approaches: *e-learning* and face-to-face (Olson, J.M., Codde, J.R. deMaagd, K., Tarkleson, 2011).

Improving critical thinking and collaboration skills can be done with *constructive e-learning*. Learning carried out with *e-learning* will reduce students' dependence on the teacher's explanations. The understanding of students is not limited to what the teacher teaches and explains.

It is necessary to learn with strategies in teaching that can engage students, provide opportunities for students to speak, and improve 21st century skills (Anazifa, RD, Djukri, 2017; Arifin, M.Z., Setiawan, 2020). One of the models that is considered to contribute to the development of these skills is the problem-based learning (PBL) model. Problem-based learning is appropriate because it focuses on helping students learn and discover the concept of solving complex real-world problems both when discussing information search and finding solutions (Rahmayanti, 2017; Rosyidi, 2018; Trilling, B & Fadel, 2009). PBL also aims to help students improve their thinking, problem-solving, and cognitive skills (Nurdin & Uleng, 2023) (Nurfajriah et al., 2022; Schwartz, 2013 as well as how to present problems, ask questions, facilitate investigations, and also open dialogues that will be developed and aid critical and creative thinking and aim to learn content, process skills, problem-solving, and study real-world problems (Bakhri, 2017; H. Hendriana, E. E. Rohaeti, 2017; Khairiyah, 2018; Nurdin, N. N., & Uleng, 2023; Nurfajriah, N., Tabroni, I., Faujiah, N., Nurjannah, R., & Putri, 2022; Sani, 2014). The application of this model is designed to encourage students to become researchers, analysts, and innovative (Kassab, SE, Hassan, N., El-araby, S. et al., 2017). Problem-based learning has many advantages, familiarizing students in problem-solving and challenging them to solve problems relevant to learning in the classroom and daily life (Suarsana, I M., Lestari, I. A. P. D., & Mertasari, 2019).

Problem Based Learning is better at solving student problems than traditional learning (Treepob, H., Chulida Hemtasin, C., Thongsuk, 2023). In this regard, (Simanjuntak, M. P., Hutahaean, J., Marpaung, N., & Ramadhani, 2021), explained the effectiveness of PBL combined with computer simulations for students' problem-solving and creative thinking skills. Their results also showed a positive relationship between problem-solving and students' creative skills. This shows that PBL combined with computer simulations is more effective than problem-based or traditional teaching methods alone. PBL education, according to (Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kuma, 2017), helps students develop problem-solving skills that can be applied in their daily lives.

It is necessary to develop an anecopbl learning model: so that students can find strategies to solve environmental problems and realize how important the environment is. The integration of e-learning with a problem-based learning model on ecosystem materials is seen as a solution to develop students' critical thinking and collaboration skills in elementary schools. The anecopbl model consists of steps, namely 1) orientating learners online on ecological problems; 2) Guiding students to study in groups or individually, organising students to learn to care 3) Guiding individual and group investigations online; 4) Developing and presenting work online; 5) Analysing and evaluating the problem-solving process.

Based on the background of the problems described above, researchers are interested and motivated to conduct research related to the development of *anecopbl* models to improve critical thinking and collaboration skills of elementary school students.

METHODOLOGY

This *research is* a type of *development* research (*research and development*) which has an orientation to produce a product and test its feasibility for use in learning. The product developed in this research is an *anecopbl* model. The learning model developed is aimed at developing critical thinking skills and collaboration. The development procedure in this study refers to the stages of the development model adapted from ADDIE (Branch, 2009). (Branch, 2009) which is carried out in 5 stages, namely, *Analysis, Design, Development, Implementation,* and *Evaluation*. (1) the analysis stage is the process of determining and necessary needs by explaining school analysis, product resource analysis *anecopbl* model analysis, and analysis of IPAS materials and concepts; (2) the design stage which is a planning stage that aims to make products, namely the *anecopbl* learning model; (3) the development stage which is the actualisation process of the previous design stage which consists of making model products, making LMS, product validation and instruments; (4) the implementation stage, at this stage the developed product is applied in learning on the IPAS learning content of ecosystem material. The goal is to produce a clear and comprehensive picture of the model developed; (5) the evaluation stage by determining evaluation criteria, selecting tools in the form of observation sheets and product feasibility questionnaires, and conducting formative and summative evaluations.

Analysis Stage

The needs analysis was conducted through two stages, namely field studies and literature studies. Needs analysis was conducted through observation of the learning process using PBL that has been running. Interviews were conducted through unstructured interviews with elementary school teachers. The results of the critical thinking ability test and student collaboration are still low so that the development of *anecoPBL* learning models is needed so that students can find strategies to solve environmental problems and become a solution to developing students' critical thinking and collaboration skills in elementary schools.

Design Stage

The learning design stage is the stage of analysing the material that will be used as an example in the learning model including the design of developing students' critical thinking skills. The design can be seen at the link https://docs.google.com/document/d/1CHZO0n6sYWBG-7dPIAhtQbz3ZXvOppQx/edit?usp=sharing&ouid=109304701955795615565&rtpof=true&sd=true.Tahap this is the stage of designing the substance that will be delivered through the learning model. At this stage, critical thinking skills, collaboration, basic achievements, flow of learning objectives, teaching modules to assessment instruments are analysed. The learning design stage also includes the preparation of learner activity sheets, teaching materials, and learning evaluations.

Development Stage

The model development stage is the third stage in this development research. This stage is carried out through the preparation of model outlines, collection of supporting materials, and production of models and model support devices. The final result of the learning design and model development stage is the draft product of the *anecopbl* learning model.

The validation stage in this research is an assessment activity intended to ensure that the resulting development product is suitable for use in learning. This step is carried out to determine the feasibility of the development product, namely the *anecopbl* learning model to be used in learning. Validation is carried out by a team of experts which at least consists of media experts and material experts. There are two types of trials in this study, namely limited trials and wider trials. The test subjects in the limited trial in the *anecopbl* model development research were students of SD Negeri Prawirotaman. The evaluation of this trial was then used as material for improving the model. The test subjects in the wider trial in the *anecopbl* model development research were at SD Muhammadiyah Notoprajan, SD Negeri Suyodiningratan 3, and SD Negeri Kowang. During the wider trial, experiments were also conducted to compare the impact of student learning after learning with *anecopbl* and face-to-face PBL. This step is done to determine the effectiveness of the application of the developed learning model.

Implementation Stage

At the implementation stage, the developed product is applied in learning in the IPAS lesson content of ecosystem material. The goal is to produce a clear and comprehensive picture of the developed model. Implementing the product in the form of this LMS in large groups of students to determine the effectiveness of the model. In the implementation stage, researchers went to the field to observe the application of the developed model. Product implementation is applied through a pseudo-experimental design, which uses two class groups, given treatment and then tested through a final test (posttest) in measuring the effectiveness of using the product.

Evaluation Stage

In detail, the stages in the evaluation are: a) Determining evaluation criteria, namely the criteria that become the standard for knowing the learning resources that have been used are relevant to the standards at the design stage. In addition, to determine the suitability of the model with the model plan so that the design stage is made. b) Selecting tools in the form of interview guides, observation sheets and product feasibility questionnaires that have been carried out in research. c) Conducting evaluation. It is carried out through formative evaluation which is carried out continuously in making improvements to the blended learning model developed. Then the summative evaluation is carried out at the end of learning by giving a test of students' learning outcomes to see the effectiveness.

Trial Design

Data on the development of students' critical thinking skills from the application of the model is needed to determine the effect of the application of the model on efforts to develop these abilities. The design of the limited trial of the *anecopbl* model uses a *one group pretest-posttest design* with the formula:

$$O_1 \ x \ O_2$$

Experimental Model with *One Group Pretest-posttest* Design (Fraenkel, J.F., Wallen, N.E., Hyun, 2012)

Description:
X = treatment in the form of applying the anecoPBL model
O1 = pretest score
O2 = posttest score
The design of this study is to give a pre-test before students do the learning and give a post-test after students do the learning.

Data collection in the broad trial design uses a *control experiment group pretest-postest*. By using this design, the control group and experimental group have the same characteristics taken from a homogeneous population. The design of this research is to give a pre-test before students do learning and give a post-test after students do learning with the same questions for both groups. Learning is done using three types of models.

In this model development research, three classes were used. The distribution of the two classes is two classes as experimental classes and one class as a control class. The experimental class is a class that uses *anecopbl* model and conventional PBL model. The control class is a class in which the learning is done face-to-face and uses the usual learning model by the teacher. As an illustration, the product trial design is shown in Table 1.

Table 1. Product Trial Design

Pretest	Treatment	Posttest
O_1	X_1	O_2
O_3	X_2	O_4
O_5	X_3	O6

Product Trial Design (Fraenkel, J.F., Wallen, N.E., Hyun, 2012)

Description:
X1 = Treatment in the form of applying learning with the anecoPBL model:
X2 = Treatment in the form of learning application with PBL model
X3 = Treatment in the form of application of learning with e-learning
O1 = pretest score in the anecoPBL model class:
O2 = posttest value in the anecoPBL model class:
O3 = pretest score in conventional PBL model class
O4 = posttest score in conventional PBL model class
O5 = pretest score in e-learning class
O6 = posttest score in e-learning class
The effect of using the developed learning model can be known based on the difference between post-test and pre-test scores and several other analyses.

The test subjects in the limited trial in the *anecopbl* model development research were grade 5 students of SD Negeri Prawirotaman, totalling 11 children. The test subjects in the broad trial in the development research of the anecoPBL model were 5th grade students of SD Muhammadiyah Notoprajan (25 children), SD Negeri Suryodiningratan 3 (28 children), and SD Negeri Kowang (19 children).

The techniques used to collect data in this study were questionnaires and written tests. Questionnaire is a technique used to obtain information from students in the form of student responses regarding the support of the *anecopbl* model to improve critical thinking skills and student responses to the learning model tools in this case the LMS. Written test is a technique used to obtain data on students' critical thinking skills.

The instruments used to collect data in this study were questionnaire sheets and pretest-posttest questions. The questionnaire sheet in this study is a questionnaire sheet for assessing the learning model and LMS by validators and a student response questionnaire related to the support of learning model devices on critical thinking and collaborative skills. The pretest-postest questions are questions related to critical thinking skills ecosystem material. The research instrument used in data collection must be a validated instrument. Validation of research instruments was carried out by two experts in the field of education on learning model assessment instruments, LMS assessment instruments, student response questionnaires to the use of the model, instrument description questions on critical thinking skills tests, validation instruments include three aspects, namely material aspects, construction aspects, language aspects, and assessment aspects.

There are two types of data analysis used in this research. The two types of analysis are qualitative descriptive analysis techniques and quantitative descriptive analysis techniques. Each analysis is used with different purposes, namely to assess the feasibility of the product or the effectiveness of the learning model product.

The feasibility study of the model was conducted to provide information on whether or not the model should be used in real learning. The data analysis technique used in this analysis is quantitative descriptive analysis technique. In this study, the feasibility of the *anecopbl* model was assessed from the results of expert judgement through the expert validation process and student responses. Expert judgement and student responses were conducted to determine the feasibility of the model itself and the feasibility of the LMS as an embodiment of the *anecopbl* model.

The analysis process begins with tabulating the data obtained from validators on each indicator on the assessment sheet. The total score obtained is then converted into a value with five-scale criteria with the category 1 means not good, 2 means less good, 3 means quite good, 4 means good, and 5 means very good. The scores obtained were then converted into a scale of five. The following are the criteria for comparing the average value of the total score of each component using a conversion reference (Sukardjo, Sari, 2009; Widoyoko, 2016) :

Table 2. Conversion Reference

Score Interval	Value	Category
X>Mi + 1.80 SBi	A	Very good
Mi + 0.60 SBi < X ≤ Mi + 1.80 SBi	B	Good
Mi - 0.60 SBi < X ≤ Mi + 0.60 SBi	C	Good enough
Mi - 1.80 SBi < X ≤ Mi - 0.60 SBi	D	Not good
X ≤ Mi - 1.80 SBi	E	Not good

Description:
Mi = Mean/mean ideal score = 1/2 (ideal maximum score + minimum score) ideal)
SBi = Ideal standard deviation = 1/6 (ideal maximum score - ideal minimum score)
X = Score obtained

The study of the effectiveness of the model is useful to determine the impact of using the model on student abilities. This study provides information on how effective the use of the anecoPBL model is on improving critical thinking and collaboration. In this study, the anecopbl-based model is declared effective if the use of the *anecopbl* model can improve students' critical thinking and collaboration after using the model, namely based on self- and group assessments.

The data analysis technique used in this analysis is descriptive analysis. Descriptive analysis is used to describe or give an overview of the object under study through sample or population data as it is without conducting analysis and making conclusions that apply to the public (35). The data presented are data obtained from the pretest and posttest results of critical thinking skills of the experimental group and control group. Mean, median, standard deviation, minimum score, and maximum score data will be presented in the form of tables and histograms so that the presentation of data is easier for readers to understand.

Data on the characteristics of the final product explores the developed product accompanied by a discussion of changes/revisions to the product that occurred during the development process. Data analysis used to reveal data on the characteristics of the final product is in the form of qualitative descriptive analysis in the form of exposure and screen display before and after revision.

RESULT AND DISCUSSION

Initial Product Development Results

The development product is the result of the implementation of development research procedures. The product of this development research is in the form of AnEcoPBL model on ecosystem material aimed at improving critical thinking and collaboration skills of elementary school students. This AnEcoPBL model is a type of *blended learning* that is realised in the *e-learning system*. The AnEcoPBL model was developed by modifying the problem-based learning model with ecoliteration and e-learning. This learning model has not existed before and was developed with ADDIE's development research procedures and has been declared feasible, namely meeting the requirements of a valid, practical, and effective learning model.

The development procedure in this study refers to the stages of the development model adapted from ADDIE determined by the researcher. ADDIE goes through 5 stages, namely, (1) analysis stage (2) design stage; (3) development stage (4) implementation stage,; (5) evaluation stage.

Description of Analysis

The needs analysis is conducted to obtain information about the characteristics of the learning model needed by prospective users, in this case primary school students. Information is needed for the development of learning models. The needs analysis was conducted through two stages, namely field studies and literature studies. Field studies were conducted to find out the learning models that have been used by teachers, especially on ecosystem material. Literature study is conducted on the material that will be focused on the learning model through the review of various literature sources.

The needs analysis is important to determine the level of need for the learning model to be developed. The main points of the needs analysis results are described as follows. a. The curriculum used in primary schools is the independent curriculum. This is known based on the results of observations on the tools used. b. Ecosystem material is taught face-to-face. Based on interviews with students, there are three kinds of learning conducted by different teachers in different schools. In the first school, learning was done by writing material and practice questions on the blackboard then students were asked to take notes and work on practice questions. In the second school, the teacher gave and explained the material with the help of power point, YouTube application, and gave practice questions. In the third class, the teacher provides material before the meeting in class and students are asked to study it so that during face-to-face learning in the form of strengthening material that has not been understood and practice questions. c. Some teachers are familiar with *e-learning* and some of them combine *e-learning* with the learning model that will be carried out. d. There is no *e-learning learning model yet.* There is no *blended learning* type *e-learning* model that facilitates the development of critical thinking and collaboration skills of elementary school students. e. There is no *blended learning* type *e-learning* model that is integrated with the pbl learning model to facilitate students' critical thinking and collaboration. The results of the needs analysis show that there is a need for a blended learning model that is integrated with the pbl learning model. The developed learning model is expected to facilitate the development of critical thinking and collaboration skills.

Description of Design Stage Results

The learning design stage is the stage of analysing the material that will be focused on the learning model. At this stage, competency and learning objectives are analysed. The results of the learning design stage are as follows. One of the contents of the IPAS class V primary school lesson which contains ecosystem material. The IPAS subject is taught face-to-face. There are a total of 6 meetings in this lesson with each meeting of 2 hours of lessons. The learning model development stage is carried out through the preparation of model components (which include the rationale or theory underlying the model, learning objectives, syntax, and management system), collection of learning materials, and production of learning management system. The preparation of model components is the main stage in this development research. This stage includes the preparation of the rationale or theory underlying the model, learning objectives, syntax, and management system. Guidelines for the development or preparation of model products are used as a reference in the development of models and instruments used in this study. The result of the learning design stage and the development of the learning model is the draft product of the *anecopbl* learning model.

The LMS production stage is carried out after the learning materials are arranged. The LMS is produced with the LMS from Moodle. The page used is https://anecopbl.com//. This stage includes the preparation of the menu and LMS content. The preparation of the menu and LMS content pays attention to the characteristics of the model developed which includes the underlying rationale or theory, syntax, learning objectives, and management system. The result of this process is the initial product in the form of an LMS that embodies the anecopbl learning model. On the page, https://anecopbl.com//, there are facilities for admins, teachers and students. After the production stage produces the initial product, then validation is carried out. Initial product validation was carried out by expert lecturers. Initial product validation was carried out with the aim of obtaining product feasibility data before testing at school.

Description of Validation Stage Results

The product of this research is a learning model and LMS which is the embodiment of the developed learning model. The process of validation, revision, and testing was carried out on the product. In this study, data obtained from the validation of the learning model by experts. The learning model validation was conducted by two experts, namely education experts and *e-learning* experts. Experts provide input and suggestions on the initial product of the anecopbl learning model. Expert input and suggestions on the product become information on parts that require revision to improve the product. Expert input and suggestions can be described as follows. The LMS is given an introduction that informs the outline of activities in the model and is equipped with a usage guide for students and teachers. The syntax of the learning model is written in Bahasa Indonesia. Product assessment by validators was also in the form of input and suggestions for the initial LMS product on the anecopbl learning model. The validator's input and suggestions on the product inform the parts that require revision to improve the product. The validator's input and suggestions are described as follows. 1) "on the home needs to be given a brief info related to what *e-learning*, for whom, about what, and so forth" 2) "activity information must be clear and can be read directly by students.

Description of the Final Characteristics of the Anecopbl Model

E-learning provides opportunities for students to gain diverse learning experiences and resources. *Anecopbl* learning model is a new form of blended learning model that combines it with PBL learning model. The use of this learning model is one way to facilitate the development of critical thinking skills and collaboration on ecosystem material. The use of the anecopbl learning model in the wider trial showed that students gained an understanding of the ecosystem material. Critical thinking skills also improved. Students stated that the anecopbl learning model provided support for their learning. The final product of research and development in the form of anecopbl learning model, anecopbl learning model book, and LMS has been obtained. The developed products have gone through the expert test, limited trial, and wider trial stages. The final product has distinctive characteristics.

Product Trial Results

Description of Anecopbl Model Feasibility Test Results

The feasibility study of the model is conducted to provide information on whether or not the model is suitable for use in real learning. In this study, the feasibility of the *anecopbl* model was assessed from the results of *expert judgement* through the expert validation process and student responses. Expert judgement and student responses were conducted to determine the feasibility of the model itself and the feasibility of the LMS as an embodiment of the *anecopbl* model. The expert validation process of the *anecopbl* learning model product and LMS was conducted by the validator. Validators in this study consisted of two expert lecturers, learning experts and *e-learning* experts. The validators assessed the anecopbl and LMS learning models from various aspects. The assessment of the validators on several aspects is a benchmark for whether or not the learning model and LMS are used in the learning process. The assessment scores given by the validators were then converted using a five scale according to (Sukardjo, Sari, 2009) with categories A (very good), B (good), C (sufficient), D (less), and E (very less). Based on the reference to the five scale, the maximum score is 5 and the minimum score is 1 given by the validator on each assessment item. The benchmark in this study is if the total score that can be converted into a scale of 5 from the results of the assessment given by the validators if it shows a minimum value of "B" with the category "Good" then the developed learning model product is deemed suitable for use. The assessment results given by validators on the learning model and LMS vary in each aspect.

Feasibility of Anecopbl Learning Model

The assessment of the *anecopbl* learning model was conducted by two experts in education and *e-learning*. The data obtained in the assessment of the model by experts are divided into aspects of the rationale or theory underlying the model, aspects of learning objectives, aspects of syntax, and aspects of the management system. The average results of the assessment of each aspect in the form of products can be converted into a scale of five (Sukardjo & Sari, 2009: 84). The convention results of the model assessment on the theoretical aspect have a value of Mi (ideal mean) = 6 and SBi (ideal standard deviation) = 1.33. While the average value of aspects in the aspect of rational or theory that underlies the model is 10.0. In the aspect of learning objectives, the value of Mi (ideal mean) = 6 and SBi (ideal standard deviation) = 1.33. and the average value is 8.5. The syntax aspect has a value of Mi (ideal mean) = 12 and SBi (ideal standard deviation) = 2.67, and an average value of 18.5. and in the aspect of the social system has a value of Mi (ideal mean) = 12 and SBi (ideal standard deviation) = 2.67, and an average value of 18.5. All aspects of the model assessment have a very good category.

The assessment of the learning model is carried out on four aspects, namely aspects of the underlying rationale or theory, learning objectives, syntax, and social system. The average score on the rational aspect or underlying theory is 10 out of a total score of 10 or equivalent to 100%, learning objectives are 10 out of a total score of 10 or equivalent to 100%, syntax is 18.5 out of a total score of 20 or equivalent to 93%, and social systems are 18.5 out of a total score of 20 or equivalent to 93%. All four aspects received an A rating in the "very good" category. The graphical display of the assessment results of all aspects of the learning model is presented in Figure 2.

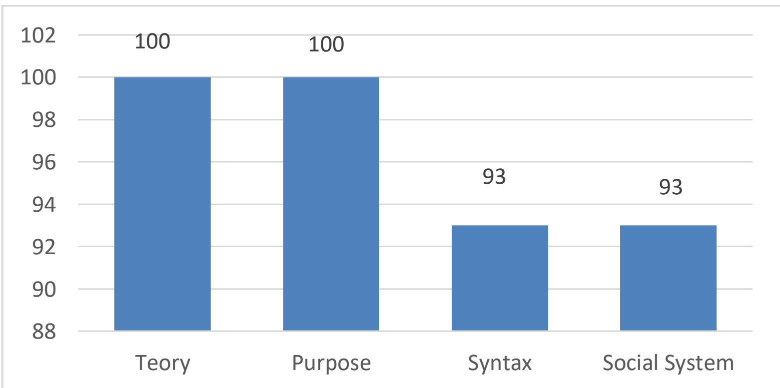

Figure 2. Graph of Average Score of Each Aspect of *Anecopbl* Learning Model

Feasibility of LMS on Anecopbl Learning Model

In this study, data on the results of LMS validation by expert lecturers were obtained. LMS assessment is seen from the learning aspect, material aspect, media aspect, and quality aspect. The conversion results of the validation assessment on the learning aspect have a value of Mi (ideal mean) = 12.5 and SBi (ideal standard deviation) = 2.5. While the average value of the aspects obtained is 23.5 with the Very Good category. The conversion results of the validation assessment on the material aspect have an average aspect value of 38.5 and a Mi (ideal mean) value = 24 and SBi (ideal standard deviation) = 5.33 with a Very Good category. The conversion results of the validation assessment on the media aspect have a value of Mi = 18 and SBi (ideal standard deviation) = 6 with an average aspect value of 26 so that it has a Good category. While the conversion results of the validation assessment on the LMS quality aspect have a value of Mi (ideal mean) = 12 and SBi (ideal standard deviation) = 2.67 with an average aspect value of 20, so it has a Very Good category.

The data obtained in the first LMS assessment is divided into learning aspects, material aspects, media aspects, and quality aspects. The conversion results of the validation assessment on the learning aspect have an average aspect value of 23.5 out of a total score of 25 or equivalent to 94% in the Very Good category. The conversion results of the validation assessment on the material aspect have an average aspect value of 38.5 out of a total score of 40 or equivalent to 96% in the Very Good category. The conversion results of the validation assessment on the media aspect have an average aspect value of 26 out of a total score of 30 or equivalent to 86.67% so that it has a Good category. While the conversion results of the validation assessment on the quality aspect of the online course have an average aspect value of 20 out of a total score of 20 or equivalent to 100%, so it has a "Very Good" category. The graphical display of the results of the assessment of all aspects of the online course is presented in Figure 3.

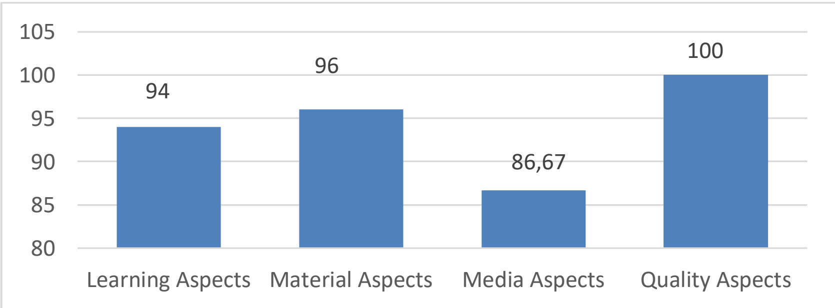

Figure 3. Average Graph of LMS Validation Results on *Anecopbl* Learning Model

Student Response on Model and LMS Support for Critical Thinking and Collaboration Skills

Data obtained on student responses obtained through a response questionnaire to the LMS. When viewed from Piaget's developmental theory (38), namely students at the age of 7-12 years are still classified as in the concrete operation stage because they still see things in real terms, students at the concrete operational stage still depend on experiences that are real in accordance with the events and circumstances experienced and the truth must be more accountable. The next data to determine the effectiveness of the *anecopbl* model is from the results of the teacher response scale and the student response scale with the response scale score interval as follows:

Table 3. Teacher Response Scale Score Interval

Score Interval	Value	Category
$X > 167$	A	Very good
$136 < X \leq 167$	B	Good
$104 < X \leq 136$	C	Good enough
$78 < X \leq 104$	D	Less good
$X \leq 78$	E	Not good

The teacher response scale was filled in by the fifth grade teacher of SD Muhammadiyah Notoprajan after observing the learning process using the *anecopbl* model with a score of 148 in the Good category. Meanwhile, the student response scale was given to two students as respondents who were chosen heterogeneously. The following is the interval score of the student response scale:

Table 4. Student Response Scale Score Interval

Score Interval	Value	Category
X > 117	A	Very good
95 < X ≤ 117	B	Good
73 < X ≤ 95	C	Good enough
50 < X ≤ 73	D	Less good
X ≤ 50	E	Not good

The student response scale was used to determine the response from the students' point of view to the anecopbl model. The first student response scale scored 125 with the category 'Very Good' while in the second student, the student response scale scored 130 with the category 'Very Good'. Based on these results, the *anecopbl* model received a very good response for use in learning.

Description of Limited Trial Phase Results

The LMS developed in this study has been trialled in small groups. The participants in this small group trial were 9 fifth grade students of SD Negeri Kowang. The trial was conducted in October 2023 for 3 meetings. From this trial, data on the testing of the anecopbl model and the use of the LMS in the anecopbl learning model were obtained. The LMS display during the small group trial is presented in Figure 4.

Figure 4. LMS Display in the Limited Test Group

The implementation of the limited trial provides information on the parts that require revision to improve the LMS product on the anecopbl learning model. The part that needs revision is described as follows (1) Often invalid parameters appear when the phone does not have a 2GB ram specification; (2) Need to remove the menu to change the new password.

Description of Broad Trial Stage Results

The broad trial was conducted with fifth grade students of SD Negeri Kowang, SD Negeri Suryodiningratan 3, SD Muhammadiyah Notoprajan. During the trial, experiments were also conducted by comparing the impact of the treatment on these fifth grade students. The extensive trial was conducted to obtain data on the effect of using LMS in anecopbl learning model, face-to-face learning with pbl model, and *e-learning* learning on improving students' critical thinking and collaboration skills.

The data from the broad trial included the assessment of critical thinking skills before and after the use of the LMS and the assessment of student collaboration. Data from the trial results on the assessment of critical thinking skills using a description question instrument that has gone through validation with expert judgement.

Analysis of Critical Thinking Skills

Descriptive data of cognitive learning outcomes taken before and after treatment are shown in Table 8. The data are students' answers to 3 literacy questions on ecosystem material. The data in the table shows that the pretest scores obtained are almost the same, although the order of the average from the lowest is obtained by the face-to-face group then the *anecopbl* and *e-learning* groups which have almost identical scores. The posttest data shows that the order of the lowest mean is obtained by the face-to-face, *e-learning,* and *anecopbl* groups.

Table 5. Initial Description of Critical Thinking Ability Score

No.	Value Type	Group		
		Control	**Experiment**	
		Face to Face	***e-learning***	***anecopbl***
			Pretest	
1.	Mean	35,96	51,79	47,33
2.	Median	33,33	58,33	41,67
3.	Standard Deviation	13,34	12,08	11,73
			Posttest	
1.	Mean	60,96	76,49	86,67
2.	Median	58,33	75,00	83,33
3.	Standard Deviation	11,13	11,80	8,67
		Difference		
1.	Difference in Value	25,0	24,7	39,34
2.	Normalised gain score	38,31	52,52	77,12
3.	Gain Category	Ineffective	Effective enough	Effective

There are differences in the scores obtained by students before and after treatment or pretest and posttest data. The data is obtained as a comparison of changes in students' critical thinking skills after treatment. The comparison can be known from the difference in changes in scores in each treatment or by calculating the *normalised gain score*. The difference in value change is known by calculating the difference between posttest and pretest scores. The *normalised gain score* value is known by dividing the difference in posttest and pretest scores by the difference in maximum and pretest scores. The results of the normalized gain score calculation are then categorized. Changes in the acquisition of learning outcomes in cognitive aspects can be known from changes in the acquisition of the average student scores before and after treatment and the *normalized gain score* obtained. Based on the data, it can be seen that the average difference value in the face-to-face pbl group is 25.0, the e-learning group is 24.7, and the anecopbl group is 39.34.

The calculation of the normalised gain score value in the form of percentages shows that the value in the face-to-face pbl group is 38.31 or categorised as ineffective, the *e-learning* group is 52.52 or categorised as moderately effective, and the anecopbl group is 77.12 or categorised as effective. Based on this, it can be seen that the anecopbl group gets the difference in mean gain and the largest *normalised gain score* compared to the other two groups. Only the *anecopbl* group obtained a high category in the *normalised gain score* value while the other two groups were in the ineffective and moderately effective categories.

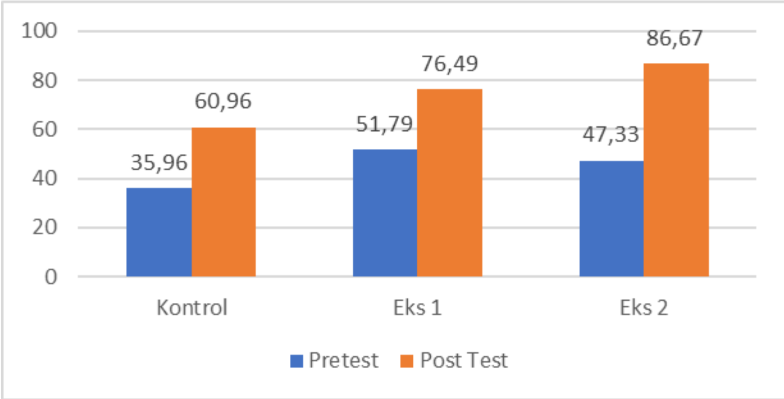

Figure 5. Graph of Critical Thinking Ability Score Description

The NGain results of the high anecopbl model show that students' critical thinking skills increase because in the IPAS learning process the ecosystem material uses the model.

Analysis of Collaboration Description

Descriptive data of collaboration skills were taken at the end after the treatment was carried out. The data is the respondent's response to the statement on the *self-assessment* on the learning model used. In the collaboration aspect, data on the collaboration aspect was obtained from two learning models, namely face-to-face pbl and *anecopbl*. Data management of the *self-assessment* results was carried out by giving an assessment of "1" for the answer "yes" and a value of "0" for the answer "no" and then accumulating and converting it into a percentage. After the average percentage of each number is known, then group it according to the indicator. There are three indicators of collaboration skills on the *self-assessment*, namely the indicator of having the same goal shown in question numbers 1 and 2, the indicator of sharing tasks and responsibilities shown in question numbers 3,4,5,6, and the indicator of cooperation between group members shown in question numbers 7,8,9, and 10. In the *self-assessment* data, the results of students' assessment of aspects of collaboration on themselves with yes / no type questions can be seen. From the results shown in the table, several things are known. All respondents (100%) in the face-to-face group and more than half of the respondents (79.5%) in the aneopbl group agreed that they had the same goals as the group. Almost all respondents (91.75%) in the face-to-face group and more than half of the respondents (69%) in the anecopbl group agreed that they shared tasks and responsibilities. Almost all respondents in the face-to-face group (87.75%) and in the anecopbl group (76.25%) agreed that there was co-operation between group members. Graphically, these results are presented in Figure 6.

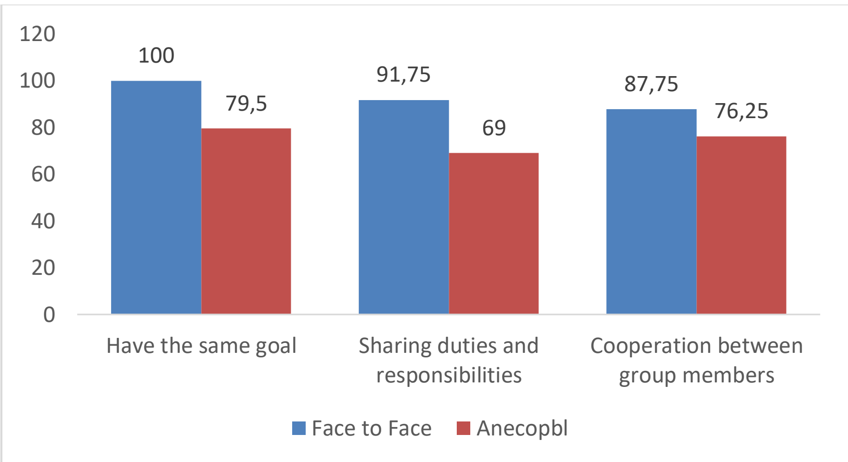

Figure 6. Graph of *Self-Assessment* Score Processing Results

Based on the explanation above, it can be seen that the *anecopbl* learning model is effective to improve critical thinking and collaboration skills. The *normalised gain score* value shows that the use of the model in the classroom can improve critical thinking and collaboration skills.

Learning in the *anecopbl* model facilitates collaboration to complete a common task. Group assignments encourage collaboration between group members. The existence of group tasks presents the mutual involvement of group members in a coordinated effort aimed at solving a common problem. This mutual involvement is a condition for collaboration according to Roschelle et al,. (1991). Collaboration in learning enables social learning and Zone of Proximal Development (ZPD) in accordance with Vygotsky's opinion. Knowledge acquisition through collaboration can provide insights to deal with contextual problems. These mechanisms relate to psychological theories; especially those that are socio-constructive and socio-cultural, they have relevance to recent work done in cognitive psychology and cognitive science. This is in line with the opinion of Dillenbourg P. Baker M., Blaye A., & O'Malley C. (2005).

The basis of the AnEcoPBL learning model is a PBL model modified with e-learning and ecoliteracy. As written by (Treepob, H., Chulida Hemtasin, C., Thongsuk, 2023) that the problem-based learning model is an ideal learning model for developing scientific knowledge and problem-solving skills. Therefore, this AnEcoPBL model aims to help students learn and discover concepts and solve problems by connecting real-world problem situations. Students can also gain a better understanding of the concept of sustainable development and awareness-driven attitudes and behaviors for a more sustainable life through the AnEcoPBL learning model.

The learning steps in the AnEcoPBL learning model start from the student orientation stage on ecosystem issues. At this stage, students are given the opportunity to read information related to the balance of the ecosystem through infographics. Students can write a problem formulation based on real environmental problems. Students are given trigger questions to guide students in understanding the information from AnEcoPBL. This is in accordance with Vygotsky's learning theory, which states that students can share pre-learning activities independently with their classmates and get explanations from teachers. At the stage of guiding students to learn in groups or individuals and organizing students to learn to care online, students learn to care and empathize with environmental problems. Students limit and organize learning tasks related to environmental issues faced such as animal extinction due to human and natural activities. At the stage of guiding individual and group investigations online, students gather appropriate information, carry out investigations, and find solutions/solutions to environmental problems with online responsibility. Students discuss in the AnEcoPBL LMS column. In the stage of developing and presenting works online, students plan, prepare, and upload appropriate works and share assignments with their friends. At the stage of analyzing and evaluating the online problem-solving process, students re-analyze the investigation and processes used in order to correct the wrong things from the process activities and the results carried out when solving problems.

The AnEcoPBL model is a strategic application considering the importance of ICT-based learning in the 21st century. Previous research revealed that the gap between dense curriculum content and time availability can be solved by combining learning with electronic platforms both online and offline (Siregar, L.S., Wahyu, W., Sopandi, 2020). The constructivism that occurs in the classroom during AnEcoPBL learning is proven in; (1) interactive communication between students and teachers based on their own knowledge so that they can identify problems, (2) teacher facilitation to students to build their ideas in solving problems (3) assignment assessment, observation, and test simulation, (4) experiential dynamic knowledge, and (5) group collaboration.

Based on this description, it can be explained that by applying the AnEcoPBL model, learning activities allow students to think critically about problems that lead to solving real problems related to ecosystems. According to the findings of this study, it is recommended to use the AnEcoPBL learning model in environmental material science classes to help students develop their critical thinking and collaboration skills, as each individual needs these skills to face complex and multidimensional challenges.

CONCLUSION

Based on the results of research and development, the following conclusions can be drawn. The AnEcoPBL learning model product is declared feasible for use in learning based on the results of expert assessment and student response.This research has produced a product in the form of anecopbl learning model. The characteristics of the *anecopbl* learning model can be seen from the underlying rationale or theory, learning objectives, syntax, and management system in the model. The anecopbl learning model is effective to improve critical thinking and collaboration skills. Critical thinking skills assessment is based on *normalised gain* value. Collaboration assessment is based on *self-assessment*. Based on the results of the research and development, the following are suggested. Anecopbl learning model to be used by teachers especially when teaching with *e-learning*. The developed learning model is expected to be an example of developing a learning model developed by applying learning techniques in online learning on other teaching materials. The developed LMS is also recommended to be used by students to learn ecosystem materials independently.

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