Jurnal Biolokus: Jurnal Penelitian Pendidikan Biologi dan Biologi
Vol. 7, Issue 2, December 2024
Pages : 143 - 165

p-ISSN: 2621-3702
e-ISSN: 2621-7538

EMKONTAN learning model to improve creativity, collaborative skills, and environmental literacy of prospective biology teachers

Nurwidodo*, Iin Hindun
Department of Biology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Malang, Jl. Raya Tlogomas No. 246, Malang, East Java, 65144, Indonesia
*corresponding author: nurwidodo@umm.ac.id

ABSTRACT

EMKONTAN is a student-centered learning model, which is oriented in creative learning, problem-solving (problem-based learning), collaborative learning, and giving opportunity for students to improve their environmental literacy. This study aims to analyze the validity and practicality of the EMKONTAN model in improving creativity, collaborative skills, and environmental literacy of prospective biology teachers. This study was carried out in the even semester of the academic year of 2020/2021 at IKIP Budi Utomo Malang and Faculty of Teacher Training and Education, Universitas Muhammadiyah Malang. This study involved 150 students in an even semester (Semester II) thru total sampling. Validity instruments used in this study comprised validation sheets for material, method, and media experts. Meanwhile, the instruments for practicality used observation sheets which were focused on the learning implementation, relevant student activities, and obstacles found during the learning processes. The results of the EMKONTAN model indicate that the model has content validity, constructs, and faces that are very feasible to be implemented in the learning process. Additionally, the results of practicality for the EMKONTAN model involve the implementation for each syntax with an average score of <3,6 in a very good category; the students' activities are in a very active category with the average score of <85%, and the obstacle found is pandemic period; thus, online learning is required. Yet, the risks can decrease the effectiveness of learning. The implication of this research is that the application of the EMKOTAN model in universities by lecturers in related subjects will support efforts to increase environmental literacy for prospective biology teacher students.

Keywords: Collaborative skills, creativity, EMKONTAN, environmental literacy, validity

INTRODUCTION

Creative thinking is a thinking skill possessed by an individual and it can lead the individual to a creative thinking; thus, the individual is able to create something new and unique that is different from previous works (Benedek et al., 2014; Larraz-Rábanos, 2021; Shao et al., 2019). Creativity refers to the ability to think outside the box, generate innovative ideas, and adapt to challenges in a dynamic environment. In a rapidly changing world, creativity becomes a crucial factor in driving excellence, as it enables individuals and organizations to find novel solutions and remain competitive. A country's competitiveness is also heavily influenced by the creativity of its human resources. Every aspect of life necessitates the use of creativity. Creativity is needed to design something, improve one's quality of life, create an alteration, or solve a problem (Lee & Trimi, 2018; Serdyukov, 2017; Song et al., 2021). Meanwhile, almost every area of human life needs problem-solving skills. In fact, one's ability to solve problems on a large and small scale determines one's level of success in life (Csapó & Funke, 2017; Dörner & Funke, 2017). In this context, creativity is considered necessary for an individual to solve problems, including increasingly complex and global environmental problems.

Collaborative problem-solving is a key the 21st-century skill—one of the essential '4Cs'—that plays a vital role in enhancing learning outcomes and boosting productivity in real-world work environments (Chiruguru, 2020; Erdoğan, 2019; Partnership for 21st Century Skills, 2015). Collaboration is a partnership relationship in which both parties rely on one another. One of the keys to education in achieving a very effective learning process is collaborative problem-solving skills (Armstrong, 2015; Bryson, 2016; Schmitz & Winskel, 2008). Collaborative problem-solving is a type of social interaction in the learning process in which each member of the group actively and constructively solves all problems (Gauvain, 2018; Soller, 2001). Effective communication skills, mutual respect, trust, giving and receiving feedback, decision making, and conflict management are all components of collaboration (Grover, 2005; Little, 2007; Sibiya, 2018).

Environmental literacy is an individual's skill to understand and interpret environmental conditions (Husamah et al., 2020; Husamah et al., 2022; Husamah et al., 2023; Husamah et al., 2024a; Husamah et al., 2024b). This skill enables individuals to make informed decisions that contribute to maintaining, restoring, and improving the environment (Coyle, 2005; Karimzadegan & Meiboudia, 2012; Mardiani et al., 2021; Muhdhar et al., 2021). Environmental literacy is important because it empowers individuals and communities to make informed decisions, foster sustainable practices, and actively contribute to solving environmental issues that threaten the well-being of both the planet and future generations. Environmental literacy, according to the most widely accepted definition, consists of awareness and concern for the environment and its related problems, as well as knowledge, skills, and motivation to work toward the resolution of current problems and the prevention of new problems (McBride et al., 2013; Wong et al., 2018; Wu et al., 2020).

Environmental science is a compulsory subject in the Department of Biology Education in Budi Utomo Institute of Teacher Training and Educational Science – Malang. Course Learning Outcomes in this subject are: a) Explaining the definition and role of environmental science in everyday life; b) Defining environmental insight and identifying environmental problems c) Analyzing population dynamics and population density problems; d) Explaining ecology as the foundation of environmental science and applying environmental science principles; e) Identifying National and Local Natural Resources; f) Explaining the management of forest resources, clean water resources, coastal resources, and the sea, as well as mineral and energy resources; g) Analyzing soil, water, and air pollution; h) Explaining 6M-based waste management and integrated waste management; and i) Understanding environmental laws and regulations.

Environmental science courses are courses that must be approached with multidisciplinary materials and approaches, because they are closely related to everyday life (Nugraheni, 2014). Some environmentally unfriendly behaviors in the community are closely related to environmental science understanding and concepts, such as cleanliness in the household environment, schools, markets, and public facilities due to littering. The rise in electronic waste as a result of the widespread use of mobile phones and computers contributes to environmental issues. Littering, for example, causes cleanliness to begin in the home, schools, markets, and public facilities (Ferronato & Torretta, 2019; Needhidasan et al., 2014).

Environmental issues are becoming increasingly complex and disconcerting, requiring environmental science learning at all levels and types of education to foster environmentally responsible behavior, which refers to actions that reduce harm to the environment, promote sustainability, and encourage the mindful use of resources to protect the planet for future generations (Fu et al., 2018; Ichsan et al., 2019). The goal of environmental science learning is to increase human awareness, respect, and responsibility for the environment as a whole. Hence, environmental learning should be prioritized in problem-solving approaches (García-González et al., 2020; Hadzigeorgiou & Skoumios, 2013; Jianping et al., 2014). This approach encourages students to identify issues or problems, analyze them, propose hypotheses, collect data, test hypotheses, and determine problem-solving options (Chotimah & Fathurrohman, 2018). To provide further clarity, the goals of problem-based learning in environmental science include: (1) helping students develop critical thinking skills by guiding them in selecting, analyzing, and re-evaluating information to reach well-informed conclusions; (2) fostering intellectual satisfaction by encouraging self-driven exploration and discovery; (3) enhancing students' intellectual capacity through exposure to real-world environmental problems; and (4) teaching students how to engage in the scientific method, enabling them to make their own discoveries and contribute to environmental solutions.

The implementation of environmental science learning will be successful if it is supported by a learning model that allows students to conduct observation, identification, and analysis of environmental problems, as well as integrate it with natural resource conservation, and to conduct monitoring and evaluation and develop a follow-up plan. The learning model is important in the learning process since it can describe systematic procedures for managing student learning experiences in order to achieve learning objectives (Baumfalk et al., 2019; Wehmeyer et al., 2012). In order to provide a better chance of success, learning models must be chosen with the student 's character and the material being taught in mind. The lecturer's role as a facilitator is crucial in encouraging student-centered learning (Hines et al., 2019). A proper knowledge transfer process enables students to master the concept of material correctly.

Environmental science, when taught using the right model (such as EMKONTAN), can help students develop 21st-century skills (Afandi et al., 2018; S. Kim et al., 2019; Peters-burton & Stehle, 2019). While the 21st-century skills and environmental literacy are important for all graduates, biology graduates, due to their field of study, are particularly positioned to contribute to addressing environmental challenges and achieving sustainable development goals (SDGs), as their expertise is directly relevant to understanding and solving environmental issues. The following are the four categories of 21st-century skills: (1) ways of thinking: creativity and innovation, critical thinking, problem-solving, decision making, and learning to learn; (2) ways of working: communicating and cooperating; (3) tools for working: general knowledge and skills of information and communication technology; and (4) way of life: career, personal and social responsibilities, including cultural awareness and competence. Combining environmental science content with 21st century skills is one of the challenges in environmental science learning (critical thinking, creative, collaborative, communicative) (Amran et al., 2019; Hasan et al., 2019).

So far, the implementation of learning processes for Environmental Science shows a lack of encouragement to improve students' creativity, collaboration skills, and environmental literacy. Preliminary study has been conducted in seven universities in Java and Sumatra with a sample consisting of four lecturers and thirty students supporting this indication. Some of the results obtained are that students tend to memorize concepts because of the application of lecturer-centered learning and the absence of learning models that encourage student creativity both in providing opportunities and creating Environmental Science products that are beneficial to life (Farwati et al., 2017). Furthermore, the lack of exploration activities for environmental problems in the field, as well as the opportunity to solve them, leads to a lack of creativity, collaboration, and environmental literacy among students.

The development of the EMKONTAN learning model focuses on student involvement in observing environmental problems, identifying, and analyzing environmental problems, developing action plans and the possibility of integration into natural resource conservation, carrying out actions to solve environmental problems, monitoring and evaluating, and follow-up plans. This development is required to make it easier for lecturers to deliver lectures.

The EMKONTAN model is a learning model that is used to teach Environmental Science material in order to improve students' creativity, collaborative skills, and environmental literacy (Nurwidodo, Hadi, et al., 2021; Nurwidodo, Romdaniyah, et al., 2021). This model is created based on a need analysis, the model's strengths and weaknesses, and the expectations of the model's development objectives. This EMKONTAN allows students to string together learning through appropriate stages for solving environmental problems, which can provide students with unified creative thinking skills, collaborative skills, and environmental literacy. Socialization and environmental observation, identification and analysis of environmental problems, planning action and integration into natural resource conservation, implementing actions to solve environmental problems and integrating into natural resource conservation, monitoring and evaluation, and follow-up plans into students' creativity programs are the learning syntax of the EMKONTAN model. The syntaxes are structured with the characteristics of creative, collaborative learning, and environmental literacy in mind. If the syntax of the EMKONTAN model is correctly applied, students' opportunities for creative thinking, collaborative skills, and environmental literacy will increase.

EMKONTAN is new model. EMKONTAN is urgent for environmental science learning because it provides a dynamic and innovative approach to engage students in real-world environmental challenges, fostering critical thinking, problem-solving, and the application of sustainable practices necessary for addressing pressing global environmental issues. The presence of this model is based on the fact that previous models have not accommodated aspects of students' creativity, collaborative skills, and environmental literacy. Previous research using blended project based learning model just to see thinking skills for environmental sustainability perspective of new students of biology education department (Husamah, 2015). Other studies only look at the effectiveness of the environmental learning model on student motivation and learning outcomes and even then only at the high school level (Perdiawan & Kartini, 2021). One other study focused on looking at the effectiveness of the ILMIZI model in environmental learning during COVID-19 on the aspects of students' attitudes (Perdiawan & Kartini, 2021). It can be said that this research has novelty in the aspects of the model and aspects of the competencies developed.

Validity is a measurement that indicates the level of validity or the validity of something. A development result (product) is stated to be valid if it is founded on adequate theory (content validity) and all components of the learning product are consistent with one another (construct validity). To determine the quality of teaching materials in relation to measure what should be measured, the validity of teaching materials is determined (Boateng et al., 2018; Richard P. Bagozzi, 2013; Santoso et al., 2017).

According to Nieveen, validity aspects can be seen from: (1) whether the developed curriculum or learning model is based on state-of-the-art knowledge; and (2) whether the various components of learning devices are consistently interrelated with one another. Based on this explanation, it is possible to conclude that a product is said to be valid if it is in accordance with the curriculum and has a relationship with other products. Thus, validity testing conveys that a product complies with applicable regulations (Nieveen, 1999).

A result of development (product) can be stated as valid if the product is based on the appropriate theory (content validity) and all components of the learning product are consistent with one another (construct validity). Meanwhile, validity of learning devices is determined to specify the quality of learning material in relation to measure what it is supposed to measure (Ahrens et al., 2020; Anwar & Rizqi, 2012; Santoso et al., 2017).

Reliability is a measurement that indicates the level of robustness when a study is repeated under the same conditions. A product must undergo a reliability assessment to ensure that it does not change when used in different locations but under the same conditions (Heale & Twycross, 2015; Price et al., 2015). On EMKONTAN products, reliability of stability, reliability of representation, and reliability of equity are all assessed.

The term "practicality" refers to how simple and easy it is to use something. The term "practicality" here refers to practicality in the field of education (Gultom, 2016; Manuel, 2021). The implementation and benefits obtained by students using models, teaching materials, student worksheets, instruments, or other products are referred to as practicality. The level of usability and application of the learning model by students and lecturers using the intended learning model is referred to as practicality. If the learning model is practical and simple to implement, it has a high level of practicality.

METHOD

This study was a development study using ADDIE type; analysis, design, development, implementation, and evaluation on the intervention of education (i.e. program, strategies, and learning materials, products, and systems). This was a solution to solve complex problems in educational practice, in which it aimed at advancing our knowledge of the characteristics of these interventions and their design and development processes (Branch, 2009). The ADDIE model was chosen for this study because of its systematic and iterative approach, which allows for continuous improvement throughout the development process. This ensures that the educational materials are effectively designed, implemented, and evaluated, aligning with the dynamic needs of environmental science learning and providing a structured framework for achieving optimal outcomes. Development model's stages were used comprising needs analysis, design, product development, implementation, and evaluation. The results of the validity and practicality of the EMKONTAN model, with the syntax as shown in Table 1, were a series of stages to improve product development.

Table 1. Syntaxes of EMKONTAN Model

Syntax	Phase Description	Lecturer Activities
Phase 1: Socialization and Observation of Environmental Problems	Student orientation on the EMKONTAN stages and observation of environmental problems	- Presenting examples of environmental problems and the steps of the EMKONTAN model - Delivering lecture objectives at each stage of the EMKONTAN step - Guiding students in observing environmental problems Asking students to document the results of observations of environmental problems
Phase 2: Identification and	Taking an inventory of environmental problems and	- Informing the need for investigation and inventory

Syntax	Phase Description	Lecturer Activities
Problem Analysis	analyzing factors that affect environmental problems	Guiding students to design and carry out investigations to analyze the factors that cause problems to arise
Phase 3: Action Plan	Presenting an action plan to solve environmental problems	- Guiding students in preparing action plans for solving environmental problems. Guiding students to present an action plan
Phase 4: Implementation of Action Plan	Implementing an action plan in the form of solving environmental problems	- Giving problems related to the concept that has been represented - Guiding students in solving multi-representation problems
Phase 5: Monitoring and Evaluation	Monitoring and evaluating the process and results of problem-solving	- Guiding students to evaluate the results of problem solving - Assisting students to reflect on the process and results of problem solving
Stage 6 Follow Up Plan	Making a follow-up plan by compiling a proposal for the Student Creativity Program	- Guiding students to compose RTL - Guiding students to develop PKM proposals based on environmental issues and natural resource conservation

This study was carried out in the odd semester on the academic year of 2020/2021 at Budi Utomo Institute of Teacher Training and Educational Science – Malang and University of Muhammadiyah Malang. Thus, this research was conducted for one semester (six months). There were 150 students of even semester who participated in this study. Sampling of this study used a saturating sample, meaning that all became samples.

The advantages of the EMKONTAN model lie in its student-centered approach, which actively engages students in real-world environmental problem-solving. By involving students in observing, analyzing, and developing action plans, the model fosters critical thinking, enhances practical skills, and promotes a deeper understanding of environmental issues. Additionally, it provides lecturers with a structured framework to deliver content more effectively, integrating interactive and collaborative learning processes that support sustainable development and conservation efforts. A validation sheet was used to test the validity of the EMKONTAN model, while a learning observation sheet was used to test its practicality. The validation sheet of learning material experts and users was the type of research instrument used to test the validity of the EMKOTAN model. While the EMKONTAN model's practical instrument was in the form of an observation sheet that focused on the implementation of learning, relevant student activities, and the barriers encountered while using the EMKONTAN model during the learning process.

Data analysis technique for the EMKONTAN model validity used average scores with the following categories: very valid (80.26% <x ≤ 100%), valid (62.6% <x ≤ 80.25%), less valid (43.76% <x ≤ 62.5 %), and invalid (25% <x ≤ 43.75%) (Aryadoust & Raquel, 2019). If the validation results reached a score of ≥ 60%, it indicated that the product development was feasible to be developed to the next stage. Beside using expert judgment, the analysis for construct validity also uses the Wilcoxon Signed Ranks Test on student competence before and after the model is applied. If EMKONTAN is a valid model, then the application of this model can significantly improve students' creativity, collaborative skills, and environmental literacy.

The data analysis technique for the EMKONTAN model's practicability was to use average score of the learning implementation (as specified in the model syntax) based on the results of five observers' observations. The model's syntax included the following steps: observing environmental problems, identifying and analyzing problems, implementing action plans, monitoring and evaluating the implementation process and results, and planning and implementing follow-up programs in the form of student creativity programs. Furthermore, the following learning implementation categories consisted of: 3.6 ≤ very good <4.0; 2.6 ≤ good <3.5; 1.6 ≤ bad <2.5; and 1.0 ≤ very bad <1.5 (Mustami et al., 2019). Whereas, the data of students' activities that were relevant would be analyzed based on frequency of activity that appeared every 5 minutes; thus, the average score of students' activities could be determined, which included observing, identifying and analyzing, preparing action plans, implementing action plans, monitoring and evaluating processes and products, and making follow-up plans. The categories indicated by the average score of student activities were as follows: 85% ≤ very active <100%; 70% ≤ active <85%; 60% ≤ less active <70%; and 25% ≤ inactive <60% (Mustami et al., 2019). Later, the observation data related to the barriers discovered during the learning process using the EMKONTAN model would be analyzed based on the appropriateness of relevant alternative solutions to support students' creativity, collaborative skills, and environmental literacy.

RESULTS AND DISCUSSION

Data analysis was done using validity questionnaire of EMKONTAN model (from the 5 expert lecturers, in which it was based on three components, namely validity of face, content, and construct) and analyze the empirical data using the Wilcoxon Signed Rank Test as reinforcement of construct validity. There are 9 aspects of questions for face validity, 5 questions for content validity, and 8 questions for construct validity.

The implication of this instrument is that it provides a reliable and valid measure for evaluating the effectiveness and quality of the EMKONTAN model. By assessing face, content, and construct validity, the instrument ensures that the model is accurately designed to meet educational objectives and addresses key environmental issues. The use of the Wilcoxon Signed Rank Test also strengthens the empirical validation, offering evidence that the model effectively supports learning outcomes and can be trusted for broader application in environmental science education.

These questions concern the implementation of content, language, presentation, and graphics. The assessment of practicality is based on aspects of implementation and benefit. There are 20 questions for the implementation aspect, while for the benefit aspect, there are 11 questions. Data analysis results indicated that the problem-based, student-centered, project-based approach of EMKONTAN model had an average validity value of 85% with a very valid category. While the results of the practical analysis of EMKONTAN had an average practicality of 87% with a very practical category. Furthermore, based on the results of construct validity analysis using the Wilcoxon Signed Ranks Test, the EMKONTAN model can be validly used to improve collaboration ($Z = 5.359$, $p < 0.001$), creativity ($Z = 3.606$, $p < 0.001$), and environmental literacy ($Z = 5.153$, $p < 0.001$).

Five experts validated the EMKONTAN model, covering learning materials, content, and usability. The evaluation results of EMKONTAN model validation reached the average score of ≥ 80%. In conclusion, the product development model is valid and can be developed to the next stage. Table 2 displays the EMKONTAN model's average validation score.

Table 2 indicates that content validity which includes need analysis and conformity with the current knowledge has the average scores of 83% and 78%, and those are categorized as very valid and valid

Table 2. Validation Results of EMKONTAN Model

Aspects	Average Score (%)	Category
A. Content Validity		
• Needs Analysis	83	Very Valid
• Suitability with Current Knowledge	85	Very Valid
Contains methods of solving environmental problems	84	Very Valid
Contains how to integrate with KSDA	82	Very Valid
B. Construct Validity		
• Model Rationality	84	Very Valid
• Theoretical and Empirical Support	81	Very Valid
• Components of Planning and Model Implementation	78	Valid
• Learning Environment of the Model	86	Very Valid
• Model Assessment and Evaluation	83	Very Valid
• Relevance to environmental issues	83	Very Valid
• Problem Solution	84	Very Valid
• Constructing KAP	79	Valid
• Constructing Student Creativity	82	Very Valid
• Collaborative Building	83	Very Valid
• Constructing Environmental Literacy	88	Very Valid
C. Face Validity		
• The Truth of Concepts (theory)	86	Very Valid
• Principles in Measurement	82	Very Valid
• Instrument Format	78	Valid
• Language	90	Very Valid
• There are stages (syntax)	85	Very Valid
• There are learning devices	83	Very Valid
• The prevailing social system	84	Very Valid
• Encourage interaction	87	Very Valid
• Translating curriculum	86	Very Valid

Meanwhile, the construct validity which includes rationalities, rationality, theoretical and empirical support, planning and implementation components of the model, model learning environment, model assessment and evaluation had an average score 84%, 81%, 76%, 86%, and 83%; moreover, those are categorized as very valid and valid. Furthermore, Face validity which includes the truth of concepts, principles in measurement, instrument format and language obtains an average score of 86%, 82%, 78%, and 90%, included in the category of very valid and valid based on the validation results of Table 2.

The observation data related to the learning implementation of EMKONTAN model are based on the implementation of syntaxes for each model, in which those are: socialization, observation of environmental problem, identification and analysis of environmental problems, planning for problem-solving action, and integrating to natural resource conservation, conducting action for solving the environmental problems and integrating to natural resource conservation, monitoring and evaluating the action, and making follow up into the preparation of student creativity program.

The average score of the model implementation in each class is presented in Figure 1. Figure 1. Indicates that the learning implementation of EMKONTAN model has average score of syntax to conduct an observation in 3.4; identifying and analyzing problems of 3,3; action plan in di 3.4; implementing the action plan in 3.4; monitoring and evaluation in 3.3; follow up in 3,5. Those data signify that the syntaxes of EMKONTAN model in the learning process are categorized as very good.

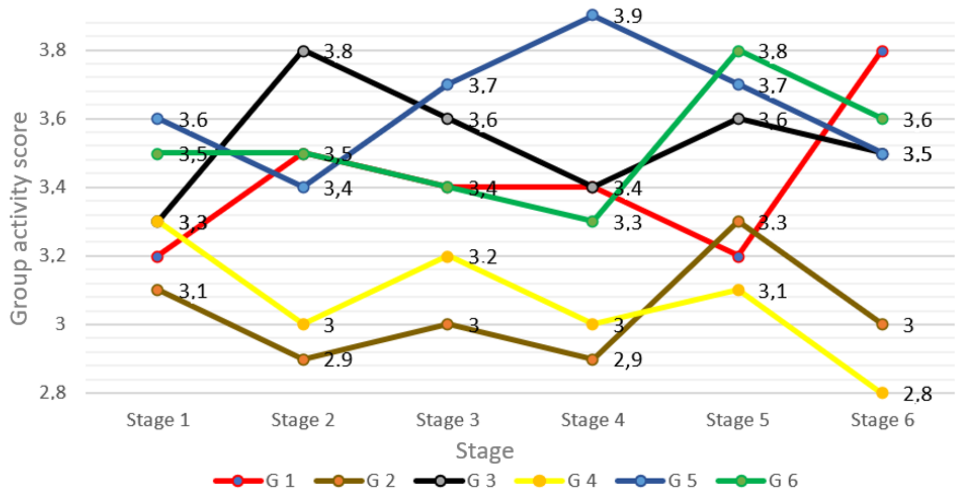

Figure 1. Working Group Activity Score at Each Stage of EMKONTAN. Note: Stages - (1) socializing and observing; (2) identifying and analyzing; (3) planning problem-solving actions and integrating natural resource conservation; (4) problem -solving actions and integration of natural resource conservation; (5) Monitoring and evaluating; and (6) Action Plan into student creativity program. Group: G1 to G6

Student activities are incorporated into the EMKONTAN model learning process. Observer assessment of student activities is performed for 5 minutes in order to obtain data on student activities between observing, identifying and analyzing problems, planning actions, carrying out actions, monitoring, and preparing follow-up plans. Figure 2 depicts the average score of student activities during the learning process.

Figure 2 signifies that there are six students' activities during the learning processes using the EMKONTAN model. The average percentage score for observing activities is 84%, 82% for problem identification and analysis, 85% for action plan activities, 81 % for action plan implementation, 82 % for monitoring and evaluation, and 83 % for follow-up planning. Those results indicate that the students are classified as active during the learning processes by using the EMKONTAN model.

The lecturer encounters several barriers while implementing learning with the EMKONTAN model, possibly requiring alternative solutions. The alternative solution is expected to make the learning process easier. As shown in Table 3, the followings are a list of constraints and alternative solutions.

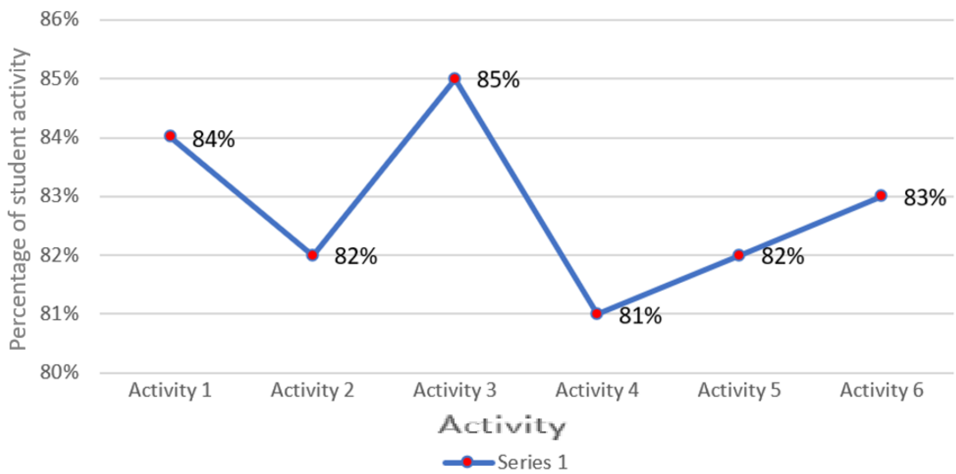

Figure 2. Student Activity Data with the EMKONTAN Model
Note: Activities - (1) observing; (2) identifying and analyzing; (3) planning action; (4) implementing action plan; (5) monitoring and evaluating process and results; and (6) establishing a follow-up plan.

Table 3. Barriers and alternative solutions to the EMKONTAN model

Barriers	Alternative solutions
There are some students who are less interested in carrying out Environmental Science lecture activities	The lecturers motivate students through demonstrations in implementing EMKONTAN to make it easier to understand
There are several problems that can encourage students to have creative solutions	Lecturers provide examples of realistic problems to inspire students with creative ideas to find solutions.
Some groups of students have not been able to implement the action plan	Lecturers provide clear directions through explanations and examples of implementation of the action plan.
Students still find it difficult to follow up on developing student creativity programs	Lecturers need to provide motivation and examples of student creativity programs

Table 3 shows that several barriers are discovered during the EMKONTAN model's learning process. These barriers include students' lack of interest in carrying out lectures, the need for creative solutions, the implementation of action plans, and the implementation of follow-up plans in the form of PKM. Based on these issues, alternative solutions must be provided, such as the lecturer demonstrating work examples that are expected to appear at each stage of EMKONTAN, providing opportunities to find problems that are relevant to students' daily lives, and providing study assistance when students encounter difficulties.

The results of expert and user validation on the EMKONTAN model are classified as valid based on the data in Table 1. This includes content, construct, and face validity. These findings suggest that the EMKONTAN model can be used in the learning process. The EMKONTAN model's syntax contributes to measures that can boost students' creativity, collaboration, and environmental literacy. Syntax in making observations encourages students to explore environmental issues on a local, regional, and international scale in order to gain a comprehensive illustration of the environmental problems that must be addressed (Pereira, 2015; Rico, 1998). Furthermore, as a follow-up to their findings, this observation requires students to understand and solve problems from various perspectives (Chin & Osborne, 2008; Lodge et al., 2018; Pedaste et al., 2015). In Environmental Science lectures, each syntax of the EMKONTAN model aims to improve students' creativity, collaboration skills, and environmental literacy. According to the study's findings, it is critical to provide students with opportunities to express their creative ideas during the learning process through identification and analysis activities (Daly et al., 2016; OECD, 2019; Samson, 2015). These activities can assess the extent to which students' knowledge, skills, attitudes, and behavior contribute to environmental problems.

Content validity criteria of EMKONTAN model that have been assessed are classified as valid. One of the is need analysis to discover the lack of learning models used. Need analysis stages need to be done in developing a learning model to ensure that the developed product is a solution for the problems occurred (Sandoval, 2014; Sulistyani, 2018). The findings of the need analysis used to create learning models will open up possibilities for the realization of relevant products.

Meanwhile, construct validity involves model rationality, theoretical and empirical support for each stage of model, model learning environment, as well as model assessment and evaluation (Plomp & Nieveen, 2013). The EMKONTAN model is created in accordance with the characteristics of the curriculum in the

Biology Education Study Program at UMM's Faculty of Teacher Training and Education, where the curriculum 2019 (Higher Education Curriculum) for revised edition is used. The EMKONTAN model's syntaxes encompass student-centered learning stages; additionally, it can encourage students to discover solutions to environmental problems. According to the findings, action plan activities allow students to discover a solution to a problem that has been identified.

The following is The activities of students and lecturers in the implementation of the EMKONTAN model syntax, which is carried out in groups at all stages, are described below: (1) student undertakes to observe the environment, (2) students try to identify problems that they find themselves in their environment and analyze the factors that cause them; (3) students plan actions to address environmental problems; (4) students carry out an action plan (implementation) to address environmental problems; and (5) students monitor and evaluate the process and outcomes of environmental problem resolution. (6) using the EMKONTAN model, students create a follow-up plan and implement it in the form of PKM based on the learning outcomes of Environmental Science.

The EMKONTAN model's learning environment encourages students to investigate information in order to find solutions to problems they encounter. The criteria of students in this context include being active learners who are curious, critical thinkers, and capable of independently exploring and analyzing environmental issues to develop viable solutions. To support the implementation of the learning model, the learning environment should be well designed; thus, problems can be solved through investigations conducted by students, and learning becomes meaningful (Herrington et al., 2014; Lin-Siegler et al., 2016). Instrument test is used to assess and evaluate the learning that uses the EMKONTAN model in order to measure the students' creative thinking skills and environmental literacy. Meanwhile, the observation sheets are used to measure the students' collaborative skills during the learning. Creative thinking skills and environmental literacy are interrelated, as both enable students to approach environmental issues with innovative solutions and a deeper understanding of ecological impacts. By fostering creative thinking, students are better equipped to analyze complex environmental problems, while environmental literacy provides the knowledge foundation to make informed, sustainable decisions.

Face validity criteria are also classified as valid, which includes the correctness of concepts, principles in measurement, instrument format, and language (Moulton et al., 2019). Validation sheet format has been known by the validators. This is supported by statements in the validation sheets that simplify the validators to validate and provide comments or suggestions to the EMKONTAN model. Additionally, the language used in the EMKONTAN model syntaxes has been met the language spelling system rules. The results of this study indicate that facial validity assessment procedures provide the feasibility of the item content through a qualitative assessment by the validator (Orr et al., 2018). Furthermore, this procedure creates a measure of the degree of agreement among experts assessing the feasibility of a measurement scale. According to the results of expert and user validation, the EMKONTAN model is valid and reliable, as shown in table 1. Following the fulfillment of these valid and reliable criteria, a practicality test on the implementation of learning in the field is required.

The model's practicability focuses on testing the implementation of learning, student activities relevant to the learning model, and the obstacles encountered and alternative solutions when carrying out the learning process. According to the data in Table 2, the syntax with the highest average score in the implementation of learning with the EMKONTAN model is the identification and analysis of environmental problems, with a score of 86.2. As a follow-up to identification, students are given the opportunity to express their own analysis of environmental problems in this syntax (Dalida et al., 2018; M. K. Kim et al., 2016). An analysis of environmental problems will emerge creative ideas, collaborative solution, and improve students' environmental literacy (Helms et al., 2015; Meilinda et al., 2017; Sumarmi et al., 2021).

According to creativity theory, creating learning environment can improve creative ideas thru an opportunity given to the students in order to think divergence (Saleh, 2019; Sternberg, 2018; Sun et al., 2020). This theory is useful in the learning process since it can support the learning process and increase students' understanding of the material being taught. The findings indicate that the learning environment is structured in such a way that students are given the freedom to explore, imagine, and come up with creative ideas about the lecturer's material (Hawley, 2018; Hossain, 2015; Milrad, 1999; Papaleontiou- Louca et al., 2014).

The implementation of the EMKONTAN model is inextricably linked to the student-centered syntax. The syntax for problem identification directs students to identify problems presented by the lecturer. The problem identification process is the first stage of problem mastery in which an object in a specific situation is identified as a problem. The study's findings indicate that problem recognition can encourage the emergence of solution ideas for the problems that surround it (Bruner & Pomazal, 1988; Erlina et al., 2018). Lecturers encourage students to find useful problems and alternative solutions to complex problems. The syntax, or the second working step in the EMKONTAN model, Identification followed by Analysis, can be used to identify problems, allowing students to produce appropriate solutions to environmental problems. Furthermore, the Action Plan syntax encourages students to be creative in developing waste recycling projects, anti-pollution campaigns, and other projects in the form of posters, animations, or designs. Students are encouraged to consider various alternative solutions when planning an action.

The study's findings show that the creative process of planning this action allows students to plan solutions as they wish, which is an expression of their sense of responsibility to the environment. Projects to solve environmental problems with students' understanding can build new knowledge that can be used to solve the problems discovered (Ardoin et al., 2020; Dalida et al., 2018; Glynn & Duit, 1996; Lind et al., 2020). The syntax for carrying out the action directs students to take the necessary steps to carry out the project plan that has been prepared. The implementation stage is based on the consideration of the implementation of the developed alternative settlement plan (multichoice). This stage allows students to practice their creative thinking skills and look for reasons why this is the best solution.

The findings of this study suggest that fostering a creative process in environmental education, where students can independently plan solutions, not only enhances their problem-solving skills but also strengthens their sense of responsibility toward environmental sustainability. This impact indicates that future research could explore deeper into how such autonomy in planning solutions affects long-term attitudes and behaviors toward the environment. Additionally, it opens up opportunities to investigate the scalability of this approach across diverse educational settings and its potential role in promoting sustainable practices at community and societal levels.

According to the study's findings, during the action's implementation, the lecturer is responsible for guiding students to take action to solve environmental problems based on the characteristics of the environmental problems encountered and their potential, in order to obtain the accuracy of the results of the action plan's implementation. The monitoring and evaluation syntaxes aim to train students to monitor the progress of projects to solve environmental problems, either individually or in groups, and to evaluate barrier that may arise as well as efforts to overcome them

The results of this study also indicate that monitoring and evaluating activities can foster a responsible attitude of students in completing a project to overcome environmental problems (Ernst & Theimer, 2011; Joshi & Rahman, 2015; Taconis et al., 2001). The monitoring and evaluation syntaxes also direct students to strengthen collaborative skills when working in groups with different personalities among group members. The evaluation and monitoring results show that the result of the implementation (action) of solving environmental problems is something that is a solution to the environmental problems encountered and has an integrative meaning for natural resource conservation.

According to the study's findings, lecturer mentoring activities are required to optimize monitoring and evaluation so that students can be facilitated in developing their responsibilities to solve problems based on their creativity and collaboration, and so that students' potential can be optimally explored (Darling-Hammond et al., 2020; Keiler, 2018; Wicaksono et al., 2017). Overall, at this monitoring and evaluation stage, students must also receive an evaluation from the lecturer on the status of students' sensitivity or concern for environmental problems, as well as efforts to overcome them. This is an attitude component in environmental literacy that consistently receives high marks in various studies. This attitude component is frequently found to be related to the knowledge domain built by environmental science courses.

The follow-up plan stage allows students to take advantage of the process and learning outcomes in creatively and collaboratively solving environmental problems, which can then be developed into student creativity programs. A variety of recommended student creativity program schemes can be used to implement a follow-up plan. According to the study's findings, at this stage in the follow-up plan, students can implement student creativity program proposals in the form of written ideas and community service. Students' creative and collaborative abilities have the opportunity to flourish at this stage. It is very logical if this follow-up plan stage strengthens students' environmental literacy in connection with the preparation of their student creativity program based on solving environmental problems and their integration in the preservation of natural resources.

The findings show that through identification and analysis activities, students gained direct experience in learning, as well as fostered creativity and critical thinking in analyzing and proving whether environmental problems pose a threat if they are not addressed collectively or collaboratively (Darling-Hammond et al., 2020; Jatmiko et al., 2015; Loeng, 2020; Milrad, 2013; Serdyukov, 2017; Tharayil et al., 2018). Students' knowledge, attitude, and responsible behavior toward the environment reflect their environmental literacy profile, which will be strengthened by following the stages of learning environmental science through the EMKONTAN model.

The EMKONTAN model, which is said to be oriented toward active student learning, is structured with learning steps that require student learning activities and the syntax. This model stage starts with the socialization stage and ends with the follow-up plan, all of which require active participation from students. Individual and group units are used for student activities. Individual units conduct observations in their respective environments, while group units coordinate and discuss which problems will be used as representations for further learning. Active learning strategies as instructional activities that involve students in doing something and thinking about what they do (Bonwell & Eison, 1991; Eison, 2010; Tharayil et al., 2018). Bonwell and Eison describe a holistic view of active learning in Creating a Significant Learning Experience, which includes all of the following components: Information Experience, Ideas, Dialogue, and Reflective. This framework can be a useful tool for thinking about how students actively learn.

The implementation of EMKONTAN model cannot be separated from the problems found in the class, such as some students who are less interested in carrying out several stages in the EMKONTAN model which requires lecturers to motivate them through demonstrations or whatever the lecturer can do. The students should have learning motivations so that the learning in class takes place in a conducive situation (Akomolafe, 2015; Gustiani, 2020; Mauliya et al., 2020; Munawaroh, 2017; Wicaksono et al., 2015). Lecturers play a key role in fostering motivation by creating a positive learning environment that encourages students to engage actively and develop a constructive attitude toward learning. By presenting relevant and challenging problems, lecturers stimulate students' creativity, motivating them to explore and devise innovative solutions. A problem causes someone to try to solve the problem at hand in various ways such as thinking, trying, and asking to solve the problem. Students must be able to understand environmental problems and know the factors that influence the emergence of environmental problems in order to analyze and provide solutions with various alternatives, which is one indicator of creative thinking in the EMKONTAN model.

The EMKONTAN model in learning stages require a cooperation and mutual cooperation to solve the environmental problems in student study groups. This fact makes EMKONTAN included in the type of collaborative learning. The last stage of EMKONTAN syntaxes is following-up in the form of student scientific papers compiled and submitted to student creativity programs. This stage indicates that a learning thru the EMKONTAN model produce a product in the form of proposal for student creativity program. Therefore, it can be realized that the EMKONTAN has a resemblance to Project Based Learning (PjBL) model. Recent studies reveal that PjBL has numerous advantages, including increased academic achievement, increased application and retention of information, creative thinking, communication, and collaboration.

CONCLUSION

Several conclusions can be drawn from the findings and discussion about the validity and practicality of the EMKONTAN model for improving prospective biology teachers' creative thinking, collaborative skills, and environmental literacy: (1) Based on expert and user validation results, the EMKONTAN model for improving creative thinking, collaborative skills, and students' environmental literacy reaches an average score of ≥ 80% with a very valid category, including content validity, constructs, and face. As a result, it is feasible to implement it into learning processes. (2) The practicality of EMKONTAN model to improve creative thinking, collaborative skills, and students' environmental literacy is as follows: (1) The implementation for each syntax of the EMKONTAN model has an average score of <3,6 with an excellent category; (2) Students' activities that are relevant with the EMKONTAN model have an average score of <85 %, with a very active category; and (3) The EMKONTEN model, which refers to the collaborative solution of environmental problems, can assist students to develop their creativity, collaborative skills, and environmental literacy. (3) The EMKONTAN model is appropriate for the learning process of Environmental Science material that requires proper competence so that students can make decisions about proper environmental problem completion and have the creativity to overcome those problems. (4) The model still requires testing for effectiveness, particularly in its ability to coherently implement the stages. The EMKONTAN model offers significant benefits, including enhancing students' creative thinking, collaborative skills, and environmental literacy by actively engaging them in solving real-world environmental problems. However, a potential limitation is the need for thorough guidance and resources to effectively implement each stage, which may pose challenges in settings with limited support or time constraints. Additionally, while the model encourages autonomy, some students may require more structured guidance to fully benefit from the open-ended problem-solving approach.

Based on the conclusions, future research should focus on examining the effectiveness of the EMKONTAN model in diverse educational settings and student populations to understand its adaptability and impact across various contexts. Additionally, longitudinal studies could explore the long-term influence of the EMKONTAN model on students' environmental literacy, creativity, and collaborative skills to assess whether these skills persist and are applied beyond the classroom. Furthermore, future research could investigate how specific components of the model contribute to individual skill development, allowing for potential refinement of the model's stages to maximize student engagement and learning outcomes.

ACKNOWLEDGMENT

We would like to thank the Universitas Muhammadiyah Malang for providing Research Funding Assistance for Thesis, which was especially helpful in completing this study. We would also like to thank the Head of Biology Education Study Program at IKIP Budi Utomo Malang for providing the opportunity to conduct the research at this institute.

REFERENCES

Afandi, Sajidan, S., Akhyar, M., & Suryani, N. (2018). A framework of integrating environmental science courses based to 21st century skills standards for prospective science teachers. *AIP Conference Proceedings*, *2014*(September), 020032. https://doi.org/10.1063/1.5054436

Ahrens, R. de B., Lirani, L. da S., & de Francisco, A. C. (2020). Construct validity and reliability of the work environment assessment instrument WE-10. *International Journal of Environmental Research and Public Health*, *17*(20), 1–19. https://doi.org/10.3390/ijerph17207364

Akomolafe, C. O. (2015). The classroom environment : A major motivating factor towards high academic performance of senior secondary school students in South West Nigeria. *Journal of Education and Practice*, *6*(34), 17–21.

Amran, A., Perkasa, M., Satriawan, M., Jasin, I., & Irwansyah, M. (2019). Assessing students 21st century attitude and environmental awareness: Promoting education for sustainable development through science education. *Journal of Physics: Conference Series*, *1157*(2). https://doi.org/10.1088/1742-6596/1157/2/022025

Anwar, K., & Rizqi, M. A. (2012). *Validity and reliability analysis of assessment for customer satisfaction at University of Muhammadiyah Gresik*. 141–152.

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, *241*, 108224. https://doi.org/https://doi.org/10.1016/j.biocon.2019.108224

Armstrong, P. (2015). Partnerships and collaboration for school improvement : a review of the evidence October 2015. *Research Report*, *October*, 1–47. https://www.gov.uk/government/publications/school-improvement-effective-school-partnerships

Aryadoust, V., & Raquel, M. (2019). *Quantitative data analysis for language assessment Volume I* (p. 288). Routledge. https://doi.org/10.4324/9781315187815

Baumfalk, B., Bhattacharya, D., Vo, T., Forbes, C., Zangori, L., & Schwarz, C. (2019). Impact of model-based science curriculum and instruction on elementary students' explanations for the hydrosphere. *Journal of Research in Science Teaching*, *56*(5), 570–597. https://doi.org/10.1002/tea.21514

Benedek, M., Jauk, E., Sommer, M., Arendasy, M., & Neubauer, A. C. (2014). Intelligence, creativity, and cognitive control: The common and differential involvement of executive functions in intelligence and creativity. *Intelligence*, *46*, 73–83. https://doi.org/10.1016/j.intell.2014.05.007

Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quiñonez, H. R., & Young, S. L. (2018). Best practices for developing and validating scales for health, social, and behavioral research: A primer. *Frontiers in Public Health*, *6*(June), 1–18. https://doi.org/10.3389/fpubh.2018.00149

Bonwell, C., & Eison, J. (1991). *Active learning: creating excitement in the classroom. 1991 ASHE-ERIC Higher Education Reports.*

Branch, R. M. (2009). *Instructional design: The ADDIE approach* (1st ed.). Springer US. https://doi.org/10.1007/978-0-387-09506-6

Bruner, G. C., & Pomazal, R. J. (1988). Problem recognition: The crucial first stage of the consumer decision process. *Journal of Consumer Marketing*, *5*(1), 53–63. https://doi.org/10.1108/eb008219

Bryson, C. (2016). Engagement through partnership: students as partners in learning and teaching in higher education. *International Journal for Academic Development*, *21*(1), 84–86. https://doi.org/10.1080/1360144x.2016.1124966

Chin, C., & Osborne, J. (2008). Students' questions: A potential resource for teaching and learning science. *Studies in Science Education*, *44*(1), 1–39. https://doi.org/10.1080/03057260701828101

Chiruguru, S. (2020). *The essential skills of 21 st century classroom*. *March*, 1–13. https://doi.org/10.13140/RG.2.2.36190.59201

Chotimah, C., & Fathurrohman, M. (2018). *Paradigma baru sistem pembelajaran*. UIN SATU Tulungagung.

Coyle, K. (2005). *Environmental literacy in America: What ten years of NEETF/roper research and related studies say about environmental literacy in the U.S.* The National Environmental Education & Training Foundation. https://files.eric.ed.gov/fulltext/ED522820.pdf

Csapó, B., & Funke, J. (2017). *The nature of problem solving. Using research to inspire 21st century learning* (Issue April). OECD Publishing. https://doi.org/10.1787/9789264273955-en

Dalida, C. S., Malto, G. A. O., & Lagunzad, C. G. B. (2018). Enhancing students' environmental knowledge and attitudes through community-based learning. *KnE Social Sciences*, *3*(6), 205. https://doi.org/10.18502/kss.v3i6.2381

Daly, S. R., Mosyjowski, E. A., Oprea, S. L., Huang-Saad, A., & Seifert, C. M. (2016). College students' views of creative process instruction across disciplines. *Thinking Skills and Creativity*, *22*, 1–13. https://doi.org/10.1016/j.tsc.2016.07.002

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied*

Developmental Science, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Dörner, D., & Funke, J. (2017). Complex problem solving: What it is and what it is not. *Frontiers in Psychology*, *8*(JUL), 1–11. https://doi.org/10.3389/fpsyg.2017.01153

Eison, J. (2010). Using active learning instructional strategies to create excitement and enhance learning. *Journal of Medical Education*, *59*(2), 20. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.456.7986&rep=rep1&type=pdf

Erdoğan, V. (2019). Integrating 4C Skills of 21st century into 4 language skills in EFL classes. *International Journal of Education and Research*, *7*(11), 113–124. www.ijern.com

Erlina, N., Susantini, E., Wasis, Wicaksono, I., & Pandiangan, P. (2018). The effectiveness of evidence-based reasoning in inquiry-based physics teaching to increase students' scientific reasoning. *Journal of Baltic Science Education*, *17*(6), 972–985. https://doi.org/10.33225/jbse/18.17.972

Ernst, J., & Theimer, S. (2011). Evaluating the effects of environmental education programming on connectedness to nature. *Environmental Education Research*, *17*(5), 577–598. https://doi.org/10.1080/13504622.2011.565119

Farwati, R., Permanasari, A., Firman, H., & Suhery, T. (2017). Integrasi problem based learning dalam STEM education berorientasi pada aktualisasi literasi lingkungan dan kreativitas. *Prosiding Seminar Nasional Pendidikan IPA*, 198–206.

Ferronato, N., & Torretta, V. (2019). Waste mismanagement in developing countries: A review of global issues. *International Journal of Environmental Research and Public Health*, *16*(6). https://doi.org/10.3390/ijerph16061060

Fu, L., Zhang, Y., Xiong, X., & Bai, Y. (2018). Pro-environmental awareness and behaviors on campus: Evidence from Tianjin, China. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(1), 427–445. https://doi.org/10.12973/ejmste/77953

García-González, E., Jiménez-Fontana, R., & Goded, P. A. (2020). Approaches to teaching and learning for sustainability: Characterizing students' perceptions. *Journal of Cleaner Production*, *274*. https://doi.org/10.1016/j.jclepro.2020.122928

Gauvain, M. (2018). Collaborative problem solving: Social and developmental considerations. *Psychological Science in the Public Interest*, *19*(2), 53–58. https://doi.org/10.1177/1529100618813370

Glynn, S. M., & Duit, R. (1996). *Learning Science in the Schools Research Reforming Practice*. Routledge.

Grover, S. M. (2005). Shaping effective communication skills and therapeutic relationship: The Foundation of Collaboration. *AAOHN Journal*, *53*(4), 177–182.

Gultom, E. (2016). Assessment and evaluation in Efl teaching and learning. *Assessment and Evaluation in Efl Teaching and Learning*, 190–198.

Gustiani, S. (2020). Students ' motivation in online learning during Covid-19 pandemic era: A Case study. *Holistics Journal*, *12*(2), 23–40.

Hadzigeorgiou, Y., & Skoumios, M. (2013). The development of environmental awareness through school science: Problems and possibilities. *International Journal of Environmental and Science Education*, *8*(3), 405–426. https://doi.org/10.12973/ijese.2013.212a

Hasan, R., Lukitasari, M., Utami, S., & Anizar, A. (2019). The activeness, critical, and creative thinking skills of students in the Lesson Study-based inquiry and cooperative learning. *JPBI (Jurnal Pendidikan Biologi Indonesia)/Indonesian Journal of Biology Education*, *5*(1), 77–84. https://doi.org/10.22219/jpbi.v5i1.7328

Hawley, K. (2018). *Creativity and knowledge*. Taylor & Francis Group.

Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. *Evidence-Based Nursing*, *18*(3), 66–67. https://doi.org/10.1136/eb-2015-102129

Helms, M. K., Farzaneh, H. H., & Lindemann, U. (2015). Creating bio-inspired solution ideas using biological research articles. In *Multidisciplinary Contributions to the Science of Creative Thinking*. Springer. https://doi.org/10.1007/978-981-287-618-8_13

Herrington, J., Parker, J., & Boase-Jelinek, D. (2014). Connected authentic learning: Reflection and intentional learning. *Australian Journal of Education*, *58*(1), 23–35. https://doi.org/10.1177/0004944113517830

Hines, M. E., Catalana, S. M., & Anderson, B. N. (2019). When learning sinks in: using the incubation model of teaching to guide students through the creative thinking process. *Gifted Child Today*, *42*(1), 36–45. https://doi.org/10.1177/1076217518804858

Hossain, M. I. (2015). *Teaching productive skills to the students: A secondary level scenario*. BRAC University.

Husamah, H. (2015). Thinking skills for environmental sustainability perspective of new students of biology education department through blended project based learning model. *Jurnal Pendidikan IPA Indonesia*, *4*(2), 110–119. https://doi.org/10.15294/jpii.v4i2.3878

Husamah, H., Miharja, F., J., & Hidayati, D., A. (2020). Environmental literacy of Islamic boarding school students: Study in MA Bilingual-Sidoarjo, East Java, Indonesia. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram,* *8*(1), 57-68. https://doi.org/10.33394/j-ps.v8i1.2766

Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). The development and validation of environmental literacy instrument based on spirituality for prospective science teachers. *Eurasia Journal of Mathematics, Science and Technology Education,* *18*(12), em2206. https://doi.org/10.29333/ejmste/12732

Husamah, H., Rahardjanto, A., Hadi, S., Lestari, N., & Ummah BK., M. K. (2023). Spirituality based environmental literacy among prospective biology teacher in Indonesia: Analysis based on gender, accreditation, and semester-level aspects. *JPBI (Jurnal Pendidikan Biologi Indonesia), 9*(3), 418-432. https://doi.org/10.22219/jpbi.v9i3.29500

Husamah, H., Rahardjanto, A., Hadi, S., & Lestari, N. (2024). What are the valuable lessons from global research on environmental literacy in the last two decades? A systematic literature review. *Biosfer: Jurnal Pendidikan Biologi*, *17*(1), 172–195. https://doi.org/10.21009/biosferjpb.37491

Husamah H., Adlini, M. N., Luzyawati, L., & Lestari, N. (2024). Trends and coverage of strengthening literacy in biology learning: Systematic literature review of the Scopus database in four decades. *Jurnal Biolokus: Jurnal Penelitian Pendidikan Biologi dan Biologi,* *7*(1), 19-38. http://dx.doi.org/10.30821/biolokus.v7i1.3550

Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Azrai, E. P., & Heryanti, E. (2019). Students' pro-environmental behavior and environmental learning outcomes based on green consumerism. *Jurnal Pendidikan*

Biologi Indonesia, *5*(1), 109–116. https://doi.org/10.22219/jpbi.v5i1.6447

Jatmiko, B., Widodo, W., Budiyanto, M., & Wicaksono, I. (2015). Inqf-Based Learning on a General Physics for Improving Student ' S Learning Outcomes. *Journal of Baltic Science Educatioan*, *15*(4), 441–451. http://www.scientiasocialis.lt/jbse/files/pdf/vol15/441-451.Jatmiko_JBSE_Vol.15_No.4.pdf

Jianping, L., Minrong, L., Jinnan, W., Jianjian, L., Hongwen, S., & Maoxing, H. (2014). Global environmental issues and human wellbeing. In L. Jianping, L. Minrong, W. Jinnan, L. Jianjian, S. Hongwen, & H. Maoxing (Eds.), *Report on Global Environmental Competitiveness (2013)* (urrent Chi, pp. 3–21). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-54678-5_1

Joshi, Y., & Rahman, Z. (2015). Factors affecting green purchase behaviour and future research directions. *International Strategic Management Review*, *3*(1), 128–143. https://doi.org/https://doi.org/10.1016/j.ism.2015.04.001

Karimzadegan, H., & Meiboudia, H. (2012). Exploration of environmental literacy in science education curriculum in primary schools in Iran. *Procedia - Social and Behavioral Sciences*, *46*, 404–409. https://doi.org/10.1016/j.sbspro.2012.05.131

Keiler, L. S. (2018). Teachers' roles and identities in student-centered classrooms. *International Journal of STEM Education*, *5*(34), 1–20. https://doi.org/10.1186/s40594-018-0131-6

Kim, M. K., Roh, I. S., & Cho, M. K. (2016). Creativity of gifted students in an integrated math-science instruction. *Thinking Skills and Creativity*, *19*, 38–48. https://doi.org/10.1016/j.tsc.2015.07.004

Kim, S., Raza, M., & Seidman, E. (2019). Improving 21st-century teaching skills: The key to effective 21st-century learners. *Research in Comparative and International Education*, *14*(1), 99–117. https://doi.org/10.1177/1745499919829214

Larraz-Rábanos, N. (2021). Development of creative thinking skills in the teaching-learning process. In *Teacher Education - New Perspectives*. IntechOpen. https://doi.org/10.5772/intechopen.97780

Lee, S. M., & Trimi, S. (2018). Innovation for creating a smart future. *Journal of Innovation and Knowledge*, *3*(1), 1–8. https://doi.org/10.1016/j.jik.2016.11.001

Lin-Siegler, X., Ahn, J. N., Chen, J., Fang, F. F. A., & Luna-Lucero, M. (2016). Even einstein struggled: Effects of learning about great scientists' struggles on high school students' motivation to learn science. *Journal of Educational Psychology*, *108*(3), 314–328. https://doi.org/10.1037/edu0000092

Lind, J., Pelger, S., & Jakobsson, A. (2020). Students' knowledge of emerging technology and sustainability through a design activity in technology education. *International Journal of Technology and Design Education*, *32*(1), 243–266. https://doi.org/10.1007/s10798-020-09604-y

Little, J. W. (2007). Professional communication and collaboration. *The Keys to Effective Schools: Educational Reform as Continuous Improvement, Second Edition*, 51–66. https://doi.org/10.4135/9781483329512.n4

Lodge, J. M., Kennedy, G., Lockyer, L., Arguel, A., & Pachman, M. (2018). Understanding difficulties and resulting confusion in learning: An integrative review. *Frontiers in Education*, *3*(June), 1–10. https://doi.org/10.3389/feduc.2018.00049

Loeng, S. (2020). Self-directed learning: A core concept in adult education. *Education*

Research International, *2020*. https://doi.org/10.1155/2020/3816132

Manuel, J. (2021). Reliability, validity and practicality. In *EnglishPost.org*. https://englishpost.org/reliability-validity-and-practicality/

Mardiani, N. D., Husamah, H., Fatmawati, D., Miharja, F. J., & Fauzi, A. (2021). Environmental literacy of students in al-rifa'ie modern Islamic Boarding School, Malang Regency-Indonesia based on gender differences and parents' occupation. *Jurnal Pendidikan Sains Indonesia*, *9*(2), 317–328. https://doi.org/10.24815/jpsi.v9i2.19316

Mauliya, I., Relianisa, R. Z., & Rokhyati, U. (2020). Lack of motivation factors creating poor academic performance in the context of graduate English Department Students. *Linguists : Journal Of Linguistics and Language Teaching*, *6*(2), 73. https://doi.org/10.29300/ling.v6i2.3604

McBride, B.B., Brewer, C.A., Berkowitz, A.R., & Borrie, W.T. (2013). Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here? *Ecosphere*, *4*(5), 67. https://doi.org/10.1890/ES13-00075.1

Meilinda, H., Prayitno, B. A., Maret, U. S., Karyanto, P., & Maret, U. S. (2017). *Student ' s environmental literacy profile of adiwiyata green school in student ' s environmental literacy profile of adiwiyata green school in Surakarta, Indonesia*. *August*. https://doi.org/10.11591/edulearn.v11i3.6433

Milrad, M. (2013). *Designing an interactive learning environment to support children ' s understanding in complex domains September 1999*.

Milrad, M. (1999). Designing an Interactive learning environment to support children ' s understanding in complex domains. *EdMedia + Innovate Learning*, *September 1999*, 1–179.

Moulton, E., Bradbury, K., Barton, M., & Fein, D. (2019). Factor analysis of the childhood autism rating scale in a sample of two year olds with an autism spectrum disorder. *J Autism Dev Disord.*, *49*(7), 2733–2746. https://doi.org/10.1007/s10803-016-2936-9

Muhdhar, M. H. I. A., Wardhani, Y. S., Prasetyo, T. I., Sumberartha, I. W., Mardiyanti, L., & Supriatin, S. W. (2021). Improved collaborative skills and environmental literacy through the E-UKBM of surrounding nature exploration. *AIP Conference Proceedings*, *2330*(March). https://doi.org/10.1063/5.0043097

Munawaroh. (2017). The influence of teaching methods and learning environment to the student's learning achievement of craft and entrepreneurship subjects at vocational high school. *international Journal of Environmental and Science Education*, *12*(4), 665–678.

Mustami, M. K., Syamsudduha, S., Safei, & Ismail, M. I. (2019). Validity, practicality, and effectiveness development of biology textbooks integrated with augmented reality on high school students. In *International Journal of Technology Enhanced Learning* (Vol. 11, Issue 2, pp. 187–200). https://doi.org/10.1504/IJTEL.2019.098789

Needhidasan, S., Samuel, M., & Chidambaram, R. (2014). Electronic waste - An emerging threat to the environment of urban India. *Journal of Environmental Health Science and Engineering*, *12*(1), 1–9. https://doi.org/10.1186/2052-336X-12-36

Nieveen, N. (1999). Prototyping to Reach Product Quality. In T. Plomp, N. Nieveen, K. Gustafson, R. M. Branch, & J. van den Akker (Eds.), *Design approaches and tools in education and training. London:* Kluwer Academic Publisher.

Nugraheni, E. (2014). Pengantar Ilmu Lingkungan. In *Pengetahuan Dasar Ilmu Lingkungan*. Universitas Terbuka.

Nurwidodo, N., Hadi, S., Ibrohim, I., & Sueb, S. (2021). Validity and practicality of the EMKONTAN learning model to improve creative thinking, collaborative and literacy environment of prospective biology teacher students. *The 12th International Conference on Lesson Study (ICLS-XII)*, 221–232. https://jurnal.unimus.ac.id/index.php/psn12012010/article/download/9015/6048

Nurwidodo, N., Romdaniyah, S. W., Sudarmanto, S., Rosanti, D., Kurniawati, K., & Abidin, Z. (2021). Analisis profil berpikir kritis, kreatif, keterampilan kolaboratif, dan literasi lingkungan siswa kelas 8 SMP Muhammadiyah sebagai impak pembelajaran modern. *Bioscientist: Jurnal Ilmiah Biologi*, *9*(2), 605–619. https://doi.org/10.33394/bioscientist.v9i2.4642

OECD. (2019). PISA 2021 creative thinking framework. *Oecd*, *53*(9), 1689–1699. https://www.oecd.org/pisa/publications/PISA-2021-creative-thinking-framework.pdf

Orr, M. T., Pecheone, R., Snyder, J. D., Murphy, J., Palanki, A., Beaudin, B., Hollingworth, L., & Buttram, J. L. (2018). Performance assessment for principal licensure: evidence from content and face validation and bias review. *Journal of Research on Leadership Education*, *13*(2), 109–138. https://doi.org/10.1177/1942775117701179

Papaleontiou- Louca, E., Varnava-Marouchou, D., Mihai, S., & Konis, E. (2014). Teaching for creativity in universities. *Journal of Education and Human Development*, *3*(4), 131–154. https://doi.org/10.15640/jehd.v3n4a13

Partnership for 21st Century Skills. (2015). *P21 Framework Definitions*. Partnership for 21st Century Skills. http://www.p21.org/our-work/p21-framework

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Perdiawan, Z., & Kartini, K. (2021). Efektivitas model pembelajaran environmental learning terhadap motivasi dan hasil belajar siswa. *Binomia*, *4*(2), 109–124.

Pereira, J. C. (2015). Environmental issues and international relations, a new global disorder. *Journal of Ecosystem & Ecography*, *58*(1), 191–209. https://doi.org/10.1590/0034-7329201500110

Peters-burton, E. E., & Stehle, S. M. (2019). Developing student 21 st Century skills in selected exemplary inclusive STEM high schools. *International Journal of STEM Education*, *1*, 1–15.

Plomp, T., & Nieveen, N. (2013). Educational design research educational design research. *Netherlands Institute for Curriculum Development: SLO*, 1–206. http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ815766

Price, P. C., Jhangiani, R., & Chiang, I.-C. A. (2015). *Reliability and validity of measurement – Research methods in psychology* (2nd Ed.). BCcampus. https://opentextbc.ca/researchmethods/chapter/reliability-and-validity-of-measurement/

Richard P. Bagozzi, Y. Y. and L. W. P. (2013). Bogazzi_Assesing construct validity in organiational research. *Administrative Science Quarterly*, *36*(3), 421–458. http://www.jstor.org/stable/2393203

Rico, M. N. (1998). *Gender, the environment and the sustainability of development*. United Nations.

Saleh, H. (2019). Convergent and divergent thinking in problem solving (Case study on junior high school students). *International Journal of Insights for Mathematics Teaching (IJOIMT)*, *2*(1), 11–21. http://journal2.um.ac.id/index.php/ijoimt/article/view/7119

Samson, P. L. (2015). Fostering student engagement: Creative problem-solving in small group facilitations. *Collected Essays on Learning and Teaching*, *8*, 153. https://doi.org/10.22329/celt.v8i0.4227

Sandoval, W. (2014). Conjecture mapping: An approach to systematic educational design research. *Journal of the Learning Sciences*, *23*(1), 18–36. https://doi.org/10.1080/10508406.2013.778204

Santoso, B., Marchira, C. R., & Sumarni, P. (2017). Development and validity and reliability tests of professionalism assessment instrument in psychiatry residents. *Jurnal Pendidikan Kedokteran Indonesia: The Indonesian Journal of Medical Education*, *6*(1), 60. https://doi.org/10.22146/jpki.25369

Schmitz, M. J., & Winskel, H. (2008). Towards effective partnerships in a collaborative problem-solving task. *British Journal of Educational Psychology*, *78*(4), 581–596. https://doi.org/10.1348/000709908X281619

Serdyukov, P. (2017). Innovation in education: What works, what doesn't, and what to do about it? *Journal of Research in Innovative Teaching & Learning*, *10*(1), 4–33. https://doi.org/10.1108/jrit-10-2016-0007

Shao, Y., Zhang, C., Zhou, J., Gu, T., & Yuan, Y. (2019). How does culture shape creativity? A mini-review. *Frontiers in Psychology*, *10*(MAY). https://doi.org/10.3389/fpsyg.2019.01219

Sibiya, M. N. (2018). *Effective Communication in Nursing*. IntechOpen. https://www.intechopen.com/books/nursing/effective-communication-in-nursing

Soller, A. (2001). Supporting social interaction in an intelligent collaborative learning system. *International Journal of Artificial Intelligence in Education*, *12*.

Song, X., Cong, Y., Song, Y., Chen, Y., & Liang, P. (2021). A bearing fault diagnosis model based on CNN with wide convolution kernels. *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-021-03177-x

Sternberg, R. J. (2018). The nature of human intelligence. In *American Educational Research Journal*. Cambridge University Press. https://doi.org/10.1017/9781316817049

Sulistyani, U. N. L. (2018). The Importance of needs analysis in a language curriculum development : An evaluation to 2013 curriculum. *UHAMKA International Conference on ELT and CALL (UICELL), November*, 143–152.

Sumarmi, Aliman, M., & Mutia, T. (2021). The effect of digital eco-learning in student worksheet flipbook to environmental project literacy and pedagogic competency. *Journal of Technology and Science Education*, *11*(2), 357–370. https://doi.org/10.3926/jotse.1175

Sun, M., Wang, M., & Wegerif, R. (2020). Effects of divergent thinking training on students' scientific creativity: The impact of individual creative potential and domain knowledge. *Thinking Skills and Creativity*, *37*(July). https://doi.org/10.1016/j.tsc.2020.100682

Taconis, R., Ferguson-Hessler, M. G. M., & Broekkamp, H. (2001). Teaching science problem solving: an overview of experimental work. *Journal of Research in Science Teaching*, *38*, 442–468. https://doi.org/10.1021/ed078p1162

Tharayil, S., Borrego, M., Prince, M., Nguyen, K. A., Shekhar, P., Finelli, C. J., & Waters, C. (2018). Strategies to mitigate student resistance to active learning. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0102-y

Wehmeyer, M. L., Shogren, K. A., Palmer, S. B., Williams-Diehm, K. L., Little, T., & Boulton, A. (2012). Impact of the self-determined learning model of instruction on self-determination: A Randomized-trial control group study. *Exceptional Children*, *78*(2), 135–153. https://doi.org/10.1177/001440291207800201

Wicaksono, I., Jatmiko, B., & Prastowo, T. (2015). Pengembangan perangkat pembelajaran fisika model learning cycle 5E untuk meningkatkan pemahaman konsep siswa pada materi fluida statis. *JPPS (Jurnal Penelitian Pendidikan Sains)*, *4*(2), 518. https://doi.org/10.26740/jpps.v4n2.p518-524

Wicaksono, I., Wasis, & Madlazim. (2017). The effectiveness of virtual science teaching model (VS-TM) to improve student's scientific creativity and concept mastery on senior high school physics subject. *Journal of Baltic Science Education*, *16*(4), 549–561. https://doi.org/10.33225/jbse/17.16.549

Wong, C. A., Afandi, S. H. M., Ramachandran, S., Kunasekaran, P., & Chan, J. K. L. (2018). Conceptualizing environmental literacy and factors affecting pro-environmental behaviour. *International Journal of Business and Society*, *19*(S1), 128–139.

Wu, E., Cheng, J., & Zhang, J. (2020). Study on the environmental education demand and environmental literacy assessment of citizens in sustainable urban construction in Beijing. *Sustainability*, *12*(241), 1–23. https://doi.org/10.3390/su12010241