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Development of a Physics Learning Model Based on Ecopedagogy Approach to Foster Disaster Mitigation Awareness

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Abstract: Climate change has drastically increased natural disasters, with Indonesia ranking third among disaster-prone countries. This research aims to develop a learning model to build disaster mitigation awareness through education. The study focuses on Pidie Regency, Aceh, an area prone to various natural disasters including earthquakes, tsunamis, and volcanic eruptions. The research employs a Research and Development design using the Plomp model, consisting of five phases: investigation, design, realization/construction, test/evaluation/revision, and implementation. The result is the Ecopedagogy Rescue (EcoRescue) learning model, which enables students to explore and discover information about disaster issues and mitigation efforts. Validation scores indicate that the EcoRescue model is valid, with 87.5% for design and 91% for content. The effectiveness score based on teacher responses reached 86.4%, categorizing the model as highly effective in physics education. This study's novelty lies in developing an ecopedagogy-based learning model incorporating disaster mitigation content. The research recommends physics teachers to implement the EcoRescue model in high school physics courses, aiming to enhance students' awareness and understanding of disaster mitigation in their local context.

Keywords: Development; Ecopedagogy; Disaster Mitigation Awareness; Plomp.

Introduction

Climate change has led to a drastic increase in natural disasters. Indonesia ranks third among disaster-prone countries with an increase of 81 percent. Therefore, disaster mitigation has become an important factor in reducing risks caused by disasters. Efforts to reduce disaster impacts heavily depend on the extent to which communities are aware of the risks they face. One strategy to raise awareness is by changing individual understanding of various aspects (Mulilis et al., 2000). Education about disasters plays a significant role in preparing individuals to face disaster challenges, both in the short and long term (Frankenberg et al., 2013). Steps to address disasters include preventive actions taken by individuals, families, and the community as a whole (Hafida, 2018). Therefore, losses due to disasters can be minimized if the community has good disaster mitigation awareness.

According to data released by the Ministry of Education and Culture, natural disasters striking Indonesia have affected 568,000 students in 5,680 educational institutions during the 2016-2019 period, with economic losses exceeding one trillion (Masrizal and Iqbal, 2022). There are 54,080 schools located in flood-prone areas, 52,902 schools in earthquake-prone areas, 15,597 schools in landslide-prone areas, 2,417 schools in tsunami-prone areas, and 1,685 schools in areas prone to volcanic eruptions (Koswara et al., 2019).

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Some of the disaster-prone schools in this data are located in Pidie Regency, Aceh. Natural disaster potentials in Pidie Regency include earthquakes, flash floods, tsunamis, strong winds, landslides, and volcanic eruptions. There is one active volcano that constantly spews lava, which is the most active underwater volcano in Indonesia named Mount Peut Sagoe, and two active volcanoes flanking the Pidie regency area. These mountains are located between the coastal areas of Sigli city, a coast swept by the tsunami waves in December 2004. The tsunami disaster submerged half of the capital area of Pidie Regency, along with hundreds of its inhabitants, according to data from BNPB and USGS (Djatmiko, 2016). In December 2016, Pidie Jaya Regency, which was expanded from Pidie Regency, was hit by a 6.5 magnitude earthquake that resulted in many casualties and damaged infrastructure. Pidie and Pidie Jaya Regencies face a tsunami threat with an alert status and a golden time (the difference between earthquake time and tsunami arrival time) of 24 minutes and 55 seconds. This time difference is the period that can be used to evacuate and save oneself from the potential tsunami threat after an earthquake, but to confirm the potential tsunami threat, real-time tidal data parameters are needed (Apriyadi et al., 2021). Besides tsunamis, other natural disasters such as flash floods and landslides in Tangse District from 2011 until now have become a special concern for the Government that has not been resolved.

According to the above data on disaster potential and impact, there is a need for efforts to build community awareness to be able to recognize disaster potential in their area and understand disaster mitigation efforts. Efforts to form disaster mitigation awareness can be done through school learning by creating learning models that allow students to explore, discover information and knowledge about disaster issues and disaster mitigation efforts. The use of innovative learning models and methods in disaster education can facilitate deeper discussions between students and teachers (Gampell et al., 2020), building environmental awareness and disaster resilience in students not only enhances their knowledge, skills, and disaster preparedness attitudes, but also has a clear impact in shaping their character and concern for the environment and encouraging active participation in disaster prevention and management efforts (Suarmika & Utama, 2017). To address the need for learning models that can form disaster preparedness or mitigation, especially for students, there are several high school physics learning materials oriented towards natural phenomena. Therefore, it is necessary to develop a physics learning model that can respond to the need for growth in students' knowledge, ecological attitudes, and environmentally caring character.

The development of a physics learning model that can hone aspects of ecological awareness and environmental character can be developed by integrating the ecopedagogy approach. The aim is to build students' knowledge and awareness regarding surrounding environmental conditions (Ahi & Balcı, 2018; McGibbon & Van Belle, 2015; Payne, 2015). This perspective is one of the efforts to change behavior and attitudes conducted by students. The goal is to increase students' knowledge, skills, and awareness about environmental values and issues. Thus, this ecopedagogy approach can be applied through physics learning. With a physics learning model based on the ecopedagogy approach, it is expected to build ecological awareness through an educational process that positions students as active subjects in learning (Muchsin & Hamdi, 2021).

The purpose of this research is to create a physics learning model based on the ecopedagogy approach in shaping students' awareness to be able to recognize disaster potential in their area and understand disaster mitigation efforts. Efforts to form disaster mitigation awareness are carried out through school learning by creating a learning model based on the ecopedagogy approach that allows students to explore, discover information and knowledge about disaster issues and disaster mitigation efforts. The resulting physics learning model includes four operational concepts of the learning model consisting of: (1) syntax; (2) social system; (3) reaction principle; (4) support system (Joyce, B., Weil, M., & Calhoun, 2004).

The advantage of the problem-solving approach taken is different from previous research related to disaster mitigation in learning. The novelty of this research is the development of a learning model based on the ecopedagogy approach that contains disaster mitigation content where students explore, investigate problems, discover information and knowledge about disaster issues.

The ultimate goal of this article is to present the development of an innovative learning model based on the ecopedagogy approach, which integrates disaster mitigation content. This model aims to enhance students' critical thinking and problem-solving skills by engaging them in exploration, investigation, and discovery of knowledge related to disaster issues. Through this approach, the article seeks to contribute to the field of educational research by offering a novel framework that addresses disaster mitigation in a more interactive and student-centered manner, distinguishing itself from previous studies.

Method

The research was conducted using a Research and Development design with the Plomp model. The Plomp model is considered more flexible compared to other development models because in each phase of its activities can be adjusted to the characteristics of the research. The application of the Plomp model consists of five phases: investigation phase, design phase, realization/construction phase, test, evaluation and revision phase, and implementation phase. However, given the conditions and time constraints, this study only applied four phases, namely (1) Initial investigation phase, conducted by analyzing problems or needs; (2) Design phase, aimed at designing problem solutions; (3) Realization/construction phase, carried out with production activities such as textbook development; and (4) Test, evaluation, and revision phase, conducted through systematically collecting, processing, and analyzing information to obtain results from problem-solving (Rochmad, 2012).

The research location is in high schools spread across Pidie and Pidie Jaya Regencies. One school from each regency will be selected to represent the trial of the learning model development. Additionally, the research subjects are students and teachers who will implement the physics learning model based on the ecopedagogy approach. Focus Group Discussions (FGD) were conducted with physics teachers in Pidie and Pidie Jaya Regencies. FGDs were held for research preparation, such as understanding the picture of physics learning implemented by teachers, forming a team for designing and developing instructional designs for the implementation of the physics learning model in schools.

The instruments used in this study are: validation sheets, observation sheets, student and teacher response questionnaires, and product assessment sheets. The data obtained during expert validation are responses or suggestions given by experts on the physics learning model. These responses form the basis for revision before trial. The trial design conducted is a field trial aimed at determining whether the physics learning model can be implemented in learning. Data Analysis Technique: Trial data were analyzed using descriptive statistical methods. This analysis is used to determine the questionnaire scores given to respondents. Response data uses a Likert scale presented in a relative frequency distribution table. To obtain relative frequency, the following formula is used (Sugiyono, 2008).

$$percentage = \frac{\sum questionnaire\ response\ scores}{n\ x\ highest\ score\ x\ \sum student}\ x\ 100 \qquad (1)$$

Description:
n = number of questionnaire items

The conclusion regarding the effectiveness of the product through teacher and student responses is shown in Table 1.

Table 1. Effectiveness Learning Model

Level of achievement	explanation
80.1% - 100%	Very effective
70.1% - 80%	Effective
60.1% - 70%	Quite effective
50.1% - 60%	Less effective
1% - 50%	Not effective

Result and Discussion

Product Design of the Ecopedagogy Learning Model

The developed learning model is named Ecopedagogy Rescue (EcoRescue). This model was developed using the Plomp model. The application of the Plomp model consists of five phases: investigation phase, design phase, realization/construction phase, test, evaluation and revision phase, and implementation phase. However, considering the conditions and time constraints, this research only applies four phases: (1) Initial investigation phase, conducted by analyzing problems or needs; (2) Design phase, aimed at designing problem solutions; (3) Realization/construction phase, carried out with production activities such as textbook development; and (4) Test, evaluation, and revision phase, conducted through systematically collecting, processing, and analyzing information to obtain results from problem-solving (Rochmad, 2012). The resulting physics learning model encompasses four operational concepts of learning models consisting of: (1) syntax; (2) social system; (3) principles of reaction; (4) support system (Joyce, B., Weil, M., & Calhoun, 2004). These are explained in the points below.

1. *Syntax*

The syntax of the Ecopedagogy Rescue (EcoRescue) learning model presents systematic steps in an ecopedagogy-based learning model, where the main focus is linking physics concepts with disaster mitigation. Each step in this syntax is designed to build students' awareness of environmental issues while enhancing their understanding of relevant physics concepts. The syntax of the developed model is shown in Table 2.

Table 2. Syntax of the EcoRescue Learning Model

Stages	Syntax/Learning Steps
Phases 1	Identify problems (issues related to disasters and environmental issues).
Phases 2	Analyze problems (problem analysis) or analyze needs (needs analysis).
Phases 3	Design learning objectives and activity implementation plans.
Phases 4	Provide an overview of disaster mitigation concepts.
Phases 5	Design an EcoRescue based learning model that integrates physics concepts with disaster mitigation.
Phases	Observe natural phenomena and conduct experiments or simulations of earthquakes/tsunamis.
Phases 7	Explain disaster phenomena and link observation results with physics theories.
Phases 8	Work in groups to design disaster mitigation solutions to solve real-world problems.
Phases 9	Present disaster mitigation solutions.
Phases 10	Provide feedback and measure student understanding through quizzes or tests.
Phases 11	Reflection.

2. *Social System*

The social system or learning environment represents the situations and norms that apply in EcoRescue Learning, such as teacher-student interactions during the learning process. The teacher acts as a facilitator who guides students to think critically, discuss, and collaborate in groups. Students are not merely recipients of information but are also active in formulating solutions and participating in disaster simulations and mitigation exercises. Social relationships among students are characterized by team collaboration in completing tasks related to disaster mitigation, such as designing earthquake-resistant buildings or creating evacuation plans. Through group work, students learn from each other and share knowledge, strengthening collective understanding of responsibilities in facing disasters.

3. *Principles of Reaction*

The principles of reaction are patterns of activity that describe the teacher's response to students, both individually and in groups, and discussing them, presenting student findings in front of the class. The principles of reaction in the learning model component also include the teacher's role in providing optimal and timely learning instructions. The principles of reaction in the EcoRescue learning model emphasize active and participatory responses from students in the learning process to form disaster mitigation awareness. The teacher acts as a facilitator who provides constructive feedback, encourages students to think critically, and links physics concepts with real-life disaster situations. Students are expected to respond to given challenges through experiments, disaster simulations, and active group discussions. In this model, student reactions are not limited to theoretical understanding but also include tangible actions in designing mitigation solutions, such as creating disaster-resistant building models or conducting evacuation simulations. Through this direct involvement, students are more motivated to understand their responsibilities towards the environment and preparedness in facing disasters, while internalizing disaster mitigation awareness in their daily lives.

4. *Support System*

The support system in the EcoRescue learning model plays a crucial role in enhancing learning effectiveness and fostering disaster mitigation awareness. This system encompasses various resources and aids that support the learning process, such as visual media (videos, digital simulations), props (earthquake-resistant building models, tsunami simulations), and disaster mitigation-based learning guides. Additionally, support from the school community, local government, and disaster management organizations is an integral part of this system. With the involvement of external parties, such as mitigation experts or rescue teams, students can gain a deeper and more contextual understanding of natural disasters and effective mitigation actions. Technological infrastructure, reading materials, and access to environmental resources are also essential in ensuring students receive a real and relevant learning experience, enabling them to better internalize disaster mitigation awareness.

Validation of the EcoRescue Learning Model Design

1. *Design/Plan Expert Validation*

Based on the human and environmental model components. The expected project outcomes in the learning model from (Joyce, B., Weil, M., & Calhoun, 2004) include 4 components in the model design: (1) syntax design of the Ecopedagogy Rescue (EcoRescue) learning model, (2) social system applicable to the developed model, (3) principles of reaction, (4) support system. These four components are validated by learning experts as a form of student activity in demonstrating disaster mitigation awareness attitudes. Table 3 below shows the results of the design expert validation. Its relation to the physics theme that serves as the basis for developing the EcoRescue model is that the syntax stages include problem-solving and solutions that are connected to the interaction theme.

Table 3. Results of Design Expert Validation

Aspek	Skor 1	2	3	4
Supporting Theory of Learning Model				√
Background of Learning Model Development				√
Objectives of Learning Model Development			√	
Description of Learning Model				√
Syntax of Learning Model			√	
Applicable Social System			√	
Model Support System				√
Use of Learning Approach			√	
Suitability of Learning Steps				√
Alignment of Learning Objectives with Material			√	
Evaluation and Assessment				√
Desired Learning Outcomes			√	

The total validation score from the design expert is 42. To determine the validity of the product, it can be calculated as follows:

$$percentage = \frac{\sum questionnaire\ response\ scores}{n\ x\ highest\ score}\ x\ 100$$
$$= \frac{\sum 42}{12\ x\ 4}\ x\ 100$$
$$= 87{,}5\%$$

Based on the score calculation, the Ecopedagogy Rescue (EcoRescue) learning model can be considered valid with an achievement of 87.5 percent, although minor revisions are recommended. This validation indicates that the learning model design has met the basic criteria for implementation in physics learning, but requires refinement in several aspects. This aligns with the perspective of (Dick et al., 2005), who emphasize that the learning model validation process aims to ensure the relevance, consistency, and effectiveness of a design in achieving learning objectives.

One of the primary revisions recommended by the validator is to clarify the learning model development objectives, especially the expected instructional impacts. According to (Winn, 2004), instructional objectives must be designed specifically to ensure that the learning process can generate measurable learning outcomes, both in cognitive, affective, and psychomotor domains. In the context of EcoRescue, this means ensuring that instructional impacts include students' understanding of physics concepts, awareness of disaster mitigation issues, as well as critical thinking and collaborative skills.

Additionally, validator input also includes revisions to the learning model syntax by adding syntactical elements that must be present in the model's implementation. According to (Joyce, B., Weil, M., & Calhoun, 2004), learning model syntax is a critical component that guides the learning process. Clear syntax will help teachers manage learning steps systematically, thereby achieving learning objectives more effectively. In this case, the EcoRescue model syntax is expected to include steps of exploration, analysis, synthesis, and implementation of disaster mitigation solutions integrated with physics concepts.

Input from the validator also serves as a basis for revisions to ensure the learning model's feasibility. As proposed by (McKenney & Reeves, 2014), the formative evaluation phase in learning model development plays a crucial role in identifying the strengths and weaknesses of the initial design, thereby producing a more effective and applicable final product. At this stage, expert feedback is used to improve weaknesses and refine the model before implementation on a broader scale.

Generally, these validation and revision results demonstrate that the EcoRescue learning model not only has the potential to enhance physics learning effectiveness but also contributes to developing environmental awareness and disaster mitigation skills among students.

2. *Content Expert Validation*

The content expert validation provides recommendations regarding relevance, accuracy, and completeness of the presentation in the developed learning model toolkit. The following are the results of the content expert validation summarized in Table 4.

The total validation score from the content expert is 51. To determine the validity of the product, it can be calculated as follows:

$$percentage = \frac{\sum questionnaire\ response\ scores}{n\ x\ highest\ score\ x\ \sum student}\ x\ 100$$
$$= \frac{\sum 51}{14\ x\ 4}\ x\ 100$$
$$= 91\%$$

Based on the validation results, the Ecopedagogy Rescue (EcoRescue) learning model has obtained a validation score of 91 percent. This indicates that the content aspects contained in the EcoRescue components can be used with minor revisions to ensure its feasibility. Based on validator input, the required improvements involve refining the learning model development objectives, especially to integrate specific instructional learning impacts. Additionally, the learning syntax is recommended to be expanded to include steps relevant to the model's practical implementation.

Table 4. Content Validation Results

Assessment Aspects	Description	Score			
		1	2	3	4
Relevance	1. The material is relevant to the competencies that students must master.			√	
	2. The completeness of the material is appropriate for the students' developmental level.			√	
	3. The material adequately meets curriculum requirements.				√
	4. The illustration of learning syntax can be understood.				√
Accuracy	1. The presented material aligns with scientific accuracy.				√
	2. The presented material corresponds to contextual and current environmental issues.				√
Completeness of Presentation	1. Presents competencies that students must master.			√	
	2. There are guidelines for the learning model.				√
Basic Concepts Content	1. Alignment with the human-environment interaction theme concept.			√	
	2. Alignment with the environmental literacy concept.				√
Conformity of Presentation with student-centered learning requirements	1. Encourages students' environmental awareness attitude.				√
	2. Encourages student interaction.			√	
	3. Encourages students to build their own knowledge and provide solutions.				√
	4. Encourages students to learn in groups.				√

These results align with the situated cognition theory-based learning model development approach, which emphasizes that the learning process becomes more effective when students are engaged in real-context-based activities. This principle is relevant to recent research showing that problem-based learning can enhance student understanding through direct involvement with environmental and disaster mitigation issues (He et al., 2023).

Furthermore, other research emphasizes the importance of coherence in learning systems, which includes curriculum alignment, instruction, and evaluation. This principle is applied in the EcoRescue model design to ensure all components support students' knowledge development progressively and comprehensively (Geier et al., 2008).

In the context of content validation, it is crucial to consider evaluator input in refining teaching materials to meet eco-pedagogy-based learning needs. For example, improving learning materials such as context-based local modules and handbooks can support students' understanding of disaster mitigation while enhancing the quality of their learning experiences (Alciso et al., 2023).

Through revisions and development based on this validation, the EcoRescue model has significant potential to become an effective tool in supporting environmentally conscious physics learning. Integrating evidence-based learning design principles can further strengthen its implementation and impact on student learning outcomes.

Implementation of the EcoRescue learning model

The implementation of the developed learning model is explained in Table 5.

Table 5. Learning Model Implementation

Aspek Penilaian	Skor			
	1	2	3	4
Convey learning objectives and motivate students			√	
Provide information about the concepts being studied				√
Divide students into heterogeneous working groups			√	
Provide worksheets to each group as a guide for group work			√	
Guide students in making observations and formulating problems, providing guidance, encouragement, and assistance when needed			√	
Ask representatives from each group to present their observation results				√
Respond to the presentations of each group				√
Ask students to demonstrate the project worked on in groups				√
Provide a base score calculated from the average performance of students in previous presentations				√
Calculate individual and group scores			√	
Give awards to the group with the best score			√	

Based on the results of teacher responses to the implementation of the model in physics learning, its effectiveness is known as follows:

$$percentage = \frac{\sum questionnaire\ response\ scores}{n\ x\ highest\ score\ x\ \sum student}\ x\ 100$$

$$= \frac{\sum 38}{11\ x\ 4}\ x\ 100$$

$= 86{,}4\%$

Based on the calculation results, the effectiveness score of teacher responses reached 86.4 percent. This indicates that the implementation of learning using the EcoRescue model in physics education can be categorized as highly effective. These findings are consistent with research emphasizing the importance of problem-based approaches to enhance student engagement in learning, particularly in topics relevant to real-life situations, such as disaster mitigation (Hmelo-Silver, 2004).

The EcoRescue model, based on ecopedagogy, is designed to integrate physics concepts with environmental issues and disaster mitigation, aligning with a contextual learning approach. As stated by (Lave & Wenger, 2012), context-based learning can improve students' understanding by connecting theory with real-world applications. In this case, students not only learn physics concepts but also understand the importance of disaster mitigation through exploration, simulation, and experimentation.

These findings are supported by previous research showing that project-based or problem-based approaches can enhance students' critical thinking skills and social awareness (Kolodner et al., 2003). The EcoRescue model allows students to analyze problems, design solutions, and present their ideas, which are crucial steps in preparing them to face real-world challenges. Additionally, research by (Freire, 1997) suggests that critical awareness-based learning can shape individuals who are more sensitive to environmental and social issues.

Compared to conventional learning models, the EcoRescue model provides a holistic approach that focuses not only on the transfer of physics knowledge but also on shaping students' character, such as environmental awareness and collaboration skills (Johnson, 1999) This is highly relevant in the context of 21st-century learning, where education must be able to produce a generation that not only masters knowledge but also possesses social care and collaborative skills (Trilling, B., & Fadel, 2009).

Thus, this research contributes new insights to the fields of physics education and disaster mitigation. The position of this research strengthens the importance of the ecopedagogy approach as an effective method for improving contextual learning effectiveness, which has not been widely applied in physics education previously.

Conclusion

The syntax of the Ecopedagogy Rescue (EcoRescue) learning model outlines a sequence of activities that encourage students to develop awareness of potential natural disasters in their region and understand mitigation efforts. The steps of the Ecopedagogy Rescue (EcoRescue) model are as follows (1) Problem identification (issues related to disasters and environmental concerns), (2) Problem analysis or needs analysis, (3) Designing learning objectives and activity implementation plans, (4) Providing an overview of disaster mitigation concepts, (5) Designing an Ecopedagogy Rescue (EcoRescue)-based learning model that integrates physics concepts with disaster mitigation, (6) Observing natural phenomena and conducting earthquake/tsunami experiments or simulations, (7) Explaining disaster phenomena and linking observations to physics theory, (8) Working in groups to design disaster mitigation solutions for real-world problems, (9) Presenting disaster mitigation solutions, (10) Providing feedback and assessing student understanding through quizzes or tests, (11) Reflection. Based on the validation score calculations, the Ecopedagogy Rescue (EcoRescue) learning model is considered valid, with scores of 87.5 percent (design) and 91 percent (content), though minor revisions are recommended. Additionally, the effectiveness score of teacher responses reached 86.4 percent, categorizing the implementation of this model in physics education as highly effective.

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Author Contributions
Muhammad Saiful contributed to conceptualizing the study, developing the product, analyzing the data, and writing the article. Muchsin, the supervisor of research activities up to article writing, conducted reviews and editing.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

References

Ahi, B., & Balcı, S. (2018). Ecology and the child: Determination of the knowledge level of children aged four to five about concepts of forest and deforestation1. *International Research in Geographical and Environmental Education*, *27*(3), 234–249.

https://doi.org/10.1080/10382046.2017.1349372

Alciso, R. M., Boo, A. A., Julongbayan, P. E., Ramos, Q. G., Aclan, B. L., & Porley, R. N. (2023). Development of outcomes-based instructional materials in professional teacher education courses for a flexible set-up. *Journal of Education and E-Learning Research*, *10*(1), 61–67. https://doi.org/10.20448/jeelr.v10i1.4378

Apriyadi, R. K., Kurniawan, W., Yulianto, S., Syamsunasir, S., Dewa Ketut Kerta Widana, I., Subiyanto, A., Bahar, F., & Cipto Kuncoro, D. (2021). Estimasi Ancaman Gempabumi dan Tsunami di Kabupaten Pidie Jaya Aceh untuk Mendukung Keamanan Nasional. *PENDIPA Journal of Science Education*, *6*(1), 1–7. https://doi.org/10.33369/pendipa.6.1.1-7

Dick, W., Carey, L., & Carey, J. O. (2005). *EDTC 6321: Instructional Design SUMMER I SYLLABUS*. 376.

Djatmiko, H. T. (2016). *Gempabumi Kuat M=6.5 Guncang Pidie Jaya, Provinsi Aceh Dipicu Akibat Aktivitas Sesar Aktif*. *2*, 2–4. https://www.bmkg.go.id/press-release/?p=gempabumi-kuat-m6-5-guncang-pidie-jaya-provinsi-aceh-dipicu-akibat-aktivitas-sesar-aktif&tag=press-release&lang=ID

Frankenberg, E., Sikoki, B., Sumantri, C., Suriastini, W., & Thomas, D. (2013). Education, vulnerability, and resilience after a natural disaster. *Ecology and Society*, *18*(2). https://doi.org/10.5751/ES-05377-180216

Freire, P. (1997). *Opening up Paulo Freire ' s Pedagogy of the Oppressed*. 1–15.

Gampell, A., Gaillard, J. C., Parsons, M., & Le Dé, L. (2020). 'Serious' Disaster Video Games: An Innovative Approach to Teaching and Learning about Disasters and Disaster Risk Reduction. *Journal of Geography*, *0*(0), 159–170. https://doi.org/10.1080/00221341.2020.1795225

Geier, R., Blumenfeld, P. C., Marx, R. W., Krajcik, J. S., Fishman, B., Soloway, E., & Clay-Chambers, J. (2008). Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform. *Journal of Research in Science Teaching*, *45*(8), 922–939. https://doi.org/10.1002/tea.20248

Hafida, S. H. N. (2018). Urgensi Pendidikan Kebencanaan Bagi Siswa Sebagai Upaya Mewujudkan Generasi Tangguh Bencana. *Jurnal Pendidikan Ilmu Sosial*, *28*(2), 1–10.

He, P., Krajcik, J., & Schneider, B. (2023). Transforming standards into classrooms for knowledge-in-use: an effective and coherent project-based learning system. *Disciplinary and Interdisciplinary Science Education Research*, *5*(1). https://doi.org/10.1186/s43031-023-00088-z

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266.

Johnson, D. W. J. and R. T. (1999). Making Cooperative Learning Work. *Theory Into Practice*, *38*(2), 67–73. https://doi.org/10.1080/00940771.1995.11496127

Joyce, B., Weil, M., & Calhoun, E. (2004). Models Of Teaching (7th Ed). *Pearson Allyn And Bacon.*, *112*.

Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., & Ryan, M. (2003). Problem-Based Learning Meets Case-Based Reasoning in the Middle-School Science Classroom: Putting Learning by Design™ into Practice. *Journal of the Learning Sciences*, *12*(4), 495–547. https://doi.org/10.1207/S15327809JLS1204_2

Koswara, A., Amri, A., Zainuddin, F. K., Ngurah, I., Muzaki, J., Muttmainnah, L., Utaminingsih, M., Saleky, S. R. ., Widowati, & Tebe, Y. (2019). *Spab*. 1–120. http://spab.kemdikbud.go.id

Lave, J., & Wenger, E. (2012). Legitimate Peripheral Participation. *Situated Learning*, *November*, 27–44. https://doi.org/10.1017/cbo9780511815355.003

Masrizal and Iqbal. (2022). Panduan Satuan Pendidikan Aman Bencana. *EUREKA MEDIA AKSARA*, 1–24.

McGibbon, C., & Van Belle, J. P. (2015). Integrating environmental sustainability issues into the curriculum through problem-based and project-based learning: A case study at the University of Cape Town. *Current Opinion in Environmental Sustainability*, *16*, 81–88. https://doi.org/10.1016/j.cosust.2015.07.013

McKenney, S., & Reeves, T. C. (2014). Educational design research. *Handbook of Research on Educational Communications and Technology: Fourth Edition*, *January 2013*, 131–140. https://doi.org/10.1007/978-1-4614-3185-5_11

Muchsin, M., & Hamdi, H. (2021). Analysis of Student's Creativity Value and Process Skills through Learning Strategies Guided Inquiry. *Jurnal Serambi Ilmu*, *22*(1), 98–109. https://doi.org/10.32672/si.v22i1.2486

Mulilis, J. P., Duval, T. S., & Bovalino, K. (2000). Tornado preparedness of students, nonstudent renters, and nonstudent owners: Issues of PrE theory. *Journal of Applied Social Psychology*, *30*(6), 1310–1329. https://doi.org/10.1111/j.1559-1816.2000.tb02522.x

Payne, P. G. (2015). Critical Curriculum Theory and Slow Ecopedagogical Activism. *Australian Journal of Environmental Education*, *31*(2), 165–193. https://doi.org/10.1017/aee.2015.32

Rochmad. (2012). Desain Model Pengembangan Perangkat Pembelajaran Matematika. *Jurnal Kreano*, *3*(1), 59–72.

Suarmika, P. E., & Utama, E. G. (2017). Pendidikan mitigasi bencana di sekolah dasar: Sebuah kajian analisis etnopedagogi [Disaster mitigation education in elementary schools: An ethnopedagogical analysis study]. *JPDI (Jurnal Pendidikan Dasar Indonesia)*, *2*(2), 18.

Sugiyono. (2008). *Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif, dan R & D.* (p. 334).

Trilling, B., & Fadel, C. (2009). 21st Century Skills: Learning for Life in Our Times. In *San Francisco, CA: John Wiley & Sons.*

Winn, W. (2004). Cognitive perspectives in psychology. *Handbook of Research for Educational Communications and Technology: A Project of the Association for Educational Communications and Technology*, *2*, 79–112.