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DEVELOPMENT OF A TEXTBOOK GLOBAL WARMING (TGW) STEM WITH AN ESD APPROACH IN ANYFLIP TO IMPROVE CRITICAL THINKING AND PROBLEM SOLVING

PUTRI A. SOLIHAH*, IDA KANIAWATI,
ACHMAD SAMSUDIN, RIANDI RIANDI

Universitas Pendidikan Indonesia, Jl. Setiabudhi No. 229, Bandung, 40154, Indonesia
*Corresponding Author: putriameliasolihah@upi.edu

Abstract

This study aims to development of textbooks provides real experiences for educators and new strategies for presenting science concepts but also provides opportunities for students to interact in an interactive, spontaneous and interesting way. Past inquire about has appeared that course reading improvement has numerous focal points in instruction, but as it were a number of centre on learning ventures, such as flexibility in issue understanding and basic considering abilities in science learning. This investigate creates an ESD-oriented STEM-based reading material worldwide warming (TGW). This course reading is to investigate the impact of course readings on Basic Considering aptitudes and issue fathoming aptitudes. The inquire about strategy utilized is Plan Based Investigate (DBR) which comprises of 4 steps, specifically (1) Investigation of commonsense issues by analysts and specialists in collaboration (2) Improvement of arrangements based on existing plan standards and mechanical advancement; (3) Iterative cycles of testing and refining arrangements in hone; and (4) Reflection to create "design principles" and progress arrangement usage. The comes about appeared that STEM-based textbooks with an ESD approach have an awfully great achievability level since the approval comes about and unwavering quality are too tall.

Keyword: Climate change, ESD, STEM education, Technology, Textbook.

1. Introduction

The field of technology, particularly the internet, is advancing quickly during the period of globalization and the fourth industrial revolution [1]. The any flip web platform utilizes digital technology to facilitate computer-based learning, enabling the development of STEM and ESD-based textbooks aimed at addressing the issue of global warming. Textbooks, including scientific textbooks, are self-contained educational resources that are specifically created to facilitate autonomous study for students in the field of science. They are structured in a methodical manner, following a certain curriculum [2], concisely and precisely organized into the smallest pieces of learning [3].

The design of the material incorporates visually appealing elements and a cohesive set of activities that are related to the subject matter, media, and evaluation. This design aims to enhance students' focus, organization, and ease of learning, ultimately helping them attain the desired competencies outlined in the learning objectives [4, 5]. Here are the results of the study literature about STEM using VOS viewer on Fig. 1.

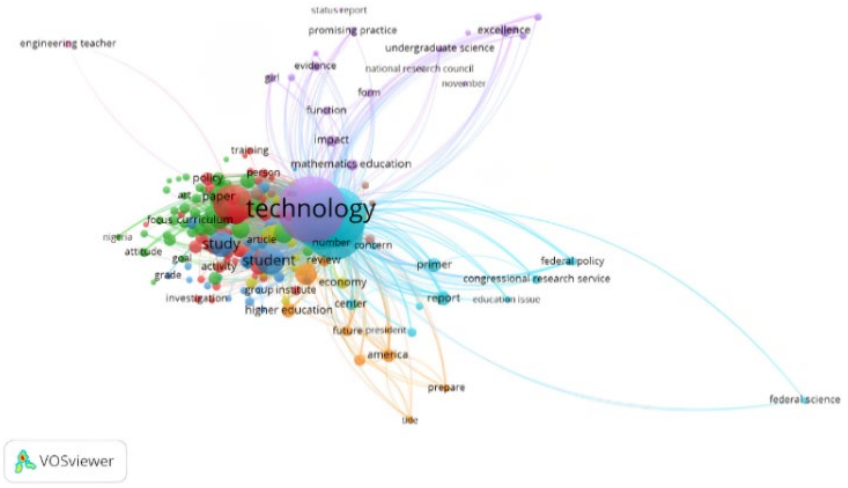


Fig. 1. Bibliometric analysis using VOS viewer.

Figure 1 depicts the network visualization technique employed to chart the connections between the keywords that frequently appear in the 128 articles acquired on the topic of "STEM Education". The VOS viewer mapping reveals several relationship characteristics among elements associated with the STEM approach, such as technology, students, and learning.

It is worth mentioning that when it comes to keywords, the concept of technology can be encapsulated by the variable of teaching materials. There is a clear requirement for the creation of textbooks specifically focused on technology, particularly those that incorporate STEM principles and use an ESD (Education for Sustainable Development) approach. The sole constraint of this study pertains to the creation of a textbook on global warming, employing a STEM (Science, Technology, Engineering, and Mathematics) and ESD (Education for Sustainable Development) framework, with the aim of enhancing critical thinking and problem-solving skills.

Conducting study in literature studies to create student worksheets using the Expression STEM approach is necessary for enhancing students' critical thinking abilities [6]. This study was also carried out by Suryansyah et al. [7] which discovered that the creation of STEM-focused science handouts was successfully utilized to enhance students' learning abilities. This analysis indicates a necessity for the creation of STEM-focused textbooks that can enhance students' learning abilities, particularly in the context of 21st century education. In addition to that, the discussion below presents literary studies on 21st century learning, specifically focusing on critical thinking. Students' critical thinking skills remain deficient and require enhancement through active and project-based learning.

Consequently, the forthcoming textbooks should adopt a STEM-focused approach with an emphasis on Education for Sustainable Development (ESD). These textbooks will incorporate projects that may effectively cultivate students' critical thinking abilities. Textbooks typically provide learning objectives as well.

Incorporating learning objectives into textbooks is crucial, especially after evaluating ten textbooks currently utilized in classrooms. Out of the total of ten volumes, three specific areas are examined, specifically the didactic, construction, and technical aspects. Regarding the educational aspect, nearly all books include goals for activities, although the elements of the textbook do not facilitate the development of critical thinking and problem-solving abilities. Even the exercises in textbooks have not been effective in facilitating ongoing education.

Regarding the construction component, there is a lack of a portion dedicated to project creation, and the evaluation primarily consists of multiple-choice questions. However, the language, sentence structure, and references employed in the 10 volumes are commendable. The technical aspects of the textbook, such as the legibility of the writing, the sort of fonts used, and the arrangement of photos and layout, are commendable. The didactic and building components require improvement, and so, the focus of the research will be on enhancing these areas based on past textbooks.

The findings of an initial investigation employing an assessment tool for critical thinking skills, namely essay questions on the topic of global warming, in junior high schools in Majalengka, Indonesia, are presented in Fig. 2. These results provide a measure of students' critical thinking ability.

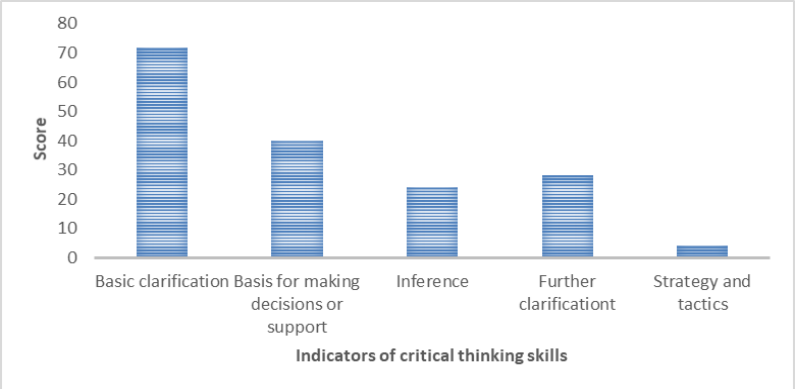


Fig. 2. Results of a preliminary study of critical thinking abilities.

Figure 2 illustrates the persistently low levels of critical thinking indicators, indicating the need for improvement through the implementation of more active and project-oriented learning methods. This improvement is crucial in order to develop textbooks that are STEM-based and incorporate an ESD approach. These textbooks, which include projects, have the potential to enhance students' critical thinking abilities.

The least developed skills include deductive reasoning and the ability to plan and execute strategies and tactics. The instructional materials will prioritize these two indicators while also ensuring a rise in the other three indicators (basic clarity, basis for making decisions, and further clarification).

Research undertaken by Brambatti Guzzo and Dall'Alba [8] focuses on practical pedagogy for integrating ESD (Education for Sustainable Development) into curricula for science, technology, engineering, and mathematics. The study findings indicate that integrating ESD into STEM curriculum is very probable to yield positive outcomes because to the evident connection between the two in terms of technical and fundamental scientific skills, such as analytical rigor, critical thinking, observation, and empirical testing.

The problems included in this integrated textbook for ESD objectives will specifically address real-world issues pertaining to ESD objectives. Through the utilization of created textbooks, students are able to get a deep understanding of physics. By engaging in this profound study of physics, it is anticipated that students would develop a genuine admiration for physics as a discipline that serves several functions in addressing diverse real-life challenges. Students are also needed to comprehend that physics has practical applications in real-world scenarios, rather than being solely a theoretical subject confined to books.

The aim of developing this textbook is to create a physics educational resource that addresses the issue of students' suboptimal critical thinking and problem-solving skills. The investigative approach employed is Design-Based Research (DBR), which consists of four steps: analysis of practical issues by researchers and experts in collaboration [9]; development of solutions based on existing design principles and technological innovation [10]; iterative cycles of testing and refining solutions in practice [11]; and reflection to generate "design principles" and enhance solution implementation [12].

It has been observed that STEM-based textbooks using an ESD approach have a high potential for success, as the validation results and reliability are also high. The unique aspect of this article lies in the integration of STEM (Science, Technology, Engineering, and Mathematics) with ESD (Education for Sustainable Development) in the creation of textbooks using technology, specifically with the use of the any flip web platform.

To facilitate understanding of the problem formulation, several research questions were prepared that describe the research so that it is more operational as follows:

R1. How to develop STEM-based textbooks with an ESD approach?

R2. What is the difference in improving critical thinking and problem-solving skills for students who use STEM-based textbooks with an ESD approach and use books commonly used in schools?

2. Literature Review

2.1. STEM education

The implementation of Science, Technology, Engineering, and Mathematics (STEM) education through the specialized approach has become more recognized in the field of instruction [13]. Currently, the Next Generation Science Standards (NGSS) can be implemented as an optional course to modify science education [14]. The implementation of the Next Generation Science Standards (NGSS) highlights the incorporation of technology and science education in schools. Technology design, when incorporated into the implementation of NGSS, can enhance student motivation, foster creative thinking skills, and facilitate the application of scientific principles in engineering.

Furthermore, the innovation plan handle is a crucial component of STEM education [15]. It is necessary for students in technology education to possess the skill of constructing a strategy. The textbook is commendable for its inclusion of suitable and comprehensible material for students. Additionally, it offers questions of varying difficulty levels, ranging from low to high. Furthermore, it is essential for textbooks to provide step-by-step instructions that facilitate the development of students' understanding and construction of scientific concepts [16].

2.2. ESD (Education for sustainable development)

ESD aims to inspire individuals to be altruistic and innovative in the face of global challenges. Education for Sustainable Development (ESD) empowers individuals to acquire the knowledge, skills, attitudes, and values necessary to design a sustainable future and adopt a more sustainable lifestyle [14]. ESD is founded upon three pillars: social, natural, and economic [15]. ESD contributes to the progress of social equity, sexual orientation equality, human rights, democratic and participatory systems, and healthcare [16]. The goal of ESD in the context of natural measurement is to enhance awareness of the physical environment's resources and vulnerability, the influence of human activities on the environment, climate change, environmental protection, and biodiversity [17].

Finally, the integration of ESD (Environmental, Social, and Governance) into financial assessment promotes awareness of the potential and constraints of economic progress, as well as its repercussions on society and the environment, responsible and sustainable consumerism, and rural development. Engaging in ESD learning can facilitate the acquisition of knowledge and understanding of sustainable practices that actively contribute to mitigating climate change. Global warming refers to the long-term changes in the Earth's climate that are caused by human activities.

3. Method

The research employed the Design Based Research (DBR) methodology. This strategy can be utilized to create novel goods that are beneficial in the realm of education and capable of addressing both individual and collective challenges. Design-Based Research (DBR) is a methodology in the field of education that involves four main processes to develop a product within a research setting. This research step encompasses the research requirements that are confined to five steps from the Design-Based Research (DBR) stage. The utilized technique is elucidated in Fig. 3.

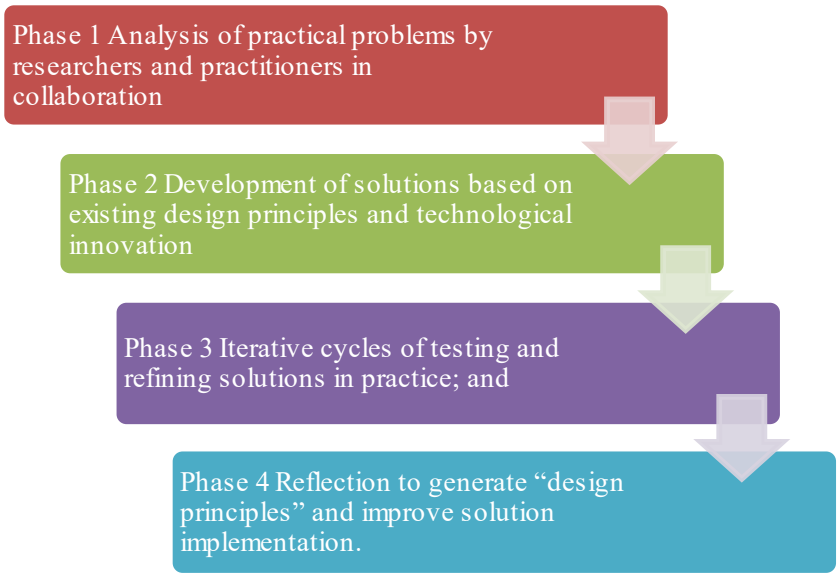


Fig. 3. Research methods with design-based research.

The textbook development approach utilized in this research is based on the ADDIE concept. This model also illustrates the fundamental phases that are crucial to traverse in the process of generating educational materials, and it is the prevailing model employed in textbook production. The selection of the ADDIE model was based on these two factors. This model comprises the stages of analysis, design, development, trial execution, and assessment.

4. Results and Discussion

4.1. R1. How to develop STEM-based textbooks with an ESD approach?

a) Analysis stage (Analyse)

The findings of the needs assessment conducted with children in Majalengka, Indonesia, indicate the presence of numerous impediments in the educational process within schools. One notable finding is that approximately 62.5% of students express a dislike for physics lectures. However, 50% of students acknowledge the high utility of physics lessons for real-life applications, while 68.8% of students struggle to apply their physics knowledge to address practical problems.

Moreover, a significant proportion of students, up to 73.8%, encounter challenges in physics lectures due to the simultaneous exposure to equations, formulae, experiments, tests, and conceptual explanations. Verified using statistical analysis. This finding is corroborated by research that posits three challenges faced by students in grasping science concepts [18], namely: misconceptions when attempting to solve problems [19], misreading or misinterpreting questions [20], and low mathematical proficiency [21].

The systematic format of STEM-ESD textbooks consists of the following components in Table 1.

Table 1. STEM-ESD textbook component format and content.

No.	Components	Content of STEM-ESD Textbooks
1.	Front cover	Contains the title of the textbook through the approach STEM-ESD, the identity of the author of textbooks.
2.	Preface Contains	An overview of textbooks STEM-ESD on the theme of climate change.
3.	Table of contents	Contains the sequence of contents of STEM-ESD textbooks on the theme of global warming and page numbers.
4.	Instructions for use	Contains stages or steps and how to use STEM-ESD textbooks on the theme climate change.
5.	Introduction	Contains the objectives of STEM-ESD textbooks on the theme of global warming to improve critical thinking skills and abilities solution to problem.
6.	Contents	Contains 2 sub-materials on climate change, namely the greenhouse effect and climate change.
7.	Competency Test	Contains critical thinking skills instruments and problem solving.
8.	Bibliography	Contains references used in making STEM-ESD textbooks.
9.	About the author	Fill in the author's biodata briefly.

b) Development of STEM-ESD textbooks

Figure 4 illustrates the progression of STEM-ESD textbooks. Using Microsoft Word software, users may create documents by inputting content, selecting colours, inserting images and text, modifying the size and colour of text and images, and arranging the positioning of images and text. Upon completion of the design development, the design outcomes are stored in .doc and pdf formats. Subsequently, the design pdf is meticulously examined and rectified for any formatting issues.

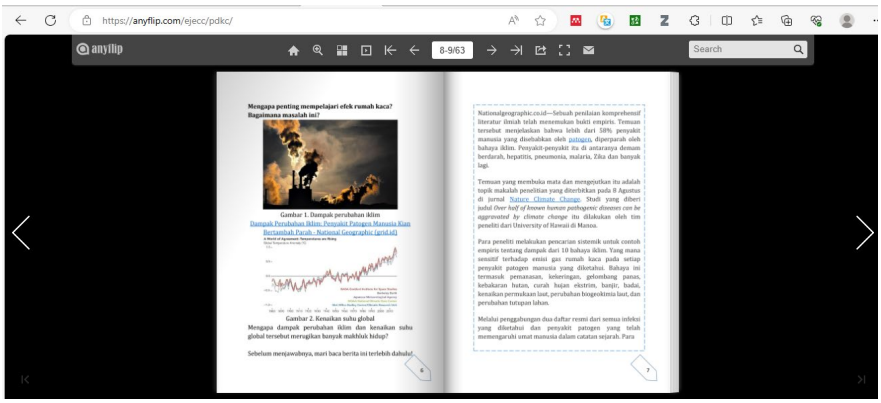


Fig. 4. Design of STEM-ESD textbooks with Anyflip.

The student worksheet comprises four sections that are part of STEM (Science, Engineering, Technology, and Mathematics) and has been combined with ESD (Education for Sustainable Development). These sections align with the three primary pillars of ESD, namely environmental, social, and economic aspects. The practice questions area includes exercises pertaining to 21st century education. At this stage, physical textbooks are transformed into digital PDF format and then

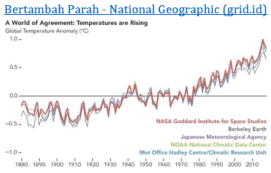
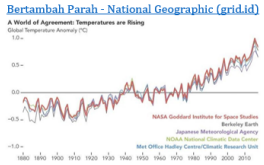
converted into an online format using Any Flip, where they are shown as web pages. Anyflip is an online platform that converts conventional printable activity sheets, such as documents, PDFs, and JPGs, into interactive online forms. It fully capitalizes on the utilization of emerging technology in the field of education [22].

c) Testing and refining of STEM-ESD textbook

The objective of this stage is to generate textbooks that have undergone revision in accordance with the feedback provided by the validator. The validation stage involves assessing the appropriateness of learning indicators with STEM-ESD textbook activities. This assessment is conducted by three expert lecturers and two science educators using a checklist validation sheet that includes the options "yes" or "no". The results of content validation are utilized to enhance STEM-ESD instructional materials.

1. Verification of Proficient Lecturers and Science Educators
Expert lecturers conducted validation to evaluate the substance of global warming material in STEM-ESD textbooks, aiming to enhance the material first.
2. Recommendations for Enhancing and Modifying the STEM-ESD Textbook
The STEM-ESD textbook underwent repairs at an early stage based on the validation results and the suggestions provided by the validator for improvement. The points of improvement in Table 2 are as follows:

Table 2. Review results textbook.

No.	Comments and Suggestion	Before Revision	After Revision
1.	On the textbook should clarified the meaning of the word "that matter; say "You think and come on" better don't written down, and typo on the word dhulu	Gambar 1. Dampak perubahan iklim Dampak Perubahan Iklim: Penyakit Patogen Manusia Kian Bertambah Parah - National Geographic (grid.id)  Gambar 2. Kenaikan suhu global Menurutmu, mengapa hal tersebut merugikan banyal makhluk hidup? Sebelum menjawabnya, yuk baca berita ini terlebih dhulu!	Gambar 1. Dampak perubahan iklim Dampak Perubahan Iklim: Penyakit Patogen Manusia Kian Bertambah Parah - National Geographic (grid.id)  Gambar 2. Kenaikan suhu global Mengapa dampak perubahan iklim dan kenaikan suhu global tersebut merugikan banyak makhluk hidup? Sebelum menjawabnya, mari baca berita ini terlebih dahulu!
2.	Preferably use comma or period two	atmosfer. Sebagai contoh, 100 tahun GWP metana adalah 21, yang berarti bahwa jika massa yang sama dari metana dan karbon dioksida diperkenalkan ke atmósfer, metana yang akan menjebak panas 21 kali lebih banyak daripada karbon dioksida selama 100 tahun ke depan. Berikut adalah GWP dari gas rumah kaca yang diatur dalam Protokol Kyoto, pada kerangka 100 tahun. Tabel 1. Gas-gas rumah kaca dan kontribusinya terhadap pemanasan global Gas | Waktu Residu | Umur (tahun) | GWP CO_2 | 100 tahunan | 7 | 1 CH4 | 10 tahunan | 11 | 21 N_2O | 170 tahunan | 150 | 206 CFC | 60-100 tahunan | 8-110 | 15.800 MENYIMPULKAN	atmosfer. Sebagai contoh: 100 tahun GWP metana adalah 21, yang berarti bahwa jika massa yang sama dari metana dan karbon dioksida diperkenalkan ke atmósfer, metana yang akan menjebak panas 21 kali lebih banyak daripada karbon dioksida selama 100 tahun ke depan. Berikut adalah GWP dari gas rumah kaca yang diatur dalam Protokol Kyoto, pada kerangka 100 tahun. Tabel 1. Gas-gas rumah kaca dan kontribusinya terhadap pemanasan global Gas | Waktu Residu | Umur (tahun) | GWP CO_2 | 100 tahunan | 7 | 1 CH4 | 10 tahunan | 11 | 21 N_2O | 170 tahunan | 150 | 206 CFC | 60-100 tahunan | 8-110 | 15.800 MENYIMPULKAN

The raw variance in Fig. 5 explained by measures value obtained was 53.2%, interpreted accordingly. So, textbooks are valid.

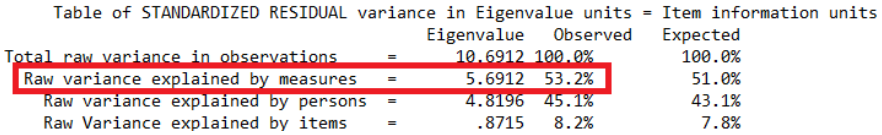
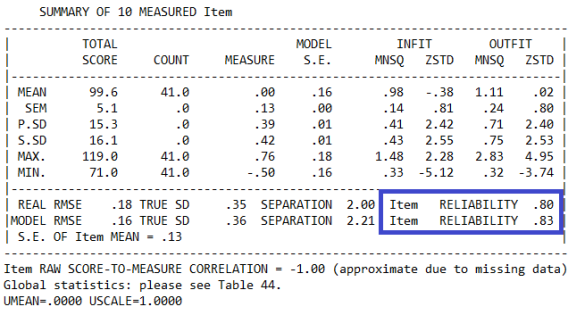


Table of STANDARDIZED RESIDUAL variance in Eigenvalue units = Item information units

		Eigenvalue	Observed	Expected
Total raw variance in observations	=	10.6912	100.0%	100.0%
Raw variance explained by measures	=	5.6912	53.2%	51.0%
Raw variance explained by persons	=	4.8196	45.1%	43.1%
Raw Variance explained by items	=	.8715	8.2%	7.8%

Fig. 5. Output: Item one-dimensionality.

In Rasch modelling using the ministep application, reliability is on the menu output 3.1 Summary Statistics. Output shows value person reliability to determine the reliability of students in answering questions and item reliability to determine the reliability of the item. Upon conducting an analysis using ministep, the obtained item reliability value in Fig. 6 is 0.80.



SUMMARY OF 10 MEASURED Item

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	99.6	41.0	.00	.16	.98	-.38	1.11	.02
SEM	5.1	.0	.13	.00	.14	.81	.24	.80
P.SD	15.3	.0	.39	.01	.41	2.42	.71	2.40
S.SD	16.1	.0	.42	.01	.43	2.55	.75	2.53
MAX.	119.0	41.0	.76	.18	1.48	2.28	2.83	4.95
MIN.	71.0	41.0	-.50	.16	.33	-5.12	.32	-3.74

REAL RMSE	.18	TRUE SD	.35	SEPARATION	2.00	Item	RELIABILITY	.80
MODEL RMSE	.16	TRUE SD	.36	SEPARATION	2.21	Item	RELIABILITY	.83
S.E. OF Item MEAN = .13								

Item RAW SCORE-TO-MEASURE CORRELATION = -1.00 (approximate due to missing data)
Global statistics: please see Table 44.
UMEAN=.0000 USCALE=1.0000

Fig. 6. Summary statistics.

This indicates that the quality of the item or question item utilized in the textbooks falls within the good category. Item dependability is assessed to evaluate the quality of question items, focusing on the validation of the item itself rather than the individual [20].

d) Reflection to generate "design principles" and improve solution implementation

The assessment of the appropriateness of teaching materials was conducted by two evaluators who are scientific teachers at the junior high school level, as well as three evaluators who are experienced lecturers. The feasibility study conducted by professional lecturers yielded an aggregate score of 95.46%, placing it in the highly feasible category. Table 3 displays the specific evaluation criteria used by the assessor to assess the adequacy of teaching materials.

Table 3. Results of the feasibility assessment of teaching materials by expert lecturer evaluators.

Feasibility Aspect	Score (%)	Category
Contents	91,89	Very Worth It
Language	94,05	Very Worth It
Presentation	94,79	Very Worth It
Graphics	97,53	Very Worth It
Total	95,46	Very Worth It

4.2. R2. What is the difference in improving critical thinking and problem-solving skills for students who use STEM-based textbooks with an ESD approach and use books commonly used in schools?

a) Improving students' critical thinking skills

Enhancing pupils' critical thinking abilities through the utilization of n-gain computations. The students' average pretest score of 29.1 increased to an average posttest score of 81.4 after using the ESD method STEM textbook. In addition, the enhancement of students' critical thinking abilities is evident in the normalized gain score, which indicates a score of 0.74. These findings demonstrate that the ESD method STEM textbook effectively enhances students' critical thinking abilities to a significant extent.

The findings align with the study conducted by Yaki [23] on enhancing students' critical thinking skills. According to this research, the introduction of STEM learning in the medium category leads to an improvement in students' critical thinking ability.

Conversely, the control class demonstrated a modest improvement of 0.5 in students' critical thinking abilities. These findings demonstrate that the ESD strategy can enhance students' critical thinking abilities in the medium range, even in the absence of STEM textbooks. In the control class, the level of development remained inferior compared to the experimental class, which utilized ESD method STEM texts. Figure 7 displays the books utilized in the control class.

(a) Cover **(b) Contents of the book on global warming**

Fig. 7. Textbook in the control class.

b) Improving students problem solving ability

In the 21st century, various facets of life, including education, have seen substantial changes over time. Students in the 21st century must cultivate talents that differ

from those of students in the preceding century [24]. Problem-solving proficiency is considered one of the essential abilities in the 21st century [25]. Problem-solving talents are essential for generating creative solutions or resolutions to address global issues. Therefore, possessing problem-solving skills is considered a crucial criterion for 21st-century students to compete effectively [26].

The improvement in students' problem-solving skills is evident from the normalized gain score, which indicates a score of 0.75. These findings demonstrate that the implementation of the ESD technique in the STEM textbook effectively enhances students' problem-solving skills, placing them in the high proficiency category.

Additionally, the improvement in students' problem-solving skills is evident from the normalized gain score, which indicates a score of 0.5. This demonstrates that in the absence of STEM textbooks, the ESD approach effectively enhances the problem-solving skills of students in the intermediate category. These findings align with the research conducted by Martín-Sánchez et al. [27] on the change of STEM education. According to this study, engaging in STEM education can enhance pupils' aptitude for solving problems. According to Tria [28], lesson planning can enhance the effectiveness of learning by carefully considering the intricacies of the learning process.

5. Conclusion

Overall, the development of STEM-ESD textbooks using the Design Based Research (DBR) development model has proven to be feasible in terms of content, language, presentation, and graphics. These textbooks have been successfully tested for science learning at the junior high school level and have demonstrated a high level of feasibility. This is due to their emphasis on project-based learning, contextualization with real-life situations, integration of different disciplines, and the cultivation of 21st century skills. Further study can be conducted on various science materials and students' abilities, such as scientific reasoning, scientific literacy, and general science skills, to enhance the development of STEM-ESD textbooks. Science educators at the junior high school level can directly utilize STEM-ESD textbooks to enhance science learning and foster students' 21st century skills in addressing Climate change.

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