Low Carbon e-Book on Climate Change with Education for Sustainable Development Framework for Sustainability Literacy of 7th Grader

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Abstract. Climate change and its impact on the environment is a topic that is aligned with low-carbon education principle to support the education for sustainable development framework. A low carbon e-book was developed to improve sustainability literacy. The e-book was then used in science learning and its effectiveness in improving sustainability literacy was investigated using a pre-experimental method with a pre-post-test design, with 40 grade 7 students of Junior High School in West Java-Indonesia as research subjects. The results showed that the developed e-book met the feasibility of the book in terms of content, presentation technique, grammar, graphics, and ease of use content validity ratio with qualified category, content validity index index with appropriate category. In addition, the book, which is presented with different examples of low-carbon education, is interesting for students because the illustrations are fun for students and the functions displayed are updated according to the character of students who are familiar with the IT world. The results show that learning with other e-books can improve students' sustainability literacy in the medium category.
Keywords: e-Book, low carbon education, perubahan iklim, sustainability literacy

Introduction

The current decline in environmental quality cannot be separated from the world's low awareness of the importance of low carbon education (LCE), especially in primary and secondary education. The lack of low-carbon education causes low sustainability literacy, which is currently a parameter of educational success. Integrating sustainability literacy into the curriculum is one way to develop students' sustainability literacy in schools. As in research conducted by Kirzen (2021), a significant relationship was found between increasing students' sustainability literacy and increasing scores on two variables, namely understanding of policies/regulations and sustainable programs (implementation).

To increase awareness of environmental quality, the solution leads to the development of low-carbon education with the education for sustainability development (ESD) framework. The ESD framework was developed by UNESCO/United Nation as a solution to accelerate the achievement of 17 global

goals sustainable development goals (SDGs). Nketsia et al. (2020) stated that ESD is an educational framework that aims to equip all children, adolescents and adults with the knowledge, skills and values to create and enjoy a sustainable future. An important finding in one study was that teachers were less likely to link community engagement with sustainable development (Chen & Li, 2019; Ferguson et al., 2021). These findings are then used as a basis for reorienting teacher education as a basis for education to build sustainability literacy.

Sustainability literacy is a person's ability to have awareness of issues that can disrupt local and global economic, social and environmental relations. Several studies show that the level of sustainability literacy is still low among both university students and primary and secondary school students (Chen & Li, 2019). Other research on secondary school students found that the sustainability literacy level of secondary school children was very low (Putri et al., 2023).

Based on the results of a survey to science teachers, it was found that the obstacle most often faced by teachers was the lack of availability of low-carbon education materials as a reference for teaching these materials. Based on previous research (Amin et al. 2020), it was found that the concept of low carbon itself was not yet understood by teachers. Low-carbon educational materials related to specific current environmental conditions such as greenhouse gases, CO_2 emissions, global warming, energy and climate change that truly contain scientific and in-depth explanations are still difficult to find. Therefore, generally teachers only explain material limited to environmental knowledge and some positive attitudes towards environmental conservation (Pratiwi et al., 2019).

The solution offered through this research is the development of low-carbon educational teaching materials with the Education for Sustainability Development framework (Hanemann, 2019; Chen et al., 2022). It is hopedby the research it is proved that that this teaching material can raise students' awareness of the need to maintain sustainability, through awareness of managing and maintaining the environment. The awareness that is meant further is that we may develop technology or industry as part of a response to the development of science and technology, and improve financial prosperity, but it must be accompanied by efforts to minimize the negative impact on the environment due to CO_2 pollution and the social environment and public health. According to research by Wu et al. (2018), environmental learning that builds awareness of the need for science and technology development that ensures the preservation of the natural and social environment by prioritizing critical and creative thinking, then this learning has implemented an ESD-based low carbon education framework.

Currently, technological developments also need to be anticipated in education, including through the development of electronic-based textbooks (e-books). E-book teaching materials can create a conducive learning environment if they are designed well (Ruspini, 2019; Khikmawati et al., 2021; Kusumaningrum & Yanti, 2021). Other research shows that the use of teaching materials with Flip PDF Professional will improve learning outcomes (Sriwahyuni et al., 2019). Apart from that, as a future generation of the nation, it is time to train students to learn using IT-based devices, even using artificial intelligence. Besides, the use of e-books which are very easy to use and can be used using an Android cellphone can

increase students' learning motivation (Agusti et al., 2019).The current decline in environmental quality is inextricably linked to the world's low awareness of the importance of LCE, especially in primary and secondary education. Some of the contributing factors are that there are still not many lessons focusing on the importance of LCE and not many books or references on the concept of low carbon itself. Low carbon education materials related to specific current environmental conditions such as greenhouse gases, CO_2 emissions, global warming, energy and climate change are minimally taught in lectures, even if they are still very general (Amin et al., 2020). The lack of low-carbon education leads to low sustainability literacy, which is currently a parameter for educational success. Integrating sustainability literacy into the curriculum is one way to develop students' sustainability literacy at school. As in the research conducted by Kirzen (2021), a statistically significant relationship was found between the growth of students' professional sustainability literacy and two variables, namely basic sustainability literacy with above-average scores and high interest in sustainability policies and programmes.

Awareness of low-carbon education ultimately leads to the development of low-carbon education with the education for ESD framework, which is a perspective on meeting current needs so that future generations can meet their needs. Nketsia et al. (2020) states that ESD is an educational framework that aims to equip all children, youth and adults with the knowledge, skills and values to create and enjoy a sustainable future. An important finding in one study was that teachers were less likely to link community engagement with sustainable development (Ferguson et al., 2021). These findings are important for reorienting teacher education as part of education for development from education for sustainable development to ensure critical issues around sustainable development.

Sustainability literacy is about awareness of issues that can disrupt local and global economic, social and environmental relationships. Some research shows that the level of sustainability literacy is still low among both university students and primary and secondary school students (Chen & Li, 2019). Another study among high school students found that the level of sustainability literacy was very low (Putri et al., 2023).

The description above shows the importance of low carbon education with ESD framework to build sustainability literacy. The solution in science education that can be offered is the development of low carbon education teaching materials with an ESD framework. Proper ESD packaging in a lesson can improve concept mastery and learning outcomes in the cognitive domain, because in learning, students are asked to perform self-evaluation in relation to the outcomes and learning process (Pratiwi et al., 2019). Among the components of environmental knowledge, attitudes and behaviour. The environmental knowledge dimension has the highest explanatory power to influence behavioural intentions, and then environmental knowledge influences environmental attitudes. According to the research conducted by Wu, et al, an effective way to improve sustainability literacy is to increase the overall level of public education and apply scientific attitudes in learning (Wu et al., 2018).

Currently, technological developments also need to be anticipated in learning, one of which is the development of e-books. This means that human resources will also need to be directed towards artificial intelligence products in the future (Ruspini, 2019). Learning media such as e-books can create a conducive learning environment if properly designed, which is reinforced by the research conducted by Kusumaningrum & Yanti (2021) in their research on the development of e-books of environmental literacy practical instructions, which obtained student response results of 85.7% in the good category. In another study

on the development of electronic learning materials using FLIF PDF Professional, the score was in the very good category (Sriwahyuni et al., 2019). Learning with low-carbon education e-books is learning that is oriented towards efforts to build environmental literacy and 21st century skills that lead to sustainability literacy.

In implementing science learning, in the era of the Industrial Revolution 4.0, it is not enough for an educator to simply transfer knowledge, but to make changes in learning patterns that focus more on the use of technology and emphasise students in finding and producing innovative and useful work in overcoming environmental problems. The implementation of ESD can be done through the media used in learning such as modules, textbooks, worksheets and games on android-based devices (Agusti et al., 2019).

Some research findings have been conducted by previous researchers in relationrelated to digital book. to the idea of low carbon education research. Amin et al. (2020) developed teaching material on low carbon education teaching materials to improve the environmental literacy of science teachers. Meanwhile, Asi et al. (2021) have developed an interactive e-book on global warming and climate change materials by integrating a social science approach to peat ecosystems, which is was very effective in improving the quality of science learning. Another study using science edutainment based low carbon poly (Lokapoly) learning on carbon footprints showed a very feasible category (Nabila et al., 2022).

The development of low-carbon e-books for education is one of the solutions that can overcome these problems. In addition, the existence of e-books as a research product will also contribute to efforts to use technology in learning. This e-book product can later be used in science learning, which is packaged in line with the ESD framework, and one of them is designed with problem-based learning with flipped classroom mode (Khikmawati et al., 2021). One study shows that the level of low-carbon literacy among Year 3 pupils is still lower than among Year 6 pupils. This can be seen in the context of activities related to energy use, such as switching off electrical appliances, water use and waste, especially plastic(Amin et al. 2020a). ESD-based learning is aimed at developing students' sustainability literacy, which is a combination of knowledge, attitudes and behaviours related to the SDGs and the outcomes of ESD (Chen et al., 2022). Other studies investigating the application of lifelong learning principles according to the fourth global goal, ESD, have shown unsatisfactory results and no significant increase in literacy (Hanemann, 2019).

Based on these on the problems and needs described, the e-book of Low carbon Education e-book was developed proposed product is a low-carbon education e-book on climate change materials developed with theusing ESD framework to improve sustainability literacy. This e-book is available for secondary student. How it is applied in learning and how students and teachers respond to this e-book is the part that has been researched.

So far, no similar e-book has been found with the characteristics of (1) the content of the climate change material is packaged to include aspects of low-carbon education, (2) the systematic flow of the e-book is developed with the ESD framework that includes critical, creative and collaborative thinking skills and covers aspects of welfare, health and environmental protection, and (3) the developed e-book is aimed at building/improving sustainability literacy needed to prepare the nation's generation to face global developments in the future. The research was conducted with 7th grade junior high school students in Cianjur Regency who were studying climate change material.

Methods

The research was conducted using the research & development (R&D) method with the ADDIE design. The research started with the analysis stage, followed by the e-book design stage, and continued with the e-book development stage. The implementation stage was carried out to ensure the feasibility of e-books in improving sustainability literacy by using 40 of 7th graders who were learning climate change subject matter. The final step is to evaluate the e-book product based on the implementation results, which will be followed by revisions and improvements. The instrument used is the adopted and adapted e-book assessment format, teacher assessment, and student assessment, as well as the sustainability literacy test instrument, which has been validated.

Some observations were conducted include along learning activities, student characteristics, conditions of learning resources used, as well as teachers activities. In order to complete the information, interviews were conducted directly with science teachers and students. Data were then analysed descriptively. For the validation step, questionnaires were distributed to 20 science teachers and three experts of subject matter, pedagogic as well as IT. data were then processed on using content validity ratio (CVR) and content validity index (CVI) formulas. Furthermore, to find out the effectivity of e-book to the enhancement of sustainability literacy, the student did the written test. data were than assess on using the simple statistic (n-gain).The research was conducted using the R&D method with the ADDIE design. The research started with the analysis stage, followed by the e-book design stage, which continued with the e-book development stage. The implementation stage was carried out to ensure the feasibility of e-books in improving sustainability literacy by using 40 junior high school students who were learning climate change material. The final step is to evaluate the e-book product based on the implementation results, which will be followed by revisions and improvements. The instrument used is the adopted and adapted e-book assessment format, teacher assessment, and student assessment, as well as the sustainability literacy test instrument, which has gone through the entire validation step.

Data analysis techniques with observation, namely observation of learning activities, student characteristics, conditions of learning resources used, as well as teachers and educational staff at MTs. Assaídiyyah Cipanas Cianjur. In order to obtain as much information as possible, interviews were conducted directly with science teachers and students at the MTs. The next data collection technique is a questionnaire to determine the validity and attractiveness of the teaching materials developed. The questionnaire used in the study is a validation questionnaire and student responses. Furthermore, to determine the completeness of the students' understanding, a learning outcome test was conducted after learning with an e-book. Effectiveness is seen from the completeness of student learning outcomes based on the classical completeness of learning outcomes that have been determined, namely student scores.

Criticisms and suggestions from all parties (supervisors, IT expert, TPACK expert) were used as basis for data analysis to improve the quality of e-book. The feasibility of e-books was measured based on the assessment of experts/teachers, include: media performance, the depth, the language, the ESD framework indicators, and its' architecture. The validity of the e-book was then calculated using the following formula (Arikunto & Safrudin, 2010)Data analysis techniques are taken from criticisms and suggestions that have been analysed as a reference for improving and perfecting low-carbon educational e-books. Suggestions for criticism of the product are developed from the validation of material experts and teaching material experts on the development of e-books. The feasibility of e-books is based on the assessment of experts/teachers. The analysis was

carried out on the feasibility of the e-book, the suitability of the main components of ESD and the media aspects. The validity of the e-book was calculated using the following formula (Arikunto & Safrudin, 2010):

$$P = \frac{\Sigma X}{X_I} \, X \, 100\% \qquad\qquad 1)$$

Description:
P   : Percentage of eligibility
ΣX   : Total number of validator score answers (real value)
ΣX_1 : Total number of highest answer scores (expected value)

The feasibility of e-books was analyzed using CVR and CVI. The questionnaire data was then entered into the CVR formula

$$\mathrm{CVR} = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \qquad\qquad 2)$$

Description:
n_e : number of respondents who stated "yes"
N   : Total respondents

The CVR value obtained depends on the percentage of validators who answered 'yes'. Whether or not the question instrument is accepted is determined by calculating the CVI.

$$\mathrm{CVI} = \frac{\Sigma \, \mathrm{CVR}}{\text{Number of sub−questions received}} \qquad\qquad 3)$$

Students' sustainability literacy was analyzed using a multiple-choice test on environmental issues. The normalized gain (N-Gain) was calculated from the pre-test score before treatment and the post-test score after learning with the LCE e-book. Significantly, N-Gain is formulated by the following equation:

$$(g) = \frac{\text{posttest−pretest}}{\text{maximum skor−pretest}} \qquad\qquad 4)$$

The calculation of normalised gain is used to determine students' sustainability literacy after learning with low carbon education e-books. The normalised gain is obtained from the students' post-treatment scores and shows a significant increase. Strategies are needed to increase sustainability awareness and understanding. In a study of strategies implemented in waste management at university level, it was successful in attracting the attention of university staff and students by starting an ongoing conversation about excessive landfill waste generated by collaborative projects, namely by promoting recycling, reduction and reuse of waste (Lee & Manfredi, 2021).

Results and Discussion

Need analysis Result
At the beginning of the research, a step of needs analysis was conducted to determine the extent of development of teaching materials in the form of electronic books (e-books) received, how feasibility and development needs. The analysis was carried out by means of observations and interviews as well as questionnaires given to teachers and students of MTs. Assaídiyyah (at West Java, Indonesia) as research subjects. The needs analysis

includes curriculum analysis, learning resources analysis, materials analysis and student characteristics analysis.

Based on the results of the curriculum analysis, the core competency and basic leading to a low-carbon education are found in basic competence 3, analyses climate change and its impact on ecosystems, and writie about ideas for adapting to/overcoming climate change problems. Those contexts were then used as a basis for developing the main ide a of e-book.

The next step is analyzed the Learning resources refer to textbooks used in learning at secondary school level. The main textbooks used in each school are books from the Ministry of Education and Culture and other supporting books from several publishers with a national reputation. The results of the analysis of textbooks in terms of low carbon content are presented in Table 1.

Table 1. Low carbon textbook analysis

Number	Book Name	Analysis
1	Book A	The material is complete enough to include pictures to enhance students' understanding of the climate change material, the low carbon content is more general in nature, but the learning is contextual and stimulates students' thinking skills.
2	Book B	The material is fairly complete, there are fewer pictures to support learning, the appearance of the book is less attractive to students, the low carbon content is more general and the learning approach is contextual.
3	Book C	The material is fairly complete, the images to support learning are complete and more interesting, the low carbon content is more general and includes.

Based on the analysis of the three textbooks, the results show that in general the textbooks have already included low carbon education principles, but the discussion along the text is still lacking in depth and contextual and less concrete examples related to low carbon education. The illustrations displayed in most books are still very lacking, and even if there are they are not very interesting. for example, when explaining that what causes global warming is carbon dioxide gas, where this gas comes from is not explained in detail. it is only described that the gas is there because there is a combustion process. In the LCE principle, it is necessary to explain in more depth how the gas is formed, what temperature changes accompany it, is there a difference if the fuel is from firewood or from gasoline or from other fuels? how does burning a number of different fuels affect the release of carbon dioxide gas and its heat energy. for example, when explaining that what causes global warming is carbon dioxide gas, where this gas comes from is not explained in detail. it is only described that the gas is there because there is a combustion process. In the LCE principle, it is necessary to explain in more depth how the gas is formed, what temperature changes accompany it, is there a difference if the fuel is from firewood or from gasoline or from other fuels? how burning the same number of different fuels will affect the amount of carbon dioxide gas and heat energy released. With these questions, students are invited to show awareness of the importance of choosing safer and more sustainable fuel. This is in line with Amin's research 2021) that LCE brings students to environmental awareness.

The needs analysis step is carried out based on the perspectives of teachers and students, included the availability of low-carbon books, the need for low-carbon books as learning materials, and the learning process related to low-carbon. The result shows that there are still very few books related to low carbon education. Even if it is available, the content is not in depth, and the explanation is only on the surface. Thus, most teachers feel a little less convincing when teaching the low carbon concept to students. Furthermore, teachers generally do not know the principles of continuous literacy-based assessment. This of course has an impact on students' low level of sustainability literacy. During the interview, it was revealed that some of the students' positions were at the lowest level, no awareness of environmental and social impacts, and some were at the second level, there was awareness of environmental and social impacts. There is no student who is at the third level (responsible for the environment) and fourth (highest, being a leader and playing a role in sustainability). The sustainability Literacy of student was assessed on using Decamps et al. (2017) and Diamond & Irwin (2013) principles on assessing sustainability literacy.

LCE e-book infrastructure

Based on the results of the needs analysis above, the LCE e-book has been developed oriented towards the ESD framework. The ESD framework is reflected in examples or contexts of low carbon education which are oriented towards material about a comfortable environment, social problems, and environmental and social problems that are linked to welfare. Likewise, this e-book has been developed to accommodate efforts to develop or practice high-level thinking skills, collaboration skills (through group work invitations) and argumentation skills.

In a preliminary study conducted by Melani, it was found that learning media that enhance 21st century skills, especially critical thinking and communication components, are still relatively scarce, especially technology-based media (Putri & Asrizal, 2023). In a study of textbooks with features related to the SDGs, it was found that the textbooks developed were effective in developing 21st century thinking skills in trainee teachers . One example that can be developed is on disasters that occur in parts of the world (Atmaja et al., 2021; Herawati & Istiana, 2021)

The LCE e-book itself was developed using the Canva and i-spring 10 applications. The architecture of LCE e-book with an ESD framework is designed starting with the macroscopic structure of subject global warming. Some of the sub-subject displayed in this structure are (1) an explanation of global warming using the context of current changes in the earth's temperature (starting with a video), (2) causal factors (greenhouse effect, increase in carbon emissions, increase in earth's temperature, and changes in the earth's orbit), and (3) impacts global warming (extinction of ecosystems, extinction of forests, decline in public health, etc.). Strengthening and deepening the material is carried out by providing various examples of cases or phenomena related to global warming and efforts to overcome it in the energy, transportation, building, industry, forestry, agriculture and food sectors. Another enrichment is the addition of low carbon content consisting of carbon footprint material, how to calculate carbon footprints and material on how to manage 5 R waste. The macroscopic structure of e-book is shown in Figure 1

Macro structure

Some of the sub-subject displayed in this structure are.

Basic competences

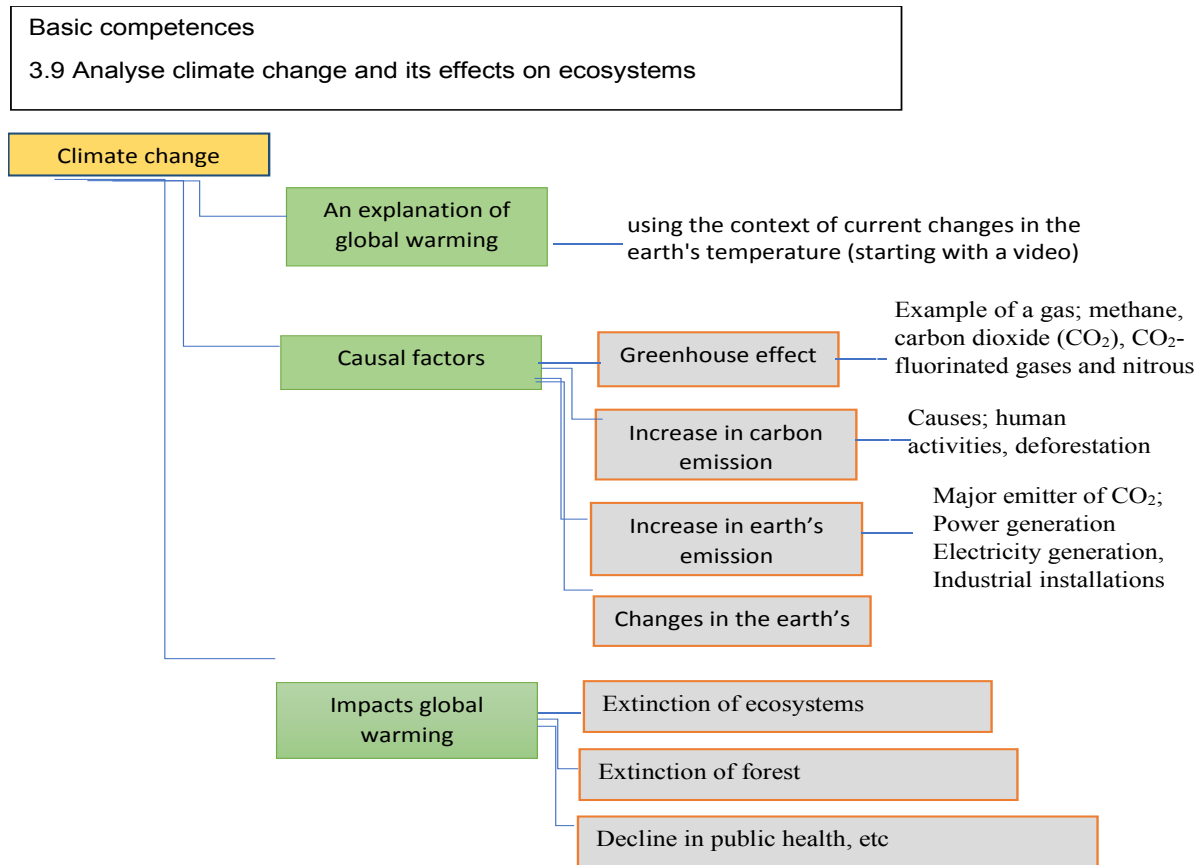3.9 Analyse climate change and its effects on ecosystems

Figure 1. Macro structure of e-book LCE

Strengthening and deepening the material is carried out by providing various examples of cases or phenomena related to global warming and efforts to overcome it in the energy, transportation, building, industry, forestry, agriculture and food sectors. Another enrichment is the addition of low carbon content consisting of carbon footprint material, how to calculate carbon footprints and material on how to manage 5 R waste.

Starting with the identity of the teaching materials (consisting of cover, foreword, table of contents), instructions for using the e-book, and materials, the LCE-e-book infrastructure is also equipped with various appearances that make the e-book more interesting and interactive.

Figure 2. e-book cover and instructions for use that students and teachers find attractive, easy to operate and very eye-friendly

Figure 3. LCE e-book is supported by supporting deepen information such as carbon footprint; how to measure your own footprints; how to measure the amount of carbon that household activities release from; how to manage waste.

Figure 4. LCE e-book is also completed by the Simple practicum laboratory work and attractive assessment.

Figure 5. The LCE e-book is ended with summary, bibliography and author biography

Validity and feasibility of e-books

Validation was carried out by 2 two IT and material expert lecturers who provided an assessment of the low carbon education e-book that had been developed. The feasibility validation emphasises emphasized all aspects available on the validation sheet with the highest score criteria of 4 and the lowest 1. Assessment of teaching materials by media experts shows that for all assessment categories consisting of aspects of cover design, content design and device engineering get a percentage of 80.43%. The conclusion of the e-book assessment by media experts is that the category is quite valid, this means that the e-book is suitable for use in learning.

The assessment by material subject experts shows that for all assessment categories consisting of aspects of cover design, content and device engineering get a percentage of 87.51%. The conclusion of the content/material assessment by the material expert on the low carbon education e-book is valid, this means that the e-book is suitable for use without revision in learning.

The final result of content validity is an assessment of the content of the questionnaire, the content validity test is carried out through two stages of testing, namely measuring the CVR and the CVI. The content validity test was carried out by 16 MTs./SMP teachers in Cianjur district. The CVI assessment was conducted to determine whether the questionnaire items were appropriate, needed revision, or needed to be eliminated.

Table 2. CVR and CVI Scores

Item	Ne	CVR		CVI	
1	16	1.00	V	1.000	Acceptable
2	16	1.00	V	1.000	Acceptable
3	16	1.00	V	1.000	Acceptable
4	14	0.75	V	0.875	Acceptable

5	16	1.00	V	1.000	Acceptable
6	16	1.00	V	1.000	Acceptable
7	16	1.00	V	1.000	Acceptable
8	15	0.88	V	0.938	Acceptable
9	16	1.00	V	1.000	Acceptable
10	15	0.88	V	0.938	Acceptable
11	15	0.88	V	0.938	Acceptable
12	16	1.00	V	1.000	Acceptable
13	15	0.88	V	0.938	Acceptable
14	14	0.75	V	0.875	Acceptable
15	15	0.88	V	0.938	Acceptable
16	16	1.00	V	1.000	Acceptable
17	14	0.75	V	0.875	Acceptable
18	14	0.75	V	0.875	Acceptable
19	16	1.00	V	1.000	Acceptable

Description: V = Valid
TV= Invalid

According to Wilson (2012), CVR and CVI are said to be valid if the value is greater than the predetermined critical value. Based on Schipper's table of critical values for CVR and CVI for 16 validators with a significance level of 95% (=0.05), the critical value is 0.425. The results of the calculation of the CVR value of the whole instrument show a CVR> 0.425; then the item is very valid and accepted.

Sustainability literacy of Student

LCE e-books which have demonstrated feasibility and have been tested are then implemented in learning for one experimental class (40 students). The increase in student literacy sustainability is then measured using a multiple-choice test of 25 questions covering 4 dimensions of literacy. The assessment results show that the average student continuous literacy pretest score before learning is 52 (maximum score 100). The implementation of e-books apparently caused an increase, followed by an increase after learning with an average post-test score of 72. The results of more precise calculations using N-gain calculations show that the increase in literacy is in the medium category, as shown in Table 3.

Table 3. N-Gain pretest and posttest

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain	40	-.48	.98	.4221	.31074
Valid N (listwise)	40				

Based on a deeper examination, it was found that the increase in students' sustainability literacy, even though it was in the medium category, was quite encouraging. From the initial position of sustainability literacy at levels 1 and 2, after learning it increased to levels 2 and 3. There were even some students who reached category 4. It can be said that books that are packaged by prioritizing contexts that are close to life can be more easily understood by students. Several examples of exercises to build environmental awareness cause students to be moved to think about becoming leaders related to efforts to build a comfortable environment. There are 5 students who want to become a leader and play a role in sustainability and they have completed skills which can contribute to achieving sustainability. 1 Students reach the highest level in the aspect of being a leader and playing a role in sustainability and the Confidence in an ability in contributing to achieving sustainability domain..

The results of the research above are in line with what Sari & Rifai (2021) found in their research, that the use of e-books is considered easier and more practical, which is confirmed by Hisbiyati & Khusnah (2017) who state that e-books are very practical based on student assessments. It was further stated that the features in e-books can facilitate students' understanding of learning so that they can increase students' interest in learning and improve student learning outcomes.

The increasing students' sustainability literacy is also reflected in how teachers and students respond to learning.
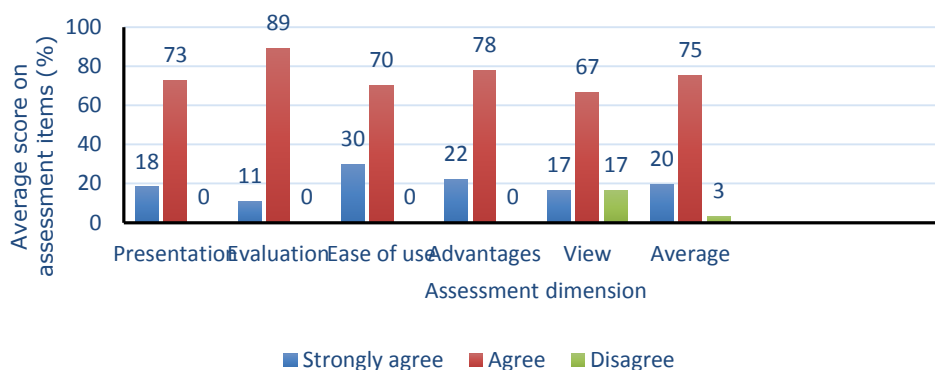

Figure 6. Percentage of students respondingTeachers' response to the LCE e-book

Figure 6 shows that teachers strongly agree that the e-book has so many benefits such as good performance, easy to use, the performance is very attractive, and hoe the subject is made student easy to understand. All of teacher stated that the e-book is very useful both for teacher and student. They agree that the e-book will leads to the enhancement of awareness of student towards environment. They also said that the book really helps teachers teach students, because the book is packaged involving various training skills in thinking, arguing and collaborating. This is in line with Diamond & Irwin (2013) the interactive e-book will leads to enhance the sustainability literacy. Moreover, Warren et.al stated that the interactive material teaching makes student have the futures thinking, values thinking, systems thinking dan strategic thinking (Warren et al., 2014). In line with research results, the use of media that contains kinesthetics activities in the form of laboratory work or educational tourism is effective in encouraging students in sustainability literacy (Ling et al., 2021).

In Fact, the student responses toward learning is strengthen the previous research, as it is shown by Figure 7.
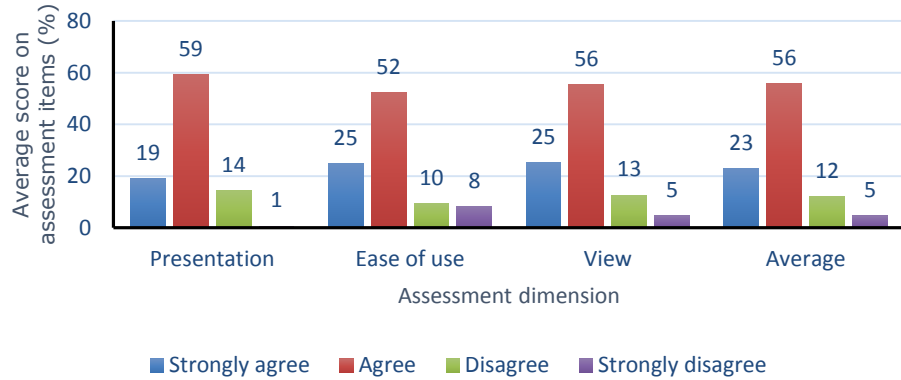

Figure 7. Student responses to low carbon education e-books

Most of student stated that the e-book is good looking, attractive, and easy to operate. They said that they prefer use the e-book rather than the printed book, because it is very handy and can save in their android so they can open it everywhere and every time. Many students also think that this e-book allows them to take exams more easily. This is in line with several previous studies, that the use of e-books shows positive value in helping students in learning and increasing enthusiasm for independent learning during the covid-19 pandemic (Khikmawati et al., 2021). Other research shows that e-books are fun for students and have a positive impact on academic achievement (Merkle et al., 2022)

Based on the research results above, it has been answered that LCE e-books with an ESD basis can increase students' sustainability literacy. However, basically the use of climate change material is also very appropriate for building students' sustainability literacy. Materials that contain low carbon education and are prepared to support ESD/SDGs can help students understand how global issues such as climate change, poverty and inequality can be overcome through individual and collaborative action. However, it needs to be noted that one of the challenges and problems of sustainability is socio-cultural factors such as family cultural background, and the values of parents, school systems, teachers and student evaluations (Motevalli et al., 2022).

Conclusion

Sustainability literacy is a skill that needs to be trained to students to face global change. Various methods are taken to ensure these skills are trained during learning. Utilizing ESD-based LCE e-books is an alternative that can be used to overcome this problem. The research results show that the LCE e-book on global warming material with the ESD framework has been proven to provide benefits both for teachers as teaching material and for students as learning material. Research results have also proven that e-books that have been tested for their suitability and effectiveness can increase sustainability literacy. Even though the increase occurred in the medium category, it is very encouraging because it produces students who are more responsible, have a high awareness of the environment and its preservation, and some even hope to become leaders in upholding environmental sustainability.

Acknowledgement

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