e-ISSN: 2355-620X
DOI: 10.12928/jrkpf.v12i1.1231

Implementing the ICARE model with AR-based e-modules on global warming to enhance students' self-efficacy

Najla Azmiatunisa, Lina Aviyanti, Duden Saepuzaman, Heni Rusnayati

Physics Education Study Program, Universitas Pendidikan Indonesia, Bandung, Indonesia

Email: najlazmiatunisa@gmail.com

Abstract
This study aims to analyze the profile and improvement of student self-efficacy by applying the ICARE learning model assisted by AR-based e-modules on global warming material. This study used a pre-experiment method with a one-group pretest-posttest design on grade X students. Data were collected using the Physics Learning Self-Efficacy (PLSE) questionnaire validated through reliability tests and factor analysis, with a Cronbach's Alpha value of 0.91. The initial profile of students' self-efficacy shows that the science content dimension has an average of 57%, while other dimensions, such as higher-order thinking, laboratory usage, scientific literacy, everyday application, and science communication, are each in the range of 60%. The results showed an average increase in the average student self-efficacy from -0.05 logits in the pretest to 0.86 logits in the posttest, with an average increase of 0.92 logits. The science content dimension experienced the highest increase of 1.70 logits. Integrating AR technology in the e-module facilitates the visualization of complex phenomena, such as the greenhouse effect and the melting of polar ice caps, making learning more interactive and meaningful. The results of this study indicate that the ICARE model assisted by AR e-modules effectively increases student self-efficacy, supports student-centered learning, and provides a more meaningful learning experience.

Keywords: augmented reality, e-modules flipbook, physics learning

Article submitted 2025-01-10. Revision uploaded 2025-02-02.
Accepted for publication 2025-02-17.
Published on 2025-04-01.
https://doi.org/10.12928/jrkpf.v12i1.1231

I. Introduction

Physics is a part of science that studies natural phenomena, starting from the smallest, such as subatomic particles, to the largest. Based on the current curriculum in Indonesia, namely the Merdeka Curriculum, physics is one of the subjects that high school students must learn. The function of physics learning is to understand concepts, apply concepts to solve problems in everyday life, and develop technology. Physics learning has an important role in developing various skills, such as students' critical thinking, analysis, and creative skills [1]. However, physics, which is abstract and complex, is often considered a subject that is difficult for students to understand [2]–[4]. In addition, students assume that learning physics is not fun [3], resulting in low final grades for physics students in school [4], [5]. Both of these can affect students' perceptions of their own abilities and the value of their efforts, which can cause negative effects on students' self-efficacy to decrease.

Self-efficacy is an assessment of each individual's own ability to perform an action. Self-efficacy affects how a person thinks, processes information, and motivates a person to achieve the goals set [6]. In the learning process, self-efficacy linearly affects students' task performance [7]. Students who have a high level of self-efficacy can face new challenges and solve complex problems. Conversely, students with low self-efficacy tend to doubt their abilities and avoid challenges so that physics learning is not carried out optimally [8]. Self-efficacy in physics learning can be seen from various dimensions, including the belief in the ability of students to use physics knowledge (Science Content), Higher Order Thinking, conduct laboratory experiments (Laboratory Usage), ability to analyze and interpret the results of experimental or laboratory activities (Scientific Literacy), physics applications in everyday life (Everyday Application), and communicate in the field of science (Science Communication) [7].

Students' self-efficacy in the classroom needs to be considered because it can help students assess the extent to which they understand learning [7]. In other words, they can evaluate themselves accurately. Various studies show that students' self-efficacy, especially in physics learning, is still relatively low [9]–[12]. Low student self-efficacy has implications for low academic achievement, affecting student learning outcomes [13]. Students with high self-efficacy will have good physics learning outcomes. Otherwise, students with low self-efficacy will have a bad effect on physics learning outcomes [14]. In addition, self-efficacy has a low correlation with higher-order thinking skills in basic physics materials. However, the relationship still shows that increasing self-efficacy can support students in developing higher-order thinking skills [15]. Therefore, self-efficacy is important, especially in learning about global warming material, which requires in-depth analysis, critical thinking skills, and evaluation of scientific data. An important factor affecting students' low self-efficacy is the learning model, which has not been effective in creating a learning environment that can support students' learning process [10], [16]. So, an innovative student-centered model, the ICARE model, is needed to facilitate student self-efficacy [17].

The ICARE learning model was developed by Bob Hoffman and Donn Ritchie in 1998. ICARE stands for Introduce, Connect, Apply, Reflect, and Extend, representing this learning model's five stages [18]. In the Introduce stage, students are given a big picture related to the learning that will be learned, such as learning objectives, concept maps, and others. At the Connect stage, the teacher presents new information from the learning, facilitates students to organize the new information obtained, and connects it with the information they already know. At the Apply stage, students write articles and conduct experiments individually or in groups. At the Reflect stage, the teacher facilitates students to reflect on the skills and knowledge gained after completing the learning. In the last stage, Extend, the teacher provides enrichment to students to further explore the material that has been learned. Applying the ICARE model has the advantage that teachers can flexibly focus on one of the learning stages. For example, at the connect stage, teachers can use approaches and methods that emphasize concept understanding [19]. This advantage can be utilized to increase student self-efficacy in the classroom. To be more effective, supporting learning media such as learning modules are needed.

Media plays an important role in learning as a channel to convey messages from teachers to students [20]. Learning modules are teaching materials to facilitate students' learning of the material. There are two types of modules, namely electronic modules and printed modules. Electronic modules can increase student involvement, or the learning process becomes more interactive because the material presented is more dynamic than printed modules [21]. Electronic modules can be integrated with technology to help students visualize and gain meaningful understanding. The technology is augmented reality (AR). Augmented reality is a technology that combines physical and virtual elements in the real world [22]. AR can provide students with an interesting and interactive learning experience [23].

Previous research shows that the ICARE model effectively increases students' mathematics self-efficacy [17]. The study shows that applying the ICARE model can increase students' self-efficacy in learning mathematics with a degree of achievement of 80.31% in the high category. Meanwhile, research by [24] shows that AR technology can increase students' self-efficacy in physics learning (wave-particle duality), which significantly increases students' self-efficacy in concept understanding, higher-order thinking, practice, and communication. Although both ICARE and AR models have proven effective in increasing self-efficacy, no research specifically integrates both in physics learning, especially on global warming material. In fact, this material requires deep conceptual understanding and higher-order thinking skills, which can be facilitated through ICARE and supported by interactive visualization from AR. Therefore, this study aims to analyze how the combination of ICARE and AR-based e-modules can support the improvement of students' self-efficacy in physics learning.

This research contributes theoretically to expanding the use of the ICARE model in physics learning by integrating AR technology. This approach provides a more immersive and interactive learning experience, particularly in understanding abstract concepts such as global warming. This research not only adapts ICARE in science but also enriches the model with 3D visualization elements and AR-based interactions to assist students in understanding global warming material and increase self-efficacy. From the practical side, this research contributes to the application of AR technology as an innovative learning medium that supports exploring global warming concepts in a more real and contextualized manner. The integration of AR allows students to observe the impact of this phenomenon directly through an interactive model. Thus, this research offers a concrete solution for educators in simplifying complex scientific concepts and increasing the effectiveness of technology-based learning. The results of this study can serve as a reference for educators in developing technology-based learning strategies to increase students' self-efficacy.

Based on the studies conducted, no research has been found that examines the effect of the ICARE learning model combined with augmented reality (AR) based e-modules on student self-efficacy, especially on global warming material. Thus, the researcher aims to analyze the profile and improve students' self-efficacy by applying the ICARE learning model, which is assisted by AR-based modules on global warming material.

II. Methods

This study is a pre-experiment research method, namely a one-group pretest-posttest design, as in Table 1.

Table 1. Schematic of design

Pretest	Treatment	Posttest
O_1	X	O_2

O_1 is the pretest of self-efficacy before treatment is given, X is the treatment of the ICARE learning model assisted by AR-based E-Module, and O_2 is the posttest self-efficacy after treatment is given

This study uses a quantitative descriptive approach to analyze students' self-efficacy profile and a pre-experiment method to measure the increase in self-efficacy after applying the ICARE model assisted by AR-based e-modules. The research was conducted in class X in one of the public high schools in Bandung City. The sample in this study involved 31 students who had not studied global warming material. Sampling was carried out using a convenience sampling technique, namely by selecting students who were easily accessible [25] without disrupting teaching and learning activities at school. This technique was chosen because it aligns more with school conditions and allows efficient data collection. Although convenience sampling allows for efficient data collection, this technique has limitations regarding sample representativeness. Since the selection of participants is based on ease of access, the results of the study may not fully represent the wider population. However, in the context of this study, this approach can still provide an initial picture of the students' self-efficacy profile and the effectiveness of implementing the ICARE model assisted by AR-based e-modules.

To obtain student self-efficacy data, the researcher used the Physics Learning Self-Efficacy (PLSE) questionnaire instrument developed by [7]. It consists of 31 statement items using a five-point Likert scale, namely 'strongly disagree' (1) to 'strongly agree' (5). The questionnaire consists of six dimensions, including:

Table 2. Six dimensions of the PLSE questionnaire

Dimensions	Question Number
Science Content (SC)	1, 2, 3, 4, 5, 6
Higher Order Thinking (HOT)	7, 8, 9, 10, 11
Laboratory Usage (LU)	12, 13, 15, 16
Scientific Literacy (SL)	14, 17, 18
Everyday Application (EA)	19, 20, 21, 22, 23, 24, 25, 26
Science Communication (SCM)	27, 28, 29, 30, 31

The PLSE instrument was found to be valid and reliable. The KMO value of 0.87 indicated excellent sample adequacy, and Bartlett's Test was significant ($\chi^2 = 2833.18$, df = 435, $p < 0.001$). The overall Cronbach's Alpha value was 0.91, with six factors accounting for 56.08% of the total variance and factor loadings ranging from 0.42-0.77. These results indicate the PLSE instrument is valid and reliable for measuring students' self-efficacy in physics [7].

After the data collection process is complete, the data is analyzed using descriptive statistics to analyze the students' self-efficacy profile. The Rasch model stacking analysis technique is used to see the increase in student self-efficacy after implementing the ICARE model assisted by AR-based e-modules. Stacking analysis in Rasch modeling is a longitudinal analysis technique used to compare individual abilities (students) before and after certain interventions or events in the context of learning [26]. Stacking analysis is used because researchers can find changes in students at the individual level after receiving treatment. In this study, the analysis of students' self-efficacy improvement was processed using WINSTEPS software version 4.5.0 by looking at changes in ability levels on the vertical ruler and changes in logit values. The criteria for increasing self-efficacy are determined based on the mean and standard deviation, as seen in Table 3.

Table 3. Improvement Criteria

Criteria	Range
Very high	(mean + SD) < logit ≤ (mean + 2SD)
High	mean < logit ≤ (mean + SD)
Medium	(mean - SD) < logit ≤ mean
Low	(mean - 2SD) < logit ≤ (mean – SD)
Very low	logit < (mean - 2SD)

Implementing the ICARE model assisted by AR-based e-modules was carried out for three meetings with 2 lesson hours or 45 minutes each. The stages of learning activities and which dimensions of self-efficacy are generally trained are described in Table 4.

Table 4. Learning Activities

Stage	Learning Activities	Self-Efficacy Dimension
Introduce	- Inform learning objectives and overview. - Showing videos as student triggers that have been listed in the AR-Based E-Module then conducting question and answer activities to students with questions related to students' prior knowledge.	- Science content - Science Communication
Connect	- Presenting new information about global warming through AR-based E-Modules. - Students explore AR in groups. - The teacher triggers students to connect with their prior knowledge. - Students listen, observe, and express opinions about the information and concepts that the teacher has presented.	- Science content - Science Communication - Higher Order Thinking
Apply	- Teacher direct students to apply one of the concepts they have learned through working on the student worksheet using PhET. - Students apply the concepts they have learned by working on the student worksheet provided by the teacher.	- Laboratory Usage - Science communication - Scientific Literacy - Higher Order Thinking - Science Content - Everyday Application
Reflect	- The teacher provides opportunities for students to reflect on what material has been learned and what skills have been acquired. - Students are given the opportunity to reflect on what material has been learned, what skills have been improved, and what kind of learning experience has been obtained.	- Science Communication
Extend	- The teacher reinforces the material. - The teacher informs the content that will be learned in the next meeting. - The teacher provides opportunities for students to do deeper exploration of the material outside of class hours. - Students conduct further exploration of the material that has been learned	- Scientific Literacy

III. Results and discussion

Profile of Students' Self-Efficacy in Physics Learning

The results of the quantitative descriptive data analysis of the PLSE questionnaire data conducted on 31 class X students who have not studied global warming material are shown in Table 5.

Table 5. Statistical Analysis

Dimensions	N	Mean	SD	Percentage
SC	538	17.4	4.7	57%
HOT	463	14.9	3.9	60%
LU	362	11.7	3.6	60%
EA	750	24.2	5.9	60%
SCM	477	15.4	3.0	60%
SL	270	8.7	2.3	60%

Percentages were calculated based on the ratio between the total average and ideal scores. Table 5 shows that the science content (SC) dimension obtained the smallest percentage of 57%. This means that students feel less confident in understanding and mastering the content of science materials. Meanwhile, the dimensions of higher-order thinking (HOT), laboratory usage (LU), everyday application (EA), science communication (SCM), and scientific literacy (SL) obtained a percentage of 60% each. This shows that students' self-efficacy in these dimensions is quite good but has not yet reached good self-efficacy. Graphically, the percentage distribution of students' PLSE by dimension can be seen in Figure 1. Based on Figure 1 and Table 5, it can be seen that there are opportunities to improve students' self-efficacy.

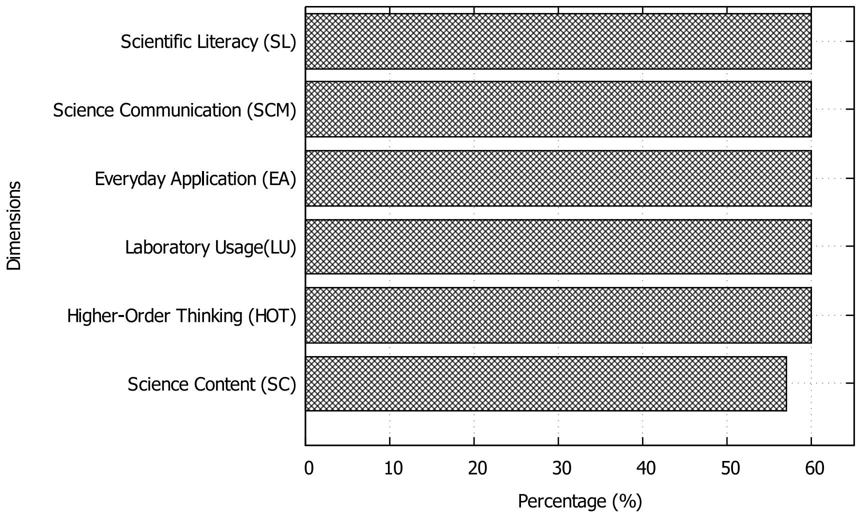

Figure 1. Profile SE Graph by Dimension

Implementation of ICARE with AR-based E-Modules

Implementing the ICARE model, assisted by AR-based E-Modules, was carried out to increase students' self-efficacy in using Global Warming material. The treatment was carried out for three meetings. Learning is carried out for two lesson hours per meeting. The duration of one lesson hour is 45 minutes. The data obtained in the form of pretest and posttest scores were converted into logit values. Data processing analysis is processed using the Rasch Model, namely stacking. The results of the stacking analysis are shown in Table 6.

Table 6 shows an increase in students' physics learning self-efficacy after applying the ICARE model assisted by AR-based e-modules. The average self-efficacy at the pretest was -0.05 on the logit scale. While the average self-efficacy at posttest is 0.86. So, there is an increase in self-efficacy of 0.92 on the logit scale. Grouping criteria can be obtained using standard deviation [27].

The average increase in logit scores is 0.92 and a standard deviation of 1.51. The results of the criteria for increasing student self-efficacy are calculated based on Table 3, and the results can be seen in Table 7. Based on these criteria, the increase in student self-efficacy is in the moderate category, with a value of 0.92. The largest increase in self-efficacy was obtained by student 21, with a logit increase of 5.76.

Analysis of the increase in self-efficacy can be described through the Wright Map. Figure 2 shows the Wright Map illustrating the relationship between the student's ability level (right) and the difficulty level of the PLSE questionnaire (left) statements. Student identity is coded with a combination of numbers and letters P or T, such as 01P. The number indicates the student's attendance in class. The letter *P* indicates the student's ability during the pretest, and the letter T indicates the student's ability during the posttest. Thus, 01T indicates the student with attendance number 1 during the posttest.

Table 6. Results of Self-Efficacy Stacking Analysis

Student's Code	Measure		Improvement
	Pretest	Posttest	
02	0.55	1.58	1.03
03	-1.15	0.78	-0.37
04	2.26	1.51	-0.75
05	-1.99	0.93	2.92
08	1.44	1.37	-0.07
09	0.55	0.24	-0.31
10	1.08	0.78	-0.3
11	-1.51	1.78	3.29
13	-0.25	1.92	2.17
14	0.07	0.07	0
15	0.24	0.63	0.39
16	-2.06	-2.68	-0.62
17	-0.72	0.39	1.11
18	-0.49	1.58	2.07
19	0.63	0.78	0.15
20	1.78	2.19	0.41
21	-3.91	1.85	5.76
22	-1	0.47	1.47
23	0.55	1.71	1.16
24	1.78	-0.01	-1.79
25	0.55	-0.01	-0.56
26	-0.49	-0.01	0.48
27	1.3	1.23	-0.07
28	-1.58	-0.17	1.41
29	-2.26	1.23	3.49
30	0.93	1.37	0.44
31	0.63	2.26	1.63
33	-2.76	-1.44	1.32
34	0.39	0.78	0.39
35	2.61	3.32	0.71
36	-1.02	0.47	1.49
Mean	-0.05	0.87	0.92

Table 7. Results Criteria for Increasing Self-Efficacy

Criteria	Range
Very high	$2.43 < \text{logit} \leq 3.94$
High	$0.92 < \text{logit} \leq 2.43$
Medium	$0.59 < \text{logit} \leq 0.92$
Low	$-2.1 < \text{logit} \leq -0.59$
Very low	$\text{Logit} < -2.0$

Figure 2 shows the distribution of student abilities and items based on Rasch analysis. The distribution of student ability on the pretest is shown on the left side of the red line. Students who are in the logit range of 0 to -3 tend to give answers with a low level of agreement with statements, while students who are in the logit range above 0 tend to give answers with a fairly high level of agreement with the statements. The distribution of students on the pretest shows that some students tend to disagree with the questionnaire statements. Meanwhile, the distribution of students' abilities on the posttest is shown to the right of the red line. After being given treatment by applying the ICARE model assisted by AR-based e-modules, it can be seen that the distribution of student abilities tends to be on a logit scale of 1 to 3. This shows that most students gave answers with a higher level of agreement with the PLSE questionnaire statements on global warming material. Some students experienced an increase in self-efficacy, such as students with codes 21 and 11, who had logit scores around -1 to -4 during the pretest and 1 to 2 after treatment. Students with code 35 had a logit score that was already high beyond the item ability and still increased after treatment.

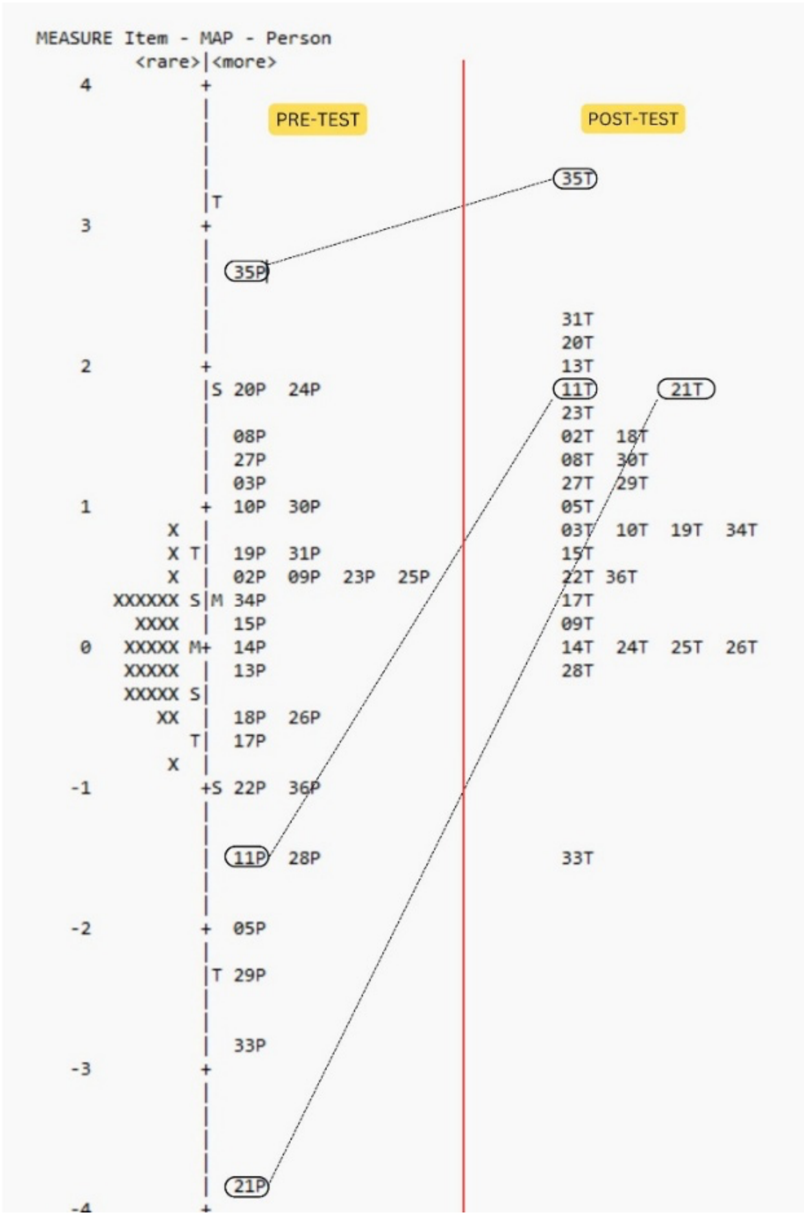

Figure 2. Wright Map of Student Self-Efficacy Improvement

Self-Efficacy Improvement Based on Dimensions

Analysis of self-efficacy data based on dimensions was conducted to see which dimensions experienced the greatest increase. The data was processed using stacking analysis. The results of the data analysis are shown in Table 8. Table 8 shows a positive improvement in all dimensions of students' PLSE, as indicated by positive logit improvement values. The categories were determined based on the mean and standard deviation. The science content (SC) dimension experienced the highest increase in logit score, with an average logit score at the pretest of -0.16 and an average logit score at the posttest of 1.55. So there was an increase in logit of 1.70. This shows that students have higher self-efficacy in understanding science content in the context of global warming.

Table 8. Self-Efficacy Data Analysis Based on Dimensions

Dimensions	Mean			SD	Category
	Pretest	Posttest	Improvement		
SC	-0.16	1.55	1.70	2.52	High
HOT	-0.03	1.21	1.24	2.50	High
LU	-0.08	1.00	1.25	3.74	High
EA	0.10	1.40	1.24	2.75	High
SCM	0.32	1.38	1.02	3.44	Medium
SL	-0.51	0.10	0.55	2.70	Medium

The category of self-efficacy improvement between dimensions is calculated based on Table 9.

Table 9. Criteria results for increasing self-efficacy between dimensions

Criteria	Range
Very high	4.10 < logit ≤ 7.05
High	1.17 < logit ≤ 4.11
Medium	-1.78 < logit ≤ 1.17
Low	-4.72 < logit ≤ -1.78
Very low	Logit < -4.72

The results showed that implementing the ICARE model combined with AR-based e-modules positively increased students' self-efficacy. This success is influenced by integrating AR-based models and e-modules implemented through learning activities in Table 3. The flexibility of the student-centered ICARE model allows adjustments to the learning needs [19]. In this study, the connect and apply phases are the main focus because they provide opportunities for students to actively connect the material with their experiences and apply the material they have learned. Integrating AR into the e-module, which is designed as a flipbook, ensures easy access for students. The AR elements are embedded as markers that students can scan using smartphones. These scans display interactive 3D visualizations of phenomena related to global warming, such as the melting of ice in the mountains, the El Nino phenomenon, and the greenhouse effect. AR helps visualize phenomena that are difficult for students to imagine. In addition, this AR-based e-module makes physics learning more interesting and triggers curiosity. Examples of AR markers and 3D shapes that AR brings up can be seen in Figure 3.

The SC dimension experienced the highest increase compared to other dimensions. This is due to the combination of the ICARE model and AR-based e-modules trained in the introduce and connect phases. Where the introduce and connect phases are directly used by AR-based e-modules. AR is used in the connect phase, where students explore AR in groups based on teacher instructions, and then representatives of each student convey the information they get orally. This helps improve student understanding while making the learning experience more meaningful so that student's confidence in their understanding of the material increases. This is in line with the research [28], which explains that the most influential source of self-efficacy is mastery experience, and research [24] also supports the results of the study by explaining that AR-based teaching materials can increase student self-efficacy because they can visualize phenomena that cannot be seen directly in the real world so that they can be observed in class.

Furthermore, the LU dimension experienced the second-highest increase compared to other dimensions. This is due to the implementation of the ICARE model, which was trained in the apply phase. Student activities in the apply phase involve students working on the worksheet in the e-module using the PhET virtual laboratory. This activity is carried out in groups, and a presentation will be conducted after the student worksheet is completed. This activity is designed to train students' confidence in conducting physics experiments. This aligns with the research [29], which explains that scientific investigation activities can increase student self-efficacy.

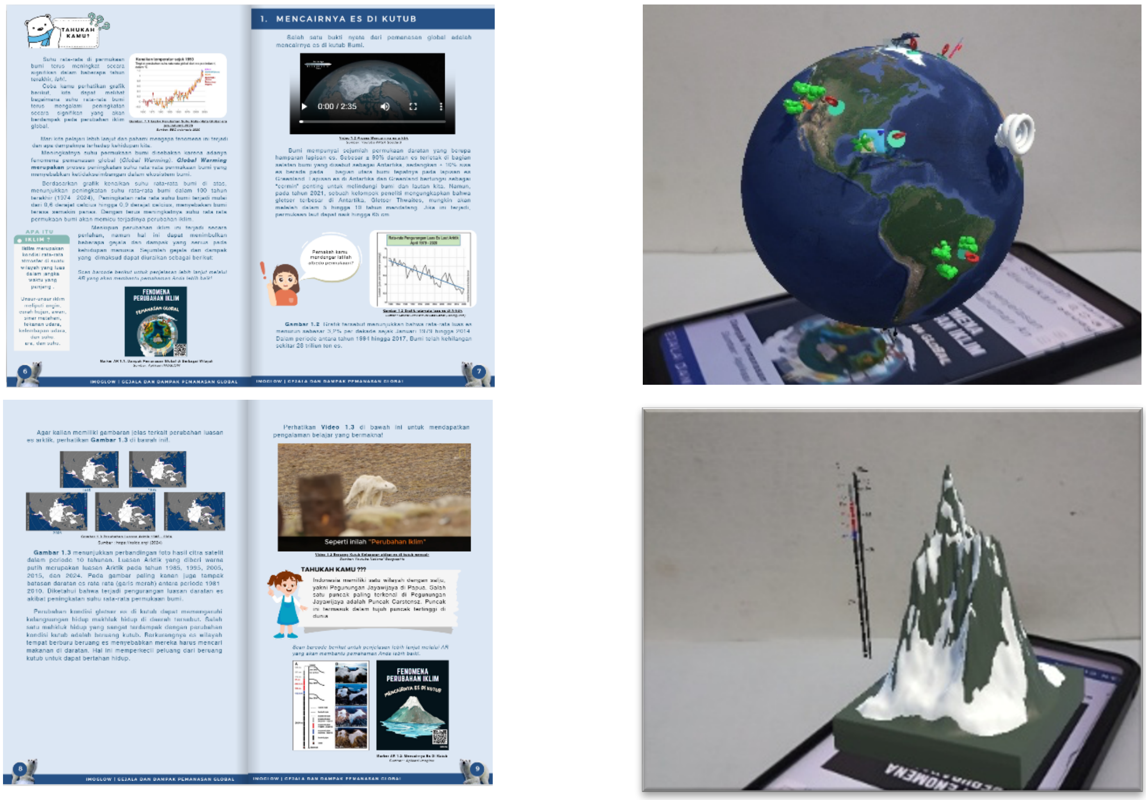

Figure 3. Preview of the AR-Based E-Module

The HOT dimension experienced an increase in logit in the high category. This is due to the implementation of the ICARE model, which is assisted by AR-based e-modules in the connect phase. As explained in Table 3, student activities in this phase use AR-based e-modules. AR as a medium to help students achieve deep understanding, accompanied by instructions from the teacher regarding things that must be considered when exploring AR, can increase students' self-efficacy in the HOT dimension. This aligns with the research [24] that using AR in learning can improve higher-order cognitive skills because this technology facilitates students to achieve deep understanding. In addition, the HOT dimension is trained in the apply phase, where students work on student worksheets assisted by PhET media, which requires confidence in using the skills of conducting scientific investigations, thinking critically, and making decisions. During the presentation, students were also encouraged to be confident in thinking creatively and critically during the question-and-answer activity between groups. This is in line with the research [14], which concluded that using student worksheets with the help of PhET can increase students' self-efficacy.

The EA dimension experienced an increase in logit in the high category. This results from implementing the ICARE model assisted by AR-based e-modules at the connect and apply stages. AR in the connect phase helps students visualize and provide an overview of phenomena that occur in the world. Meanwhile, students are encouraged to design solutions to overcome global warming using alternative energy in the apply phase. Both activities support students in increasing their confidence in applying science to real life so that self-efficacy in the EA dimension can increase. These results are supported by research [24], which explains that using AR in learning can provide a learning environment that gives students a deeper sense of relevance to learning materials.

The SCM dimension experienced a logit increase in the medium category. This result is the implementation of the ICARE model assisted by AR-based e-modules. This dimension is trained in the introduce, connect, apply, and reflect phases. Each phase encourages students to express opinions on learning materials, discussion questions, or discussion results. This can increase student confidence in expressing opinions and increase student self-efficacy. This is in line with research [30], which explains that the ICARE model can facilitate students to practice their communication skills in class, which are trained at the connect stage. In addition, the teacher provides feedback on each opinion so that students are more confident in discussing and expressing opinions related to learning material. These activities train students' self-efficacy in the SCM dimension. Feedback and appreciation activities for each student expressing an opinion help increase student self-efficacy. This is included in the source of student self-efficacy, namely verbal persuasion [29]. Therefore, self-efficacy in the SCM dimension has increased.

Finally, the SL dimension experienced the smallest logit increase compared to the other dimensions. The SL dimension is trained in the apply and extend phases. In the apply phase, in addition to conducting investigations in the virtual laboratory, the student worksheet requires students to interpret the data and make conclusions based on the data. In addition, in the extend phase, students must conduct a deeper exploration of the material outside of class hours until the next meeting. The SL dimension experienced the lowest increase possible because the apply and extend phases were not optimal. The apply phase was not optimally carried out due to the limited time spent working on the student worksheet in class, so the teacher did not accompany the teacher in analyzing and interpreting the results. In addition, there is no special assessment that oversees the extend activity, so the teacher does not know whether students really do independent exploration.

This research can still be developed further, especially to improve the science literacy dimension, which experienced the smallest increase. The implications of this study indicate that applying the ICARE model assisted by AR-based e-modules can be an effective alternative learning strategy to increase student self-efficacy. However, the limited implementation time of the model can affect the optimization of each phase, especially on aspects that require in-depth exploration by students. Therefore, future research is recommended to allocate more adequate time so that each phase in the ICARE model can be implemented optimally so that students' self-efficacy can increase

IV. Conclusions

This study concluded that the initial profile of students' self-efficacy showed that the science content dimension was relatively higher than other dimensions. After implementing the ICARE model assisted by AR-based E-Modules, there was an increase in student self-efficacy, as seen from the change in logit value between pretest and posttest, which showed positive results.

However, this study has several limitations. Convenience sampling may limit the generalization of these findings to a wider population. In addition, this study was only conducted in one school with a relatively small sample size, so the results may not reflect conditions in other schools. The limited duration of the study is also an obstacle to seeing the long-term impact of ICARE implementation assisted by AR-based e-modules on student self-efficacy. For further development, future research can test the effectiveness of AR-assisted ICARE with a more robust experimental design, such as a quasi-experimental with a control group. In addition, the development of AR e-modules can be expanded with additional interactive features that better support students' scientific literacy dimensions. The application of this model to other physics materials can also be further studied to test the consistency of its impact on various learning topics.

References

[1] J. J. Sudirman, "Capaian pembelajaran pada pendidikan anak usia dini, jenjang pendidikan dasar, dan jenjang pendidikan menengah pada kurikulum merdeka," 2024, *Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi*. [Online]. Available: https://guru.kemdikbud.go.id/dokumen/74r6Yln0zK

[2] D. Wangchuk, D. Wangdi, S. Tshomo, and J. Zangmo, "Exploring students' perceived difficulties of learning physics," *Educational Innovation and Practice*, vol. 6, 2023, doi: https://doi.org/10.17102/eip.6.2023.03.

[3] R. Rahmadhani, "Meta-analysis of the effect of inquiry training learning model on the learning outcomes of high school physics students class x," *Journal of Learning and Technology in Physics*, vol. 3, no. 1, p. 29, 2024, doi: https://doi.org/10.24114/jltp.v3i1.57020.

[4] A. A. Dalila, S. Rahmah, W. Liliawati, and I. Kaniawati, "Effect of differentiated learning in problem based learning on cognitive learning outcomes of high school students," *Jurnal Penelitian Pendidikan IPA*, vol. 8, no. 4, pp. 2116–2122, 2022, doi: https://doi.org/10.29303/jppipa.v8i4.1839.

[5] Zakirman, W. Widiasih, D. Sukmayadi, R. Aprianti, and K. Nadiyyah, "New Pattern to Improving Student Physics Learning Outcomes," *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 9, pp. 7439–7444, 2023, doi: https://doi.org/10.29303/jppipa.v9i9.3324.

[6] Bandura, Self efficacy-the excercise of control, 2nd ed. Standford University, New York: W.H Freeman and Company, 1997.

[7] N. Suprapto, T.-S. Chang, and C.-H. Ku, "Conception of learning physics and self-efficacy among indonesian university students," *Journal of Baltic Science Education*, vol. 16, no. 1, pp. 7–19, 2017, doi: https://doi.org/10.33225/jbse/17.16.07.

[8] A. Sabur, D. Saepuloh, S. Subaidah, and D. Firmansyah, "Effectiveness of implementation of high order thinking skills (HOTS) and self efficacy of students in improving economic literacy," in *Proceedings of the 3rd International Conference on Educational Development and Quality Assurance (ICED-QA 2020)*, Atlantis Press SARL, 2021, pp. 579–584. doi: https://doi.org/10.2991/assehr.k.210202.100.

[9] R. Anjiana, Y. S. Makiyah, and E. Susanti, "Pengaruh model creative problem solving (CPS) terhadap self efficacy dan keterampilan berpikir kreatif peserta didik pada materi optik," *Jurnal Penelitian Pembelajaran Fisika*, vol. 15, no. 2, pp. 204–212, 2024, doi: https://doi.org/10.26877/jp2f.v15i2.17896.

[10] S. Hadijah, S. Sarwi, and M. Masturi, "Analyzing physics learning to determine the character and self-efficacy of high school students," *Physics Communication*, vol. 6, no. 1, pp. 7–11, 2022, doi: https://doi.org/10.15294/physcomm.v6i1.34463.

[11] N. Nurulwati, L. Khairina, and I. Huda, "The effect of students self-efficacy on the learning outcomes in learning physics," *J Phys Conf Ser*, vol. 1460, no. 1, p. 012113, 2020, doi: https://doi.org/10.1088/1742-6596/1460/1/012113.

[12] I. A. Rizki, E. F. Khoir, F. Nikmah, B. K. Prahani, and E. Hariyono, "Effect of physics inquiry learning with low-cost experiment tool on students' problem-solving skills and self-efficacy," *Physics Education Research Journal*, vol. 6, no. 1, pp. 1–10, 2024, doi: https://doi.org/10.21580/perj.2024.6.1.19001.

[13] A. G. Dewayani and N. Suprapto, "Keterkaitan self-efficacy dalam pembelajaran fisika materi gas ideal dan teori kinetik gas dengan model pembelajaran kooperatif tipe jigsaw terhadap hasil belajar siswa," vol. 08, no. 02, 2019, doi: https://doi.org/https://doi.org/10.26740/ipf.v8n2.p%25p.

[14] Bektiarso, N. Megawati, and S. H. B. Prastowo, "Self-efficacy and student physics learning outcomes in problem based learning (PBL) with PhET media," *Gravity : Jurnal Ilmiah Penelitian dan Pembelajaran Fisika*, vol. 8, no. 2, pp. 108–116, 2022, doi: http://dx.doi.org/10.30870/gravity.v8i2.13975.

[15] N. Nurulwati, C. R. Afdar, S. Zakaria, and Y. Yusrizal, "The relationship of self-efficacy towards high level of thinking ability of USK physics education student in basic physics I course," *Jurnal Pendidikan Sains Indonesia*, vol. 10, no. 3, pp. 527–537, 2022, doi: https://doi.org/10.24815/jpsi.v10i3.24153.

[16] C. S. Ugwuanyi, "Motivation and self-efficacy as predictors of learners' academic achievement," *Journal of Sociology and Social Anthropology*, vol. 11, no. 3–4, 2020, doi: https://doi.org/10.31901/24566764.2020/11.3-4.351.

[17] L. E. Sartika and N. Sepriyanti, "Self-efficacy of students in mathematics learning using the icare learning model," in *5th UIN Imam Bonjol International Conference on Islamic Education*, 2024, pp. 152–160.

[18] A. Walid, R. N. Sasongko, M. Kristiawan, R. G. T. Kusumah, and M. Andaria, "ICARE (Introduction, Connection, Application, Reflection, and Extension): Analysis of Effectiveness in Improving Student's Communication and Collaboration Ability," *Jurnal Penelitian Pendidikan IPA*, vol. 7, no. 3, pp. 305–309, May 2021, doi: https://doi.org/10.29303/jppipa.v7i3.685.

[19] N. Agustini, "Penerapan model pembelajaran ICARE (introduction, connect, apply, reflect, extend) untuk meningkatkan kemampuan memahami dan mengaplikasikan dalam konteks dunia nyata siswa sma.," 2016. [Online]. Available: http://repository.upi.edu/

[20] S. Afifah, F. Bakri, and D. Muliyati, "Augmented reality integrated poster as a media to introduce gauss science figure and the concept of electric fields," *JoTaLP: Journal of Teaching and Learning Physics*, 1(2023):, vol. 8, pp. 33–38, 2023, doi: http://dx.doi.org/10.15575/jotalp.v8i1.24319.

[21] Nasruddin *et al.*, *Pengembangan bahan ajar*, 1st ed. Padang: PT. Global Eksekutif Teknologi, 2022. [Online]. Available: Www.Globaleksekutifteknologi.Co.Id

[22] Z. Tacgin, "Virtual and augmented reality: an educational handbook," *Cambridge Scholar Publishing*, 2020.

[23] H. Faridi, N. Tuli, A. Mantri, G. Singh, and S. Gargrish, "A framework utilizing augmented reality to improve critical thinking ability and learning gain of the students in Physics," *Computer Applications in Engineering Education*, vol. 29, no. 1, pp. 258–273, 2021, doi: https://doi.org/10.1002/cae.22342.

[24] S. Cai, C. Liu, T. Wang, E. Liu, and J. Liang, "Effects of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning," *British Journal of Educational Technology*, vol. 52, no. 1, pp. 235–251, 2021, doi: https://doi.org/10.1111/bjet.13020.

[25] Santoso, Singgih, and F. Tjiptono, *Riset Pemasaran: Konsep dan aplikasi dengan SPSS*. Jakarta: PT Elex Media Komputindo, 2001.

[26] M. I. Sukarelawan, T. K. Indratno, and S. M. Ayu, *N-gain vs stacking : analisis perubahan abilitas peserta didik dalam desain one group pretest-posttest*. Bantul: Penerbit Suryacahya, 2024.

[27] B. Sumintono and W. Widhiarso, *Aplikasi model rasch: untuk penelitian ilmu-ilmu sosial*. Cimahi: Trim Komunikata Publishing House, 2013.

[28] E. Appiah-Twumasi, Y. Ameyaw, and I. Kwasi Anderson, "Development and validation of questionnaire for physics learning self-efficacy among ghanaian senior high schools," *East African Journal of Management and Business Studies*, vol. 2, no. 1, pp. 8–18, 2022, doi: https://doi.org/10.46606/eajess2022v03i01.0141.

[29] S. L. Britner and F. Pajares, "Sources of science self-efficacy beliefs of middle school students," *J Res Sci Teach*, vol. 43, no. 5, pp. 485–499, 2006, doi: https://doi.org/10.1002/tea.20131.

[30] P. Siahaan, E. Dewi, and E. Suhendi, “Introduction, Connection, Application, Reflection, and Extension (ICARE) Learning Model: The Impact on Students’ Collaboration and Communication Skills,” *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, vol. 9, no. 1, pp. 109–119, Apr. 2020, doi: https://10.24042/jipfalbiruni.v9i1.5547.