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Improving Students' Sustainable Environmental Awareness Using the Read-Answer-Discuss-Explain-Create Learning Model with Greenhouse Effect Animation Video: A Stacking Analysis

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Abstract. Despite increasing global attention to environmental issues, many elementary school students still lack adequate awareness and understanding of sustainable environmental practices. This low level of awareness poses a significant challenge to achieving long-term environmental sustainability, as early education plays a critical role in shaping pro-environmental attitudes and behaviors. This study aims to examine the effect of RADEC learning model assisted by greenhouse effect animation video on improving elementary school students' sustainable environmental awareness. Using a quasi-experimental design and pretest-posttest approach, data were collected through tests measured by logit scores before and after the intervention, which included aspects of knowledge, attitudes, behaviors, and practices related to the environment. The analysis technique used was Rasch analysis with the stacking method to evaluate changes in students' environmental awareness. The results showed that the RADEC learning model with the greenhouse effect animation video successfully improved students' sustainable environmental awareness in all measured dimensions, especially in the emotional, attitudinal and behavioral, and practice dimensions. In contrast, the control class using conventional learning showed only limited improvement, with some students even experiencing a decline in ability. These findings suggest that the use of visual media and an inquiry-based approach in RADEC is more effective in improving students' environmental awareness compared to traditional learning. Therefore, this study makes an important contribution to the development of inquiry-based learning methods and visual media in sustainability education in primary schools.
Keywords: RADEC model, greenhouse effect animation, sustainable environmental awareness, Rasch analysis, stacking method.

Introduction

Sustainable environmental awareness has become a major focus in 21st-century education due to the escalating global environmental crisis and the urgent need to foster responsible citizenship from an early age (Chawla & Cushing, 2021; Sass et al., 2025; Hidayat et al., 2025). However, several studies have reported that elementary school students still exhibit low levels of environmental literacy and lack the skills to translate knowledge into concrete environmental actions (Ardoin et al., 2020; Pauw et al., 2015). This issue is compounded by the abstract nature of scientific concepts related to sustainability, such as climate change and global warming, which are often difficult for younger students to grasp (Lehtonen et al., 2018; Liu & Green, 2024).

One strategy to overcome this challenge is through the integration of engaging visual media in science education. Animated videos, in particular, have been shown to enhance students' understanding of complex scientific phenomena and improve retention by combining visual and auditory learning channels (Putri & Apriza, 2024; Hanif, 2020). For instance, an animated video depicting the greenhouse effect can help students visualize invisible processes, such as the interaction between greenhouse gases and the earth's atmosphere, which are often difficult to convey through conventional teaching methods (Zhu et al., 2021; Hanif, 2020; Maurer et al., 2020; Aulia et al., 2024). These media also increase students' motivation and engagement, fostering deeper learning and greater environmental awareness.

However, while animated videos can enhance conceptual understanding, they must be complemented by pedagogical approaches that promote active learning and critical thinking. The RADEC model provides an inquiry-based framework that encourages students to engage with content through multiple cognitive processes, from comprehension to creativity. Research has shown that RADEC improves students' critical thinking, collaboration, and engagement with scientific topics (Fatikhin et al., 2024; Fatimah et al., 2024; Kiska et al., 2024; Agustina et al., 2024; Burhanudin et al., 2024). When combined with visual media, RADEC can offer a more holistic and meaningful learning experience, especially in the context of sustainability education.

While numerous studies have explored the individual benefits of either RADEC or animated videos, there is a scarcity of research that integrates both strategies to improve sustainable environmental awareness, particularly at the elementary level (Lasari et al., 2023; Oliveira et al., 2021). Moreover, most existing studies rely on conventional statistical methods that do not fully account for individual differences in student responses or the ordinal nature of assessment data. In response, this study adopts rasch modeling with the stacking method—a powerful psychometric approach that allows for more valid and reliable analysis of changes in student awareness over time (Boone et al., 2020).

This study aims to examine the effect of using the RADEC model aided by a greenhouse effect animation video on increasing elementary school students' sustainable environmental awareness. Using the rasch stacking analysis technique, this study evaluated the changes in students' awareness before and after the intervention measured through pre-test and post-test data from the experimental class. The novelty of this study lies in the innovative combination of the inquiry-based RADEC model with a greenhouse effect animation video, an approach that has not been widely explored in the context of education for sustainability.

In addition, this study also applied the rasch stacking technique, which is rarely used in the analysis of animation media-based learning and the RADEC model, to provide deeper insights into the effectiveness of the instrument and the impact of learning on students' environmental awareness. This makes an important contribution in evaluating the effectiveness of instruments that measure environmental awareness more validly and reliably through advanced statistical approaches, which account for variability between

students and test items. This study aims to examine the effect of RADEC learning model assisted by greenhouse effect animation video on improving elementary school students' sustainable environmental awareness.

Methods

This study adopted a quasi-experimental design using a pretest-posttest approach involving two groups. The target population was all fifth grade students in an elementary school in Bandung City. A purposive sampling technique was applied to select the participant sample. In this case, the researcher collaborated with the IPAS subject teacher to determine two classes, namely the experimental class and the control class, both of which had not been taught material related to the greenhouse effect. The experimental class consisted of 33 students, while the control class consisted of 32 students.

A pretest was conducted prior to the intervention to assess the level of students' sustainable environmental awareness in the experimental and control classes. In the experimental class, the intervention was conducted by applying the RADEC model supported by an animated video on the greenhouse effect. Meanwhile, the control class followed conventional learning. In the experimental class, the first stage, read, began with the provision of independent reading material to students, which was equipped with an animated video of the greenhouse effect. The video serves to help students understand complex processes, such as how greenhouse gases block the release of heat from the earth's surface, which ultimately leads to global warming. In addition, the animation also illustrates the negative impacts of increased greenhouse gas emissions, such as climate change, increased global temperatures, and extreme weather. With an engaging visual display, students can see first-hand the impact of human activities on the environment, such as deforestation, burning fossil fuels, and intensive agriculture that increase the concentration of greenhouse gases in the atmosphere.

In the answer stage, students are asked to analyze and answer questions that have been prepared before learning, using the information they have obtained from the reading materials and the animated video. This aims to hone students' analytical skills and connect the knowledge gained through the animation media with deeper scientific concepts. Through group discussions in the discuss stage, students share their understanding of the influence of greenhouse gas emissions and its impact on the global environment. In the last stage of RADEC, create, the animation video serves as a source of inspiration for students to create creative works that communicate solutions in reducing the impact of the greenhouse effect. Student groups were asked to create projects related to efforts to reduce greenhouse gases such as educational posters, environmental songs, and campaign videos that invite people to reduce carbon footprints, save energy, and preserve the environment, which were then reinforced by teachers/educators. After all learning stages were completed, a posttest was conducted to evaluate the students' level of sustainable environmental awareness after the intervention.

This study measures students' sustainable environmental awareness by using an instrument that is rarely used by previous researchers who mostly use questionnaires. The instrument used is a test question with a choice of statements that must be chosen correctly by students for aspects of knowledge, behavior and attitudes, and sustainable awareness practices. The content in this test question contains material related to the greenhouse effect taught at the elementary school level. This instrument is adapted from (Hassan et al., 2010; Ruslindawati et al., 2022) which measures the same aspects of sustainable environmental awareness on different topics. An example of a sustainable environmental awareness test question is shown in Figure 1.

Look at the following statements carefully!
(1) I turn off the TV or other electronic devices after use.
(2) I burn garbage in my yard to reduce waste.
(3) I advise my family to plant trees around the house.
(4) I support the use of public transportation to reduce air pollution.
(5) I don't care if I use disposable plastics in large quantities.
Which combination reflects a sustainable attitude towards the greenhouse effect?
a. (1), (3), (4)
b. (2), (3)
c. (3), (4), (5)
d. (1), (4)

Figure 1. Example sustainable environment awareness test

The instruments used in this study have been validated by experts and tested for construct validity and reliability with the Rasch technique, using winsteps software version 5.7.1.0. The results of the instrument validity test were carried out by testing dimensionality and item fit. The results of the dimensionality test are shown in Figure 1, where based on raw variance in the appropriate category> 20%, eigen value on unexplained variance in 1st contrast < 3, and observed on unexplained variance in 1st under 15%.

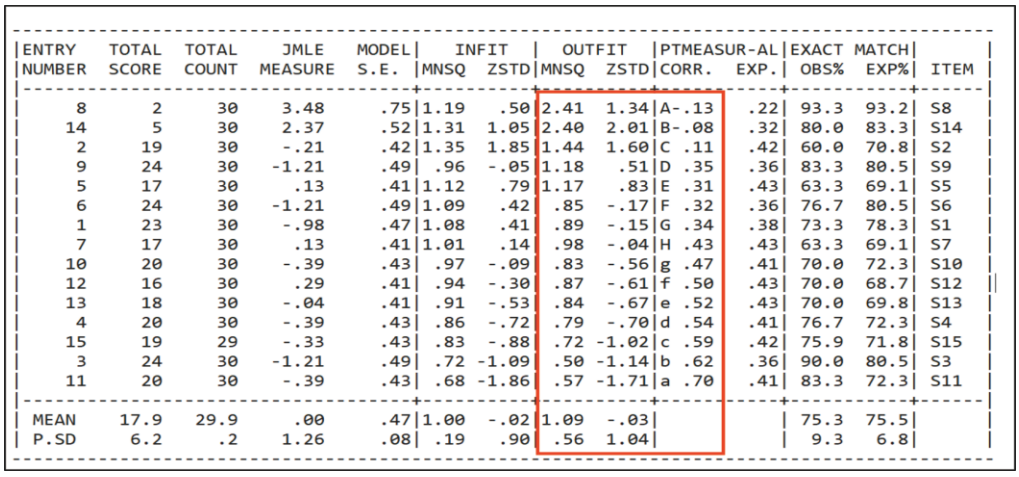
TABLE 23.0 Rash KLB - Copy.xlsx ZOU281WS.TXT Jun 22 2025 17:03
INPUT: 30 PERSON 15 ITEM REPORTED: 30 PERSON 15 ITEM 2 CATS WINSTEPS 5.7.1.0

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

	Eigenvalue	Observed		Expected
Total raw variance in observations =	22.1375	100.0%		100.0%
Raw variance explained by measures =	7.1375	32.2%		31.6%
Raw variance explained by persons =	3.2771	14.8%		14.5%
Raw Variance explained by items =	3.8604	17.4%		17.1%
Raw unexplained variance (total) =	15.0000	67.8%	100.0%	68.4%
Unexplned variance in 1st contrast =	2.5122	11.3%	16.7%	
Unexplned variance in 2nd contrast =	2.4379	11.0%	16.3%	
Unexplned variance in 3rd contrast =	1.8592	8.4%	12.4%	
Unexplned variance in 4th contrast =	1.6964	7.7%	11.3%	
Unexplned variance in 5th contrast =	1.3809	6.2%	9.2%	

Figure 2. Dimensionality test results

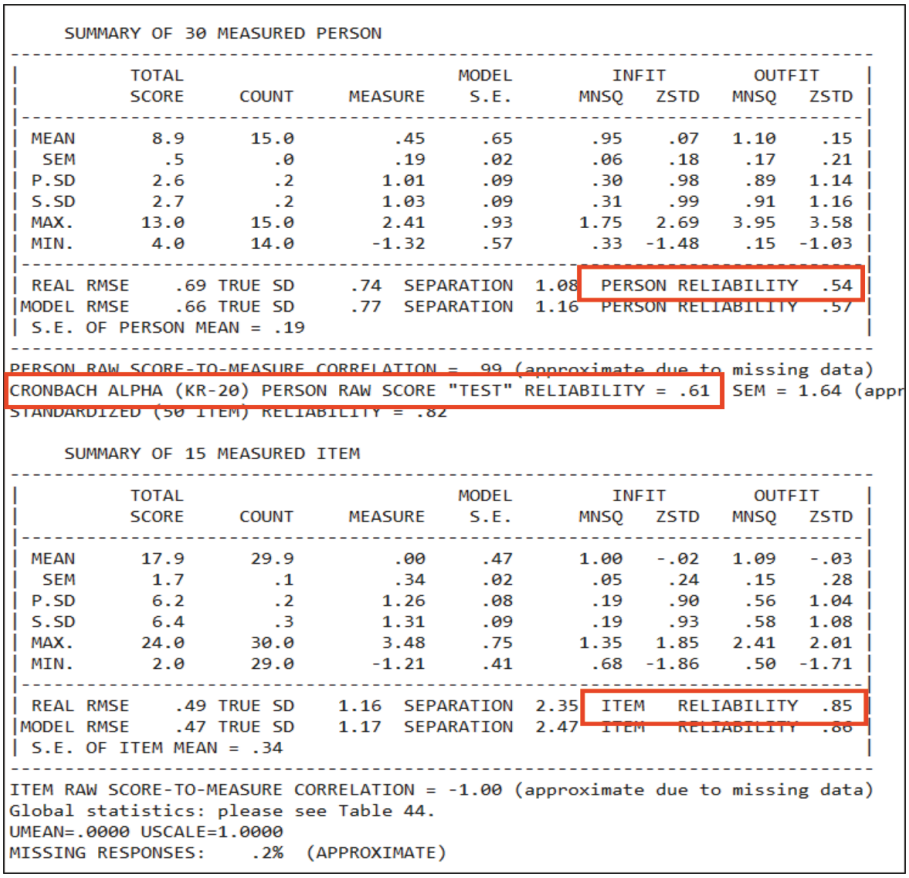
The item fit test is conducted to test the construct validity of the questions by considering three testing criteria, namely MNSQ, ZSTD, and PT measure corr. A question is considered valid if it meets all three criteria or at least one of them (Nebe et al., 2020; Ismail et al., 2025). The item fit test process used Winsteps software version 5.7.1.0, and the results can be seen in Figure 2. Of the 15 questions tested, there was one question that did not meet the three criteria, so the question needed to be improved, both in terms of the question wording and the answer choices.



ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	JMLE MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	ITEM
8	2	30	3.48	.75	1.19	.50	2.41	1.34	A -.13	.22	93.3	93.2	S8
14	5	30	2.37	.52	1.31	1.05	2.40	2.01	B -.08	.32	80.0	83.3	S14
2	19	30	-.21	.42	1.35	1.85	1.44	1.60	C .11	.42	60.0	70.8	S2
9	24	30	-1.21	.49	.96	-.05	1.18	.51	D .35	.36	83.3	80.5	S9
5	17	30	.13	.41	1.12	.79	1.17	.83	E .31	.43	63.3	69.1	S5
6	24	30	-1.21	.49	1.09	.42	.85	-.17	F .32	.36	76.7	80.5	S6
1	23	30	-.98	.47	1.08	.41	.89	-.15	G .34	.38	73.3	78.3	S1
7	17	30	.13	.41	1.01	.14	.98	-.04	H .43	.43	63.3	69.1	S7
10	20	30	-.39	.43	.97	-.09	.83	-.56	g .47	.41	70.0	72.3	S10
12	16	30	.29	.41	.94	-.30	.87	-.61	f .50	.43	70.0	68.7	S12
13	18	30	-.04	.41	.91	-.53	.84	-.67	e .52	.43	70.0	69.8	S13
4	20	30	-.39	.43	.86	-.72	.79	-.70	d .54	.41	76.7	72.3	S4
15	19	29	-.33	.43	.83	-.88	.72	-1.02	c .59	.42	75.9	71.8	S15
3	24	30	-1.21	.49	.72	-1.09	.50	-1.14	b .62	.36	90.0	80.5	S3
11	20	30	-.39	.43	.68	-1.86	.57	-1.71	a .70	.41	83.3	72.3	S11
MEAN	17.9	29.9	.00	.47	1.00	-.02	1.09	-.03			75.3	75.5	
P.SD	6.2	.2	1.26	.08	.19	.90	.56	1.04			9.3	6.8	

Figure 3. Sustainable environmental awareness instrument validity results

The reliability test was conducted by examining the Cronbach alpha, item reliability, and person reliability values. The reliability test results shown in Figure 3 indicate that the Cronbach alpha value is > 0.6 (fair), item reliability > 0.8 (good), and person reliability < 0.65 (weak) (Sumintono & Widhiarso, 2014). Based on these results, it can be concluded that this instrument has a fairly good reliability, where the items in the instrument measure the same aspects consistently. Although the quality of the items in the instrument is good enough, there is a weakness in the consistency of respondents' answers.



SUMMARY OF 30 MEASURED PERSON

	TOTAL SCORE	COUNT	MODEL MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	8.9	15.0	.45	.65	.95	.07	1.10	.15
SEM	.5	.0	.19	.02	.06	.18	.17	.21
P.SD	2.6	.2	1.01	.09	.30	.98	.89	1.14
S.SD	2.7	.2	1.03	.09	.31	.99	.91	1.16
MAX.	13.0	15.0	2.41	.93	1.75	2.69	3.95	3.58
MIN.	4.0	14.0	-1.32	.57	.33	-1.48	.15	-1.03

REAL RMSE .69 TRUE SD .74 SEPARATION 1.08 PERSON RELIABILITY .54
MODEL RMSE .66 TRUE SD .77 SEPARATION 1.16 PERSON RELIABILITY .57
S.E. OF PERSON MEAN = .19

PERSON RAW SCORE-TO-MEASURE CORRELATION = .99 (approximate due to missing data)
CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .61 SEM = 1.64 (appr
STANDARDIZED (50 ITEM) RELIABILITY = .82

SUMMARY OF 15 MEASURED ITEM

	TOTAL SCORE	COUNT	MODEL MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	17.9	29.9	.00	.47	1.00	-.02	1.09	-.03
SEM	1.7	.1	.34	.02	.05	.24	.15	.28
P.SD	6.2	.2	1.26	.08	.19	.90	.56	1.04
S.SD	6.4	.3	1.31	.09	.19	.93	.58	1.08
MAX.	24.0	30.0	3.48	.75	1.35	1.85	2.41	2.01
MIN.	2.0	29.0	-1.21	.41	.68	-1.86	.50	-1.71

REAL RMSE .49 TRUE SD 1.16 SEPARATION 2.35 ITEM RELIABILITY .85
MODEL RMSE .47 TRUE SD 1.17 SEPARATION 2.47 ITEM RELIABILITY .86
S.E. OF ITEM MEAN = .34

ITEM RAW SCORE-TO-MEASURE CORRELATION = -1.00 (approximate due to missing data)
Global statistics: please see Table 44.
UMEAN=.0000 USCALE=1.0000
MISSING RESPONSES: .2% (APPROXIMATE)

Figure 4. Instrument reliability test results based on cronbach alpha, person reliability, and item reliability data.

The pretest and posttest data from students in both the experimental and control classes were analyzed using the stacking technique. The pretest and posttest data were collected simultaneously, then processed and converted into an equivalent interval scale (logit). Changes in students' abilities were analyzed by looking at the shifts in the position of ability levels on the vertical ruler as well as changes in logit values obtained from Winsteps software version 5.7.1.0. The stacking technique allows researchers to observe changes in students' abilities over time in greater depth, especially after an intervention (Nebe et al., 2020; Ismail et al., 2025). As in the stacking technique, pretest and posttest data were collected at the same time, then the raw data were converted to an interval scale (logit). Changes in item difficulty levels were analyzed through shifts in item positions on the vertical ruler as well as changes in logit values recorded in Winsteps software version 5.7.1.0.

Results and Discussion

The stacking analysis technique was used to compare the level of students' sustainable environmental awareness before and after the application of the RADEC learning model supported by the greenhouse effect animation video in the experimental class, with the conventional model in the control class as a comparison. Students' sustainable environmental awareness was measured using logit values. A positive change in logit value indicates an increase in student ability, while a negative value indicates a decrease in student ability (Laliyo, 2021). To facilitate the tabulation process, students were coded based on sequential numbers. Table 1 presents a summary of the mean values, standard deviations of logit value person (LVP), and LVP categorization for each class based on the results of the Rasch stacking test.

Table 1. Mean logit values, standard deviations, and lvp categorization of students' awareness of environmental sustainability

Class	Mean logit (M)	Standard deviation (SD)	Category				
			Very high, LVP > M+2SD	High, M+2SD ≥ LVP ≥ M+SD	Medium, M+SD > LVP > M-SD	Low, M-SD ≥ LVP ≥ M-2SD	Very low, LVP < M-2SD
Experimental class (pre-test)	0.32	1.32	1 student	-	23 students	9 students	-
Experimental class (post-test)			2 students	6 students	20 students	5 students	-
Control class (pre-test)	-3.04	0.98	-	6 students	21 students	4 students	1 student
Control class (Post-Test)			-	8 students	17 students	7 students	-

The results of the pretest and posttest data analysis of experimental class students can be seen in Table 2.

Table 2. Measure of sustainable environmental awareness of experimental class students

Person	Measure		Difference	Category
	Pretest logit values	Posttest logit values		
R1	-0.23	0.08	0.31	Positive
R2	-0.53	1.11	1.64	Positive
R3	-0.23	2.18	2.41	Positive
R4	-0.23	1.57	1.8	Positive
R5	-0.53	0.39	0.92	Positive
R6	1.57	1.57	0	Positive
R7	-0.23	2.18	2.41	Positive
R8	-2.11	1.57	3.68	Positive
R9	-0.23	1.11	1.34	Positive
R10	1.11	2.18	1.07	Positive
R11	1.11	1.11	0	Positive
R12	0.73	1.11	0.38	Positive
R13	0.73	1.57	0.84	Positive
R14	-0.53	0.73	1.26	Positive
R15	-1.6	0.68	2.28	Positive
R16	3.12	3.12	0	Positive
R17	-0.23	-0.23	0	Positive
R18	1.57	2.18	0.61	Positive
R19	0.39	1.57	1.18	Positive
R20	-1.2	-1.2	0	Positive
R21	-1.2	0.39	1.59	Positive
R22	-1.2	-1.2	0	Positive
R23	-1.2	0.08	1.28	Positive
R24	-0.23	0.73	0.96	Positive
R25	-0.53	-1.2	-0.67	Negative
R26	-0.85	-1.6	-0.75	Negative
R27	-2.11	-1.6	0.51	Positive
R28	-1.2	3.12	4.32	Positive
R29	-0.53	1.57	2.1	Positive
R30	-0.23	1.11	1.34	Positive
R31	-0.53	-0.23	0.3	Positive
R32	-0.53	2.18	2.71	Positive
R33	-1.2	2.18	3.38	Positive
Mean	-0.28	0.91	1.19	Positive

The results of the pretest and posttest data analysis of control class students can be seen in Table 3.

Table 3. Measure of sustainable environmental awareness of control class students

Person	Measure		Difference	Category
	Pre-test logit values	Post-test logit values		
R1	-3.96	-3.03	0.93	Positive
R2	-2.04	-2.39	-0.35	Negative
R3	-2.04	-1.64	0.4	Positive
R4	-4.31	-2.04	2.27	Positive
R5	-4.31	-2.72	1.59	Positive
R6	-3.64	-2.04	1.6	Positive
R7	-2.04	-2.39	-0.35	Negative
R8	-1.64	-2.72	-1.08	Negative
R9	-3.33	-3.64	-0.31	Negative
R10	-3.96	-1.64	2.32	Positive
R11	-2.72	-2.39	0.33	Positive
R12	-3.33	-2.39	0.94	Positive
R13	-3.03	-2.72	0.31	Positive
R14	-3.03	-2.72	0.31	Positive
R15	-4.72	-2.83	1.89	Positive
R16	-2.39	-1.64	0.75	Positive
R17	-3.96	-3.64	0.32	Positive
R18	-3.33	-1.64	1.69	Positive
R19	-2.72	-2.04	0.68	Positive
R20	-1.17	-4.31	-3.14	Negative
R21	-2.39	-4.31	-1.92	Negative
R22	-2.72	-4.31	-1.59	Negative
R23	-3.33	-4.72	-1.39	Negative
R24	-5.23	-2.72	2.51	Positive
R25	-2.39	-4.31	-1.92	Negative
R26	-2.39	-4.72	-2.33	Negative
R27	-2.04	-4.72	-2.68	Negative
R28	-4.31	-1.17	3.14	Positive
R29	-3.33	-2.39	0.94	Positive
R30	-3.96	-3.03	0.93	Positive
R31	-3.64	-3.33	0.31	Positive
R32	-3.96	-3.03	0.93	Positive
Mean	-3.17	-2.92	0.25	Positive

Table 2 shows the pretest and posttest logit scores for the experimental group students, which showed positive changes in most participants, indicating an improvement in their environmental awareness. The difference between the pretest and posttest logit

scores shows that most students improved, except for one student (R25) who decreased. In addition, several other students (R6, R11, R16, R17, and R20) showed a value of "zero" in the difference between the pretest and posttest, indicating that they experienced no change in ability in terms of either improvement or decline. These findings suggest that the RADEC learning model aided by the greenhouse effect animation video was effective in improving students' environmental awareness, as evidenced by the positive change in their posttest logit scores.

In the control class, as shown in Table 3, although some students showed an increase in ability (positive category), the number of students who experienced a decrease in ability (negative category) was quite significant. Students such as R2, R7, R8, R9, R20, R21, R22, and others experienced a decrease in posttest logit scores compared to their pretests. This negative logit value difference indicates a decrease in students' environmental understanding or awareness after following conventional learning. However, the control class as a whole still showed a positive average change in logit scores, with an average difference of 0.25. This indicates that while there was a decrease in some students, there were still some students who managed to show an increase, although the impact of conventional learning was more limited compared to the RADEC learning model in the experimental class.

The logit analysis also illustrated the students' ability levels, visualized through vertical ruler analysis, which showed a clear increase in environmental awareness after the intervention. Meanwhile, the vertical ruler analysis of the experimental class is shown in Figure 5 and Figure 6.

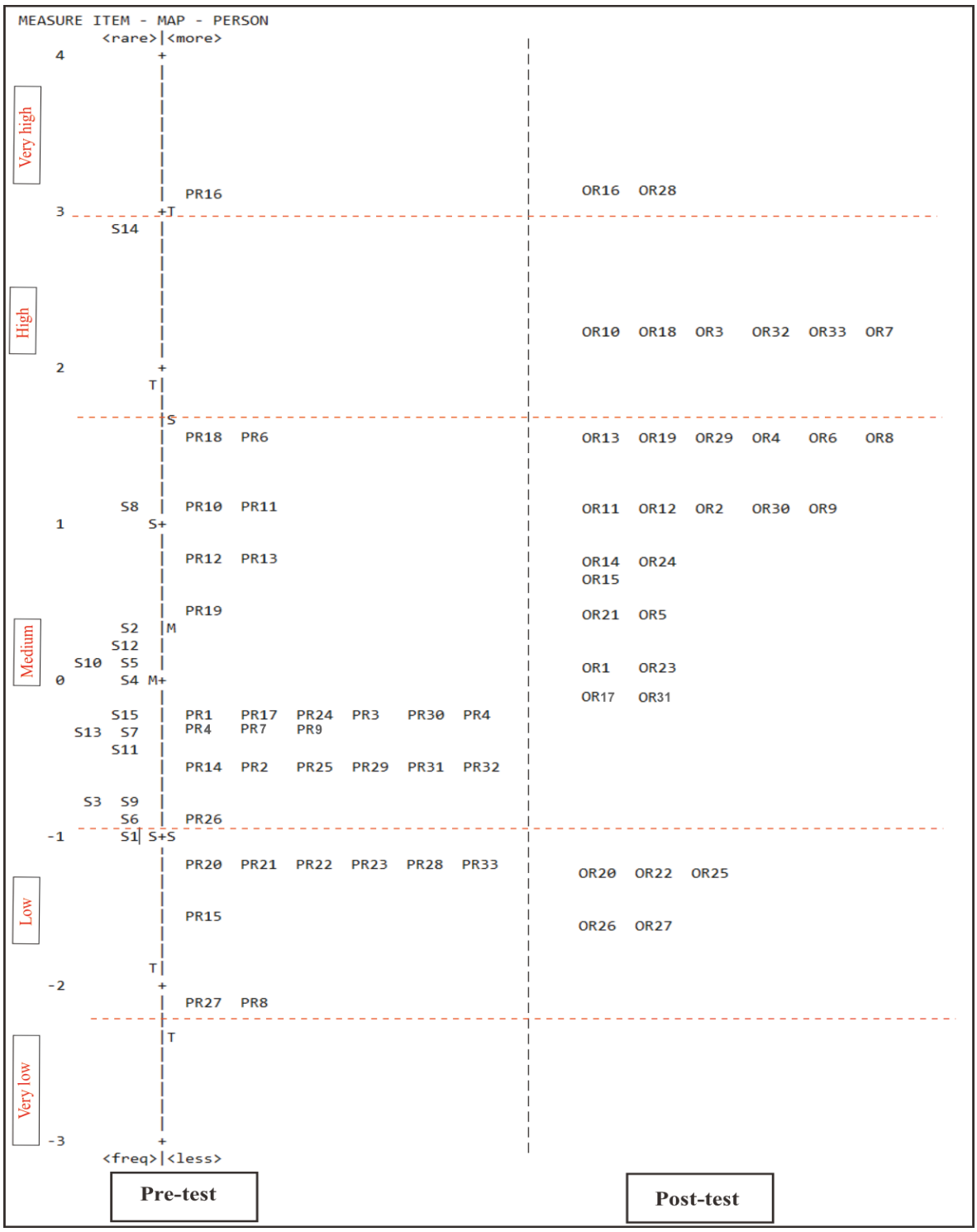


Figure 5. Wright map stacking analysis of experimental class students' sustainable environmental awareness.

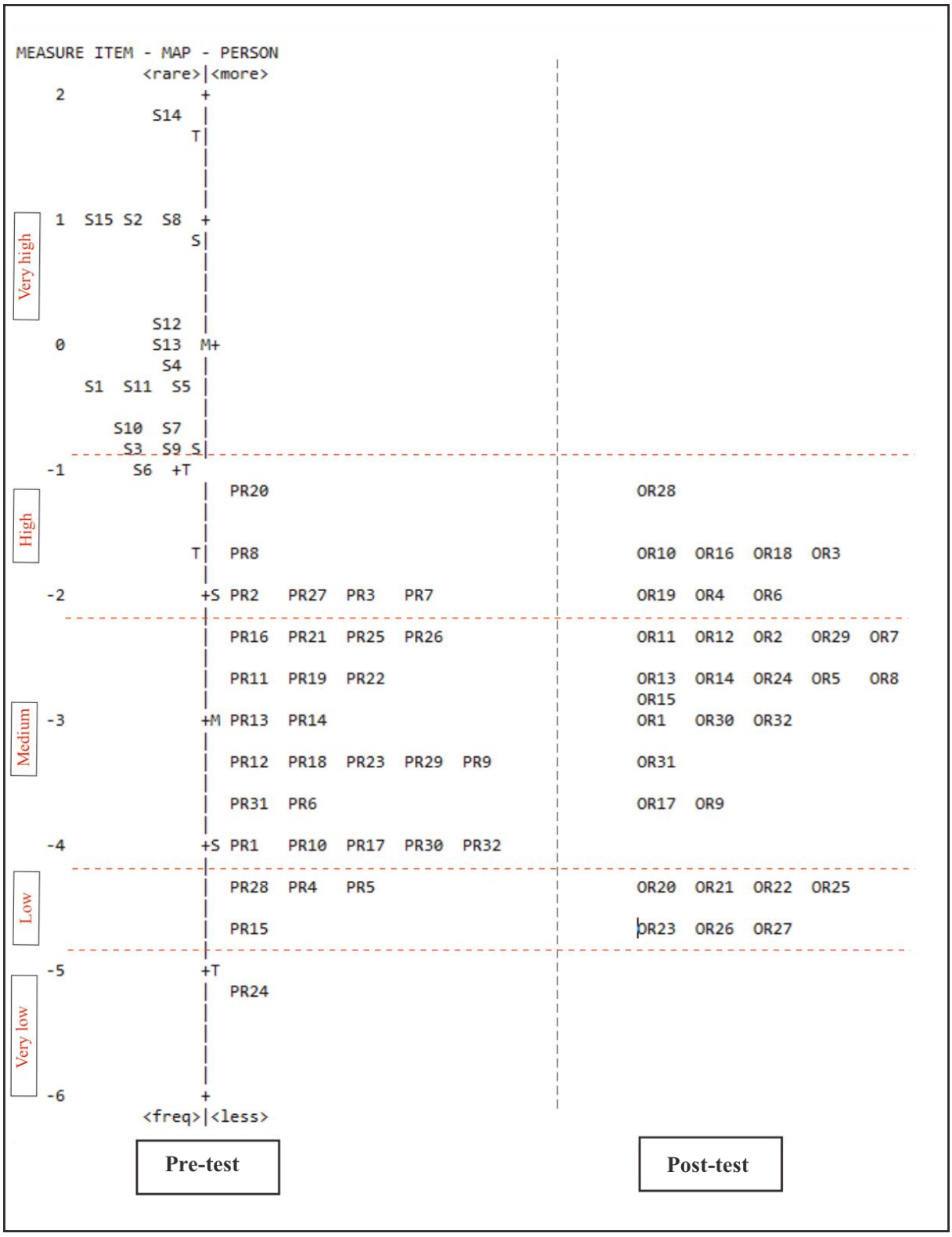


Figure 6. Wright map stacking analysis of control class students' sustainable environmental awareness.

The results of the wright map analysis between the experimental and control classes showed significant differences in the improvement of students' sustainable environmental awareness, especially in the emotional, attitude and behavior, and practice dimensions. In the experimental class, almost all students showed significant improvement, reflected in the positive logit value change in the post-test compared to the pre-test. This indicates that RADEC-based learning supported by the greenhouse effect animation video has successfully improved students' understanding and awareness of environmental issues. The most visible improvement is in the emotional dimension, where students not only understand the importance of environmental issues, but also feel the impact emotionally. This finding supports research by Lestari et al. (2021), which showed that education for sustainable development (ESD) based learning with inquiry approaches such as RADEC can increase students' emotional awareness of environmental issues. The use of visual media, such as animated videos, strengthens students' engagement in the learning process, thus allowing them to feel more affinity with the environmental issues discussed.

In contrast, in the control class, although there was an improvement in some students, the overall change in students' ability was relatively small and insignificant. Most students in the control class showed little change in logit scores, and some students such as R2, R7, and R8 even experienced a decline in ability. This indicates that although conventional learning provides a basic understanding of environmental issues, the approach is not effective enough in driving deeper changes in sustainable environmental understanding and awareness. Research by Maurer et al. (2020) also confirmed that visual media-based learning, such as animated videos of the greenhouse effect, has a greater impact on improving understanding of complex scientific concepts compared to more traditional, lecture-based learning.

In the attitude and behavior dimension, the experimental class showed more meaningful changes. Students in the experimental class not only understood the concept of sustainability, but also connected it to changes in their attitudes and behaviors, as seen in the creation of educational posters and environmental campaign videos. This reflects that the RADEC model can encourage students to think more critically and act more proactively on environmental issues. This finding is in line with the findings of Anggraeni et al. (2024), who stated that the RADEC model, which is oriented towards student engagement and the development of critical thinking skills, can improve students' attitudes and behaviors related to environmental sustainability. In contrast, although there was an improvement in the control class, the change in students' attitudes was more limited. Conventional learning, which focuses more on providing information rather than active student engagement, may not be enough to promote significant attitude change in an environmental context.

The practical dimension shows a clear difference between the experimental class and the control class. Students in the experimental class not only understand environmental issues but also apply them in real actions, such as creating carbon footprint reduction campaigns and energy saving efforts. Animation-based learning and the RADEC model provide opportunities for students to think more critically and take real actions that support sustainability. Research by Lestari et al. (2023) reveals that the ESD-based approach in RADEC successfully improves students' ability to implement their knowledge in practical actions. On the other hand, the control class showed limitations in translating knowledge into real action. Although there was a slight increase in student knowledge, these results indicate that conventional learning does not sufficiently provide experiences that encourage students to apply their knowledge in concrete actions. This highlights the importance of more interactive and media-based approaches to improve the application of knowledge in real life.

Overall, the comparison between the wright map of experimental and control classes indicates that the RADEC learning model assisted by the greenhouse effect animation video

has a much more significant impact in improving students' sustainable environmental awareness compared to conventional learning. Visual media-based learning and active interaction, which involves students in a more in-depth learning process, proved to be more effective in improving students' understanding, attitudes, behaviors and actions towards environmental issues. This finding is in line with the results of previous research showing that inquiry-based learning and visual media are more effective in increasing environmental awareness compared to traditional learning approaches (Anggraeni et al., 2024). Therefore, the application of an inquiry-based learning model and animated media, as conducted in this study, has great potential to be a more effective method in increasing sustainable environmental awareness in elementary schools, by providing a broader and deeper impact on students compared to more traditional learning approaches.

Conclusion

This study concludes that the application of the RADEC learning model supported by animated videos on the greenhouse effect has proven effective in increasing elementary school students' awareness of environmental sustainability. Analysis using Rasch stacking techniques showed a significant increase in students' knowledge, attitudes, behavior, emotional involvement, and practical application after participating in the learning intervention. Thus, this study successfully answered the research question and achieved its main objective, which was to test the effect of combining the RADEC model and animated videos on increasing students' awareness of environmental sustainability in a more measurable and in-depth manner.

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