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Investigating Students' Perspectives on Implementation of 3C3R PBL on Climate Change Topic Using the Rasch Model

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Abstract: This study investigates high school students' responses to the implementation of the 3C3R Problem-Based Learning (PBL) model in climate change education. Given the complexity of climate issues, the 3C3R model, emphasizing Content, Context, Connection, Research, Reasoning, and Reflection, was applied to foster students' critical thinking and collaborative problem-solving. A descriptive quantitative method was used, with data collected through questionnaires and analyzed using the Rasch model. The Wright Map was employed to visualize the distribution of student agreement. Findings show that students responded positively to structured materials, meaningful group tasks, and opportunities to present their work. The most endorsed items highlighted teacher preparation, honest self-assessment, and active involvement in poster presentations. However, student responses also indicated limited participation in collaborative aspects like experiment design and shared responsibility during group work. These results suggest that while the 3C3R PBL model enhances cognitive and emotional engagement, additional support is needed to improve students' communication and teamwork. The study offers valuable insights for educators aiming to deepen student involvement in climate change learning

Keywords: 3C3R PBL, climate change, students' perspectives.

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INTRODUCTION

Climate change represents one of the most pressing environmental challenges of our time, demanding not only scientific literacy but also active civic engagement from younger generations. In science Education, particularly at the secondary level, equipping students with the ability to understand, evaluate, and respond to complex environmental issues is essential. However, conventional instructional methods often fall short in fostering the critical thinking, collaboration, and problem-solving skills required to navigate such multifaceted topics.

In recent years, Problem-Based Learning (PBL) has gained traction as a practical pedagogical approach to promote deeper understanding and active engagement. Among the variations of PBL, the 3C3R model, comprising Content, Context, and Connection (3C), along with Researching, Reasoning, and Reflecting (3R), offers a structured yet flexible framework to scaffold learning through inquiry and authentic tasks. The model is designed to connect scientific content with real-world contexts while simultaneously encouraging metacognitive reflection and reasoning processes.

Despite its conceptual strength, empirical evidence on the effectiveness of the 3C3R PBL model, particularly in environmental science topics such as climate change, remains limited. Even less is known about how students perceive and respond to this learning model in classroom settings. Understanding students' affective and cognitive responses is crucial to evaluating the pedagogical relevance and practical implementation of 3C3R PBL.

This study aims to investigate high school students' responses to learning climate change through the 3C3R PBL model. Using a quantitative descriptive approach and Wright Map analysis, the research explores the aspects of the model that are well-received by students and those that present challenges. The results are expected to inform future instructional design and contribute to the broader discourse on student-centred learning in science Education.

The growing urgency of addressing complex global issues such as climate change has highlighted the need for active, inquiry-based science education. Traditional science instruction, which often emphasises rote memorisation and content transmission, is insufficient in preparing students to tackle real-world environmental problems, particularly those involving ethical, political, and social dimensions (Zeidler & Nichols, 2009; Zeidler, Sadler, Simmons, & Howes, 2005). To foster environmental literacy and empower students to reason through socio-scientific issues, science education must go beyond cognitive understanding to include affective engagement and ethical reasoning (Zeidler, Sadler, Simmons, & Howes, 2005; Monroe et al., 2017).

Problem-Based Learning (PBL) has emerged as a promising pedagogical approach in this context. Grounded in student-centred inquiry, PBL encourages the development of higher-order thinking skills and learner autonomy (Hmelo-Silver, 2004). Among the various PBL frameworks, the 3C3R model developed by Hung (2009) stands out for its structured integration of both content and cognitive processes. The model comprises three core components, Content (disciplinary knowledge), Context (authenticity and real-world relevance), and Connection (linking prior and new knowledge), as well as three essential processes: Researching, Reasoning, and Reflecting. This design aims to support not only conceptual understanding but also metacognitive awareness and transfer of learning across domains.

Several empirical studies have demonstrated the effectiveness of the 3C3R model in enhancing student learning outcomes. Tam (2018) discusses how Problem-Based Learning (PBL) can be used to develop higher-order thinking skills (HOTS). Tam also highlights the importance of PBL as an innovative approach to shifting learning from a passive and teacher-centred to an active, reflective, and student-centred approach. Likewise, research in secondary education settings has shown that embedding real-world problems into science curricula fosters deeper conceptual understanding (Yeo & Tan, 2014) and increases student motivation (Chin & Chia, 2006). Additionally, previous studies have demonstrated that learning using the 3C3R model is effective in enhancing students' critical thinking skills (Malik et al., 2020) and problem-solving abilities (Asthari, 2014; Othman, 2014; Magaji, 2021).

Despite these promising findings, relatively few studies have explored how students emotionally and cognitively respond to the 3C3R model, particularly in the domain of climate change education.

Understanding student engagement is critical to evaluating and improving instructional approaches. Engagement encompasses behavioural, emotional, and cognitive dimensions, serving as a key indicator of the quality of learning experiences (Fredricks, Blumenfeld, & Paris, 2004). Assessing these dimensions requires methodological rigour. Advanced psychometric tools, such as the Rasch model and Wright Map analysis, offer precise insights into student response patterns on attitudinal scales, providing a more profound understanding beyond what raw scores can reveal (Bond & Fox, 2015).

Given the demands of climate change education, which include fostering not only knowledge but also affective involvement and ethical reasoning, it is essential to examine how learners perceive and experience instructional models, such as the 3C3R PBL. This study contributes to the field by integrating the 3C3R model with climate change education and employing quantitative analysis tools to assess student engagement and perception, thereby identifying both strengths and potential areas for instructional improvement.

The Rasch Model is a probabilistic measurement approach within Item Response Theory (IRT) that is widely used in educational and social science research to analyse responses to assessments or questionnaires. Developed by Georg Rasch, the model converts ordinal raw scores (e.g., from Likert scales) into interval-level data, enabling more precise measurement of latent traits such as abilities, attitudes, or perceptions (Bond & Fox, 2015). One of its key strengths lies in its capacity to estimate both person ability and item difficulty on the same linear logit scale, which allows for meaningful comparisons between learners and assessment items. In the context of education, Rasch analysis is particularly useful for validating questionnaires, assessing learning outcomes, and exploring student engagement, as it offers diagnostic tools that go beyond descriptive statistics. For instance, the Wright Map, one of Rasch's key outputs, visually represents the distribution of item difficulty and student ability, enabling educators to identify mismatches between task demands and learner capacity (Bond & Fox, 2015). In the Rasch Model, the Wright Map (also known as a person-item map) is a visual representation that places both person abilities (person measures) and item difficulties (item measures) on the same logit scale. This map facilitates interpretation by showing how individual abilities compare to item difficulties in a single vertical layout. When a person and an item are located at the same logit level, the probability of answering correctly is approximately 50%. The Wright Map helps identify whether the test items are well-targeted to the participants' abilities, whether there are gaps in item distribution, and whether any individuals fall outside the measurement range. Therefore, it serves as a crucial tool for evaluating instrument quality and ensuring alignment between test-takers and items (Bond & Fox, 2015; Boone, Staver, & Yale, 2014).

In the Rasch Model, the item measure refers to the level of difficulty of an item, expressed in logit units (log odds). It is used to position items on a linear scale that aligns with the ability of the test-takers. The higher the item's measure value, the more difficult the item is for respondents; conversely, the lower the value, the easier the item. The Rasch model assumes that the probability of a respondent answering an item correctly depends on the difference between the person's ability and the item's difficulty. When these two values are equal, the probability of a correct response is approximately 50%. The use of item measures enables the objective and scientific evaluation of measurement instruments, aiding in the construction of well-balanced and properly calibrated test items (Bond & Fox, 2015; Boone, Staver, & Yale, 2013). Rasch enables invariant measurement, which means that person ability estimates do not depend on specific items used, and item difficulty estimates are independent of the sample, provided model assumptions are met (Baghaei, 2008). Given these advantages, the Rasch Model has become a valuable method in educational assessment and research, particularly when precise measurement of attitudes, perceptions, or competencies is needed.

METHODS

This study employed a quantitative descriptive design to examine students' perceptions of a 3C3R-based problem-based learning (PBL) learning experience. The focus was on exploring how learners responded to instructional practices implemented during a climate change unit, using the 3C3R framework.

Participants were 7th-grade 28 junior high school students enrolled in a natural sciences course at a public junior high school in Rangkasbitung City, Banten Regency, Indonesia. All participants received instruction using the 3C3R PBL model as part of their regular curriculum on the topic of climate change. To preserve honesty and confidentiality, student responses were collected anonymously.

The learning intervention was designed using the 3C3R framework, incorporating problem scenarios grounded in real-life climate issues. Activities included pretests and posttests, guided worksheets, small-group investigations, poster presentations, and student-led assessments. Each stage of the lesson emphasised at least one element of the

3C3R framework.

A structured student response questionnaire consisting of 25 Likert-scale items was used to capture students' affective and cognitive responses to the learning experience. Items assessed perceptions of instructional clarity, collaboration, engagement, problem-solving, and reflection.

Quantitative data from the questionnaire were analysed using Rasch modelling, with Wright map visualisations employed for interpretation. This approach enabled an exploration of both student-level response tendencies and item-level agreement patterns.

RESULTS

Results should Student response data to the 3C3R PBL model is processed and visualised through the Wright Map in the Figure. On the left side of the line are the respondents; respondents 11P and 12P are the respondents who most readily agree with each of the questionnaire items. Respondents 9P and 18L are the respondents who found it most challenging to agree with each of the questionnaire statement items. It should be noted that the questionnaire respondent code and the test item respondent code are different because, when filling out the questionnaire, students do not write their names, and the information is confidential. This aims to ensure that respondents can provide more honest responses to learning with the 3C3R PBL model on climate change material.

On the right side of the Wright Map line in Image 1, the order of the logit values of the questionnaire statement items is from the smallest (bottom) to the largest (top). The bottom item is the one with which the respondents agree the most, and the top item is the one with which they disagree the most overall.

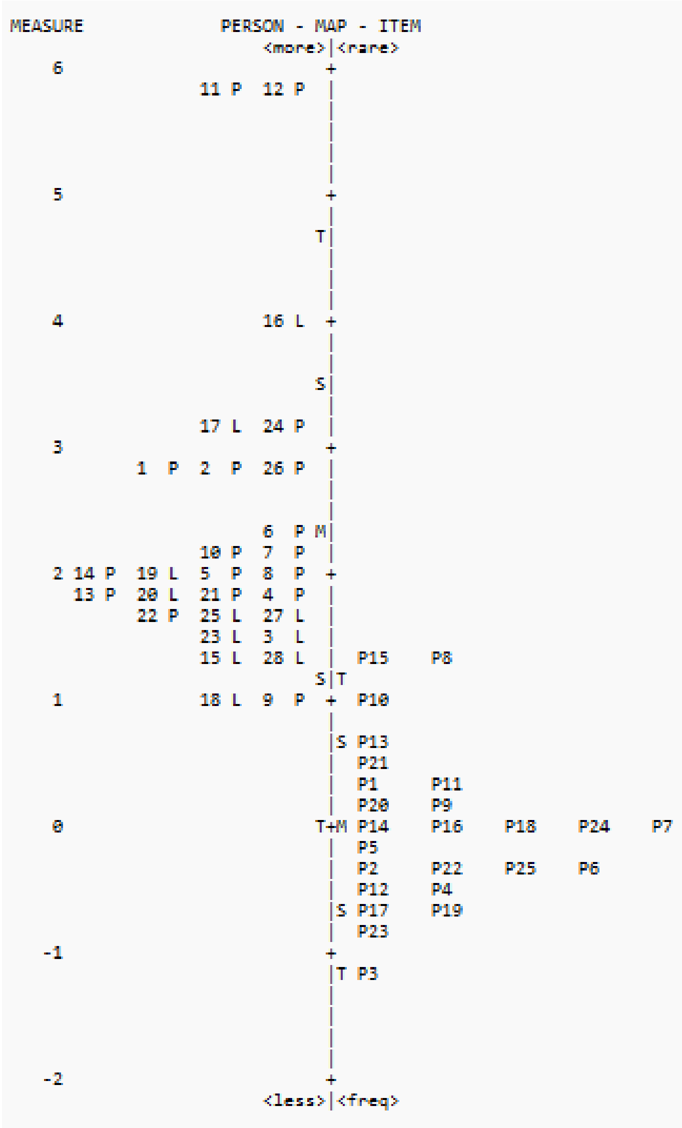

Image 1. Wright Map of Student Responses to the Learning Process

The Wright Map analysis revealed clear patterns in students' responses to the implementation of the 3C3R Problem-Based Learning (PBL) model. Items with the lowest logit values, indicating the highest level of agreement, were Items 3, 17, and 23. These items reflected strong student appreciation for the clarity of problem design, the opportunity to present group posters, and the encouragement of honest self-assessment. These findings suggest that students responded positively to structured and tangible aspects of the learning experience, particularly those that provided ownership and visibility of learning. This aligns with the findings of Blumenfeld et al. (1991), who emphasised that tasks perceived as meaningful and leading to public demonstration increase student motivation and engagement.

The Wright Map of student responses to the 3C3R PBL model shows that the logit (measure) values of questionnaire statement items 3, 23, and 17 at the bottom are the smallest (see the appendix). This means that items 3, 23, and 17 are items that are strongly agreed upon by students among other statements. Students strongly agree with the statement that the teacher plans the problems given in climate change learning activities well, with 68% of students Strongly Agreeing and 32% Agreeing. Students strongly agree with the statement that they can provide an honest assessment of their group, with 61% of students Strongly Agreeing and 39% Agreeing. Students also strongly agree with the statement that they presented a global warming poster made by their group, where 71% of students Strongly Agree, 21% Agree, 4% Doubtful, and 4% Strongly Disagree.

Table Of Grouping Student Responses To Learning With 3C3R PBL On Climate Change Material Based On Measure Items

Item Number	Statement	Item Measure	Categories
8	Discussion activities help me improve my communication skills.	1.31	**Very Disagree**
15	I share tasks with friends when working on group assignments.	1.26	
10	The activity of designing global warming experiments increases my interest in seeking information.	1	
13	I report the results of my group's practicum by writing them in the worksheet.	0.72	
21	I am interested in listening to the presentations from other groups.	0.52	**Disagree**
1	The teacher informs the students of the learning objectives for the material on global warming.	0.29	
11	I enjoy doing global warming practicums.	0.29	
20	Group learning activities make it easier for me to determine the completion of group assignments.	0.21	
9	Discussion activities motivate me to seek information from various sources (books, the internet, etc.) needed for discussion activities.	0.13	
14	I express my ideas by working on group assignments (designing experiments and making posters).	0.04	
18	I enjoy doing assignments in groups.	0.04	
7	The questions in the worksheets help me learn to solve problems.	-0.06	**Agree**

Item Number	Statement	Item Measure	Categories
16	I enjoy making global warming posters.	-0.06	
24	I can give honest assessments to other groups.	-0.06	
5	Global warming and climate change are environmental problems that I also experience in my daily life.	-0.16	
2	The questions (from the initial test) on the global warming material given previously increased my interest in participating in the learning process. The questions in the worksheets increase my interest in learning.	-0.26	
6	The questions in the worksheets increase my interest in learning.	-0.26	
22	The assessments made by the teacher during the learning process motivate me to be more actively involved in the learning process.	-0.26	
25	After participating in the learning process, I can answer the final test questions more easily.	-0.26	
4	The teacher prepares the Student Worksheets used in the learning process well.	-0.49	
12	The global warming practicum activity improves my understanding of environmental issues.	-0.49	
19	I am responsible for working on assignments in groups.	-0.61	
17	I published a poster created by my group on the topic of global warming.	-0.74	
23	I can give an honest assessment to my group.	-0.88	**Very Agree**
3	The teacher plans the problems effectively for the learning process on global warming.	-1.18	

The group of statement items agreed upon by students, in order of lowest to highest logit values , consists of items 19, 12, 4, 25, 22, 6, 2, 5, 24, 16, and 7. Students agree that the pretest given increases their interest in participating in learning, with 50% strongly agreeing, 46% agreeing, and 4% being doubtful. They also feel that after participating in learning, they can answer the posttest more easily, with 54% of students Strongly Agreeing, 39% Agreeing, 4% Being Doubtful, and 4% Disagreeing. Students also agree that climate change is an environmental issue that concerns them, with 39% strongly agreeing and 61% agreeing.

Regarding the statement about the LKPD, students agree that the Teacher (researcher) compiled it well, with 50% of students Strongly Agreeing and 50% agreeing. Students also agree that the questions in the LKPD increase their interest in learning, with 50% strongly agreeing, 46% agreeing, and 4% disagreeing. In addition, the questions in the LKPD help them learn to solve the problems given, with 39% of students Strongly Agreeing, 57% Agreeing, and 4% Doubting.

Students agree that the practicum activities increase their understanding of environmental problems, with 57% strongly agreeing, 36% agreeing, and 7% Expressing Doubt. Students showed that they enjoyed making posters on global warming or climate change, with 54% strongly agreeing, 36% agreeing, 4% Being Doubtful, and 7% disagreeing. They felt responsible for working on learning assignments in groups and giving honest assessments to other groups, with 68% of students Strongly Agreeing, 21% Agreeing, 7% Being Doubtful, and 4% Disagreeing. Students also agreed that the assessments made by the Teacher during learning motivated them to be more active in their participation, with 50% strongly agreeing, 43% agreeing, and 7% Being Doubtful.

The group of statement items included in the category of students' disagreement, from the lowest to the highest logit values, consists of items 18, 14, 9, 20, 11, 1, and 21. Not all students enjoy doing assignments in groups (7% Disagree), practicums (4% Undecided and 4% Disagree), group discussions, and seeking information from various sources (4% Undecided). Students feel that they do not express their ideas effectively when completing group assignments, such as practicums and poster presentations (7% Undecided). Not all students believe that group learning makes it easier for them to complete tasks (11% Undecided), and they are less interested in listening to presentations from other groups (14% Undecided). Not all students also feel that the teacher has informed them of the learning objectives (18% Undecided). The group of statement items that are strongly disagreed with by students, among other statements, in order of the lowest to highest logit values, consists of items 13, 10, 15, and 8. Some students feel that they do not report the results of their group's practicum (11% Doubtful and 7% Disagree). Students also feel that designing experiments has not increased their interest in seeking information (11% Doubtful and 25% Disagree). In group activities, students feel that they do not share tasks with friends (7% Doubtful and 25% Disagree), and discussion activities have not trained their communication skills (18% Doubtful).

Other highly endorsed items related to learning motivation, the relevance of content, and the effectiveness of student worksheets. Many students expressed that the topic of climate change was relevant to their personal lives and worth exploring in more detail. This supports prior research that asserts authentic, context-rich tasks, as emphasised in the 3C components of the model (Content, Context, Connection), play a critical role in enhancing learner interest (Barab & Luehmann, 2003). Moreover, the LKPD was perceived as helpful in guiding independent inquiry and promoting problem-solving, confirming the role of structured scaffolds in facilitating learning in PBL contexts (Hmelo-Silver & Barrows, 2006).

However, the Wright Map also identified items with higher logit values, suggesting lower agreement or uncertainty, particularly about collaborative and reflective activities. Items such as 8, 10, 13, and 15 revealed student discomfort in areas such as group task sharing, expressing ideas, and participation in experimental design. These findings point to a notable gap in students' collaborative competencies. While students recognised the relevance and structure of the content, they struggled with interpersonal engagement and peer interaction. This is consistent with research by Gillies (2016) and Strijbos (2010), which highlights that effective collaboration in PBL requires deliberate support for group regulation, shared responsibility, and prior experience in cooperative learning.

Furthermore, items related to listening to presentations from other groups and reflecting during discussions received lower endorsement. Although the 3R elements (Researching, Reasoning, and Reflecting) were present in the instructional design, student engagement with these processes appeared uneven. This may stem from limited metacognitive training or classroom cultures that emphasise task completion over deep reflection (Chin & Osborne, 2008). Activities such as designing experiments or engaging in group reflection may require more structured guidance and repeated exposure to be internalised effectively by learners.

The results indicate that the 3C3R PBL model successfully supports student engagement in structured, relevant, and product-oriented tasks. Students positively responded to instructional clarity, topic relevance, and opportunities for authentic expression. However, aspects involving inquiry autonomy, collaboration, and critical discourse require more intentional instructional scaffolding. Future implementations should incorporate strategies that explicitly develop students' interpersonal, collaborative, and metacognitive abilities to fully realise the transformative potential of the 3C3R model in science education.

DISCUSSION

The discussion should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

In discussion, it is the most important section of your article. Here you get the chance to sell your data. Make the discussion corresponding to the results, but do not reiterate the results. Often should begin with a brief summary of the main scientific findings (not experimental results). The following components should be covered in discussion: How do your results relate to the original question or objectives outlined in the Introduction section (what)? Do you provide interpretation scientifically for each of your results or findings presented (why)? Are your results consistent with what other investigators have reported (what else)? Or are there any differences? Use at least 10 relevant and up-to-date references.

CONCLUSION

This study examined junior high school students' responses to the 3C3R PBL instructional model in a climate change unit. Results showed that students essentially responded positively to components involving teacher guidance, content relevance, and product-based tasks. These suggest that the 3C3R model has strong potential to foster cognitive engagement and personal investment in environmental learning.

However, findings also revealed resistance or disengagement in collaborative and inquiry-driven tasks, including group planning and experimentation. These outcomes highlight a critical need to scaffold collaboration and facilitate metacognitive dialogue within group settings.

In conclusion, the 3C3R PBL model can serve as a practical instructional framework for climate change Education at the high school level, provided that thoughtful facilitation strategies support it.

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