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Teacher Effort in Strengthening Student's Thinking Skill and Awareness upon Environment Conservation: PLS-SEM of Climate Change Education (CCE) Study

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ABSTRACT

Teachers are essential in creating awareness among students about protecting the environment. Climate Change Education (CCE) can be used as an alternative approach to raise awareness of climate change. This research examines the impact of teacher motivation on student awareness and thinking skills in the context of CCE. The study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the data. A total of 254 students were selected using simple random sampling to participate in the research. The results indicate that teacher motivation significantly and positively impacts student awareness and thinking skills. This suggests that teacher motivation and strategies are critical in improving the effectiveness of environmental education. The research provides valuable insights into the factors that enhance teacher motivation in the context of CCE, which can inform the development of innovative approaches and teaching methods. The pedagogical model produced by this research can serve as a starting point for developing more targeted models in further research related to CCE studies.

1. INTRODUCTION

Protecting and preserving the environment is the responsibility of all world citizens. In this decade, discussions emerged about climate change caused by environmental damage. Climate change has become one of the problems of particular concern to the world. This can be seen from the inclusion of climate change issues in the Sustainable Development Goals (SDGs) agenda as a world agenda initiated by the United Nations (UN) to achieve sustainable development for the world [1]. Climate change is included in point number 13, namely climate action. Apart from that, other points can be linked to climate change, nine other SDG targets [2], including SDGs point number 4, namely quality education.

One effort that can be made to make people aware of climate change is through an educational approach. In particular, Climate Change Education (CCE) is an alternative effort that can be made to create awareness about climate change through environmental learning [3, 4]. In this research, awareness about climate change through ecological learning is essential for teachers and students in the school community. The importance of environmental education, especially in schools, is to make people aware that protecting the environment is a shared responsibility of the community. Environmental problems are increasing disproportionately and contributing to global warming, one of humanity's most significant challenges [5]. Schools, as educational institutions, play a vital role in cultivating this awareness.

CCE is essential for the younger generation to learn This young generation will be at the forefront of environmental protection efforts in the future. As a preparatory effort, it is necessary to develop new forms of Climate Change Education that directly involve the younger generation in responding to climate change's scientific, social, ethical, and political complexities [6, 7]. Scientifically accurate knowledge generally increases with age. This shows a need for guidance in childhood to protect the environment. However, misunderstandings still exist in the age range of children and adolescents, so there is a need for reinforcement from various parties, including the school.

CCE can reduce the impact of climate change on society and the environment because awareness of climate change is the beginning of resolving the challenges of climate change itself [8]. Therefore, the existence of learning about the environment is an indicator of the efforts made by schools to solve these challenges. Environmental learning can train students to be more aware and sensitive to the environment around them [9].

Several schools are making various efforts to increase their community's awareness of climate change. There are several other schools that even directly implement environmental education learning. This was done by one of the schools, trying to implement it with direct action such as giving an appeal not to throw plastic bottle waste in the school environment [10]. Furthermore, there is an appeal to bring lunch containers to school to create zero waste in the school environment [11]. Even though the impact of these efforts is not very significant, at least there are efforts to increase environmental awareness.

The existence of environmental education learning accompanied by various efforts made by schools ideally provides students with awareness about the environment. Apart from that, having direct environmental education also helps the role of schools in CCE. Education can be an essential and valuable weapon for solving climate problems [12]. However, based on facts in the field, awareness of protecting the environment could be more optimal, especially in school environments. The ongoing issue of careless littering indicates a lack of facilities in schools to support environmental protection. Additionally, inadequate public transportation and insufficient outreach to schools for reducing carbon emissions remain challenges [13, 14]. Furthermore, there are research results that show that the use of fossil fuels contributes to climate change (through CO_2 emissions) and local air pollution (primary NOx and PM10 emissions), which are known to have a significant impact on the environment and health [15]. Thus, this phenomenon shows that awareness of protecting the environment regarding climate change has yet to be optimal.

Adequate knowledge about climate change significantly impacts awareness of climate change. This concern also positively impacts students' self-efficacy and willingness to act to protect the environment. However, implementing CCE in the classroom needs to consider the teacher's difficulties [16, 17]. CCE presents a broad challenge to the scientific community because the topic of CCE is complex, given the global context and differences of opinion on the subject. Of course, this complexity needs to be made easier to understand, one of which is through efforts by teachers to make students aware of the importance of CCE.

The different experiences gained by students provide different views regarding environmental awareness. The information students receive also influences their initial knowledge about environmental education before gaining more knowledge about environmental awareness at school [8]. Based on this, researchers in this study tried to look at the learning experiences regarding the environment for students. This research refers to the Bicycle Model on Climate Change Education, which focuses on the experiences gained by students [18].

Teachers working in the environmental domain understand that changing environmental impacts requires changes in knowledge and attitudes about protecting the environment and the related motivation that is determined by oneself [19, 20]. Motivation is essential to increase students' knowledge and attitudes in protecting the environment. Other research shows a positive influence on teacher performance regarding competence, motivation, and learning environment [21]. This indicates that motivation is essential to protect the environment, especially the learning environment.

Teachers can instill environmental awareness in students by motivating CCE. This research explores teacher motivation's role in students' awareness and thinking skills regarding the environment. To explore this, the formulation of this research problem is related to (a) the influence of motivation from teachers on student awareness, (b) the influence of motivation from teachers on thinking skills, and (c) the influence of motivation from teachers on student awareness and thinking skills simultaneously. The results and discussion can illustrate the urgency of this awareness and skills as one of the reasons for them to protect the surrounding environment.

2. LITERATURE REVIEW

2.1 SDGs and CCE

SDGs are global targets to address various worldwide social, economic, and environmental challenges. The SDGs include 17 interrelated goals, from ending poverty and hunger to ensuring access to inclusive and quality education, tackling climate change, and protecting the earth's ecosystem [22, 23]. With a focus on sustainability, the SDGs aim to create a more just, sustainable, and resilient world. More investment is needed to monitor environmental stressors and climate change [24]. So, with cross-sector collaboration and international cooperation, implementing the SDGs is the key to achieving sustainable global development, improving human welfare, and protecting our planet for future generations [25, 26]. Therefore, joint efforts from government, the private sector, civil society, and individuals are essential in achieving the transformational vision of the SDGs to create a better world for all.

CCE plays an integral role in building public awareness and understanding of the challenges of global climate change. CCE aims to provide basic knowledge about climate science and motivate positive action to reduce negative human environmental impacts [27, 28]. Apart from this, involving students in exploring the concept of climate change encourages critical thinking about environmental problems [29]. Involving students in this can foster a deep understanding of the causes and impacts of climate change and motivate collective efforts to overcome this challenge.

CCE emphasizes the importance of building interpersonal, leadership, and teamwork skills. This involves a socio-cultural approach to shape students' character, help them overcome obstacles, and develop tolerance and empathy [30, 31]. CCE also needs to develop critical thinking and problem-solving skills, enabling students to face the world's complexity in analytical and creative ways [32, 33]. By designing learning experiences that include real-world challenges, CCE prepares students for academic success and provides a strong foundation for achieving personal well-being and positive societal contributions [34].

CCE also recognizes the importance of inclusion and diversity in education. CCE integrates discussions on climate change with the values of inclusion and diversity [35]. This creates an environment where every student is valued and supported, regardless of cultural background, abilities, or other differences. By understanding the uniqueness of each individual, CCE creates a foundation for motivating and relevant learning, ensuring that each student can reach their full potential [36, 37]. Moreover, CCE is not only about what is taught in the classroom but also about how learning creates a deep understanding of the world and oneself [38, 39]. Therefore, CCE shapes not only thinking but even more so actions to protect the environment.

The importance of CCE is increasingly emphasized in the digital era, where rapid change and information complexity demand high adaptability. CCE responded to this by including digital literacy and technological understanding as critical components in its approach. Like other fields, CCE requires literacy skills to effectively engage with the subject matter, hence the term 'climate literacy' [40]. Climate literacy helps students understand what is happening in the environment, especially climate, how to respond to this, and the appropriate actions to take [41, 42]. CCE prepares students for the

industrial world and empowers them to become innovative and environmentally responsible global citizens in this digital era.

2.2 Environmental education

Environmental education (EE) is crucial in forming community awareness and responsibility for environmental sustainability. EE teaches facts about ecosystems and environmentally friendly behavior and stimulates critical thinking and real action to maintain the sustainability of the earth [43]. In the EE curriculum, students are invited to understand the complex relationship between humans and the environment and the impact of human activities on ecosystems [44]. Through this in-depth understanding, EE aims to form a mindset that is caring and responsible for environmental sustainability.

The importance of EE lies not only in recognizing environmental issues but also in developing sustainable living skills. EE creates opportunities for students to develop skills such as problem-solving, leadership, and collaboration, which are essential in facing global environmental challenges [45, 46]. Through environmental projects and practical activities, students can experience the direct impact of their actions, strengthening their sense of responsibility towards environmental sustainability and positively contributing to society.

EE is important in making global citizens aware of communities' environmental challenges. By presenting global environmental issues such as climate change, biodiversity loss, and land degradation, EE opens students' views to the broader impacts of human actions [47]. This education gives them the skills to recognize and understand these global issues and design local and international solutions to deal with them.

The importance of EE is further strengthened by the fact that environmental challenges are not only scientific but also involve ethical and moral dimensions. EE education should provide a basis for developing values such as responsibility, justice, and respect for the entire ecosystem [48]. Thus, EE is about giving knowledge and forming students' character and values needed to become citizens who care about and are responsible for the environment. EE is also an essential bridge between theoretical knowledge and real action in society. EE involves students in environmental action projects, such as tree planting, recycling campaigns, or environmental cleanup projects [49]. In other words, EE provides practical experiences that help students feel the positive impact they can make in the environment around them.

In this way, EE is part of the curriculum and a global movement to form a generation capable and ready to face environmental challenges. Through this education, it is hoped that students will become active agents of change, leading efforts to maintain the planet's sustainability and create a better future for all living things.

3. METHODS

The method used is a quantitative approach with path analysis for data analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM). The PLS-SEM technique is used as a multivariate analysis technique, a method used to process varying variables. This modeling method allows the estimation of complex causal relationships in path models with latent variables. Based on this, PLS-SEM was used in this research. Structural Equation Modeling is a multivariate statistical method that tests and measures complex relationships between variables in a conceptual model [50]. The aim is to find the influence of several variables on a variable simultaneously.

This research used PLS-SEM to develop a theory to make predictions. The subjects of this research are students who have experience learning about the environment in high school. The sampling technique uses Convenience Sampling. Convenience Sampling is selecting research participants based on availability rather than through random or systematic sampling methods [51, 52].

The population of this research is university students who have received environmental education at the upper secondary school level. The sampling technique used was accidental sampling, a form of convenience sampling. In this research, there were 254 students.

The instrument contains information regarding the respondent's identities, but this data is not displayed. This is part of publication ethics in a series of research activities. The respondents have agreed to publish their answers relating to the variables studied.

Data were collected using survey techniques with a Likert scale instrument modified into four scales. Scale one strongly disagrees, scale two disagrees, scale three agrees, and scale four strongly agrees. The instrument was developed based on variables such as teacher motivation, student awareness, and thinking skills, making it more complete and comprehensive for addressing the research questions.

PLS-SEM is used to investigate the relationship between variables and analyze the simultaneous influence of these variables on the predicted variables. PLS-SEM can also be used to simultaneously determine the impact of variables on predicted variables [53]. By utilizing this technique, this research can contribute to understanding the factors that influence the environment among high school students. In-depth data analysis from survey results with a modified Likert scale will provide more detailed insight into students' perceptions and attitudes towards the environment.

4. RESULTS

4.1 Test the reliability and validity of the PLS-SEM model

The research results model is shown in Figure 1.

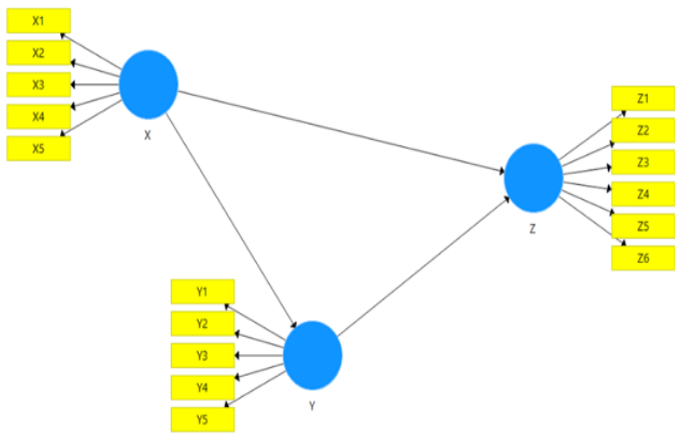

Figure 1. Path analysis model
Note: Variables studied consist of motivation from teachers (X), students' thinking skills (Y), and student awareness (Z).

Table 1. Composite reliability

	Composite Reliability
Motivation from Teacher	0.909
Student Awareness	0.952
Thinking Skills	0.884

Table 1 shows the reliability or Composite Reliability level for the three factors measured in a study: motivation from teachers, student awareness, and thinking skills. Teachers' motivation has a Composite Reliability value of 0.909 > 0.7, while student awareness has the highest level of reliability, with a value of 0.952 > 0.7. The thinking skills factor has a Composite Reliability value of 0.884 > 0.7. All these values indicate that the instruments or questions used to measure these three factors are consistent.

High reliability shows that the research instrument can be used in further research. The instrument can also be used for places and other respondents who have received environmental education at high school.

Table 2. Discriminant validity

	Motivation from Teacher	Student Awareness	Thinking Skills
Motivation from Teacher	0.817		
Student Awareness	0.692	0.877	
Thinking Skills	0.712	0.744	0.779

Table 2 provides an overview of how much the constructs measured by the three factors, namely motivation from teacher, student awareness, and thinking skills, significantly differ. The values on the table's diagonal, such as 0.817 < 0.9 for Motivation from Teacher, 0.877 < 0.9 for student awareness, and 0.779 < 0.9 for thinking skills, each indicate the level of discriminant validity between these factors.

Discriminant validity ensures that each concept from each latent model is different from other variables. This validity test is carried out to determine how precisely a measuring instrument performs its measurement function. Based on the calculation results obtained, it can be described that the variables motivation from teacher, student awareness, and thinking skills show the level of discriminant validity in the resulting model.

Table 3. R-square

	R Square	R Square Adjusted
Student Awareness	0.607	0.604
Thinking Skills	0.507	0.505

Table 3 presents the R Square and R Square adjusted values for the two dependent variables, student awareness and thinking skills. The R Square value of 0.607 for the student awareness variable indicates that the regression model used can explain around 60.7% of the variability. The Adjusted R-Square value, namely 0.604, means that after adjusting for the number of independent variables in the model, around 60.4% of the variability can still be explained. Meanwhile, the R-Square value of 0.507 for the thinking skills variable means that the regression model can explain around 50.7% of the variability. The Adjusted R-Square value was 0.505, indicating that approximately 50.5% of the variability remained explained. The R Square and Adjusted R-Square values provide information regarding how well the regression model can explain the variability in the dependent variable, with higher values indicating a better level of explanation.

The R-square result is a value that shows how much the independent (exogenous) variable influences the dependent (endogenous) variable. In this case, the Motivation from the teacher variable influences student awareness, and the motivation from the teacher variable influences students' thinking skills in understanding how to protect the environment.

Table 4. F-square

	Student Awareness	Thinking Skills
Motivation from Teacher	0.135	1.028
Thinking Skills	0.327	

Table 4 provides F-Square values for various combinations of independent variables (motivation from teacher, student awareness, and thinking skills) in an analysis. There are F-Square values such as 0.135, 1.028, and 0.327, each related to the combination of the variables motivation from teacher, student awareness, and thinking skills.

F-square calculates the magnitude of the influence between variables with effect size. This shows that motivation from teachers influences student awareness and thinking skills based on the effect size analysis results.

Table 5. Fit model

	Saturated Model	Estimated Model
SRMR	0.061	0.061
d_ULS	0.501	0.501
d_G	0.218	0.218
Chi-Square	321.583	321.583
NFI	0.892	0.892

Table 5 shows the results between the Saturated and Estimated Models. These results indicate good agreement between the estimated model and the known data. Based on the results obtained, it can be seen that there is no difference between the Saturated Model and the Estimated Model, so the data shows the suitability between this model and the theory being developed.

The next stage is testing the model's goodness of fit, which aims to test its predictive power and feasibility. Based on the results of data analysis, this model is suitable for use as a prediction model in research.

4.2 PLS-SEM model measurement results

The results of model analysis based on research data and calculations carried out with the help of the SmartPLS application are shown below.

Figure 2 generates path coefficients as follows.

Table 6 shows the path coefficients for the relationships between variables in a model. In the context of this analysis, there are three main variables: student awareness, thinking skills, and motivation from the teacher.

From the table results, it can be concluded that a positive relationship between motivation from teachers and student awareness is indicated by a path coefficient of 0.328. This

means that the higher the Motivation from the Teacher, the higher the level of student awareness. Furthermore, there is a stronger positive relationship between motivation from teachers and thinking skills, with a path coefficient of 0.712, indicating that the higher the motivation from Teachers, the higher the students' thinking skills.

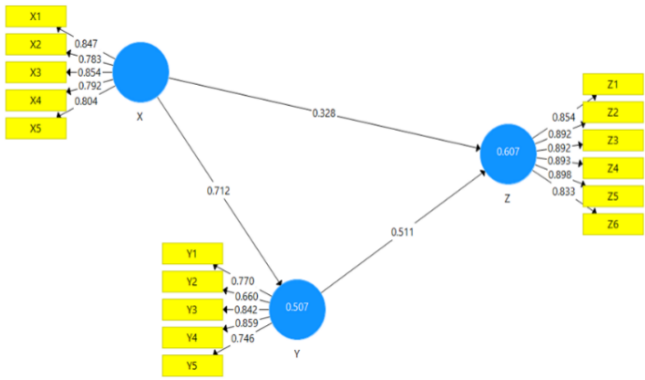

Figure 2. Calculation results of path analysis model with PLS-SEM

Table 6. Path coefficients

	Student Awareness	Thinking Skills
Motivation from Teacher	0.328	0.712
Thinking Skills	0.511	

In addition, a positive relationship exists between student awareness and thinking skills, indicated by a path coefficient of 0.511. This means that the higher the student's level of awareness, the higher the student's thinking skills.

Table 7. Indirect effect

	Student Awareness
Motivation from Teacher	0.364

Table 7 illustrates the indirect effect of teachers' motivation on student awareness through indirect channels. The value listed, namely 0.364, shows how much motivation from teachers indirectly influences student awareness. In other words, this indirect effect indicates that around 36.4% of the influence of motivation from teachers on student awareness can be explained through the indirect path. This can be caused by intermediary variables or other factors mediating the relationship between motivation from teacher and student awareness.

Overall, the value of 0.364 in the indirect effect table illustrates the contribution of the indirect effect of motivation from teachers to the level of student awareness in the analysis model.

4.3 Hypothesis test

Table 8. Total effect

	Student Awareness	Thinking Skills
Motivation from Teacher	0.692	0.712
Thinking Skills	0.511	

Table 8 presents the total effect value of motivation from teachers on student awareness and thinking skills and the total effect of student awareness on thinking skills. In this analysis, the total impact of Motivation from Teacher to Student Awareness reached 0.692, reflecting both direct and indirect influences, including through indirect paths that may involve intermediary variables. Meanwhile, the total effect of motivation from teacher to thinking skills is 0.712, reflecting the total influence on students' thinking skills.

In addition, the table shows that the total effect of student awareness on thinking skills is 0.511, indicating a direct influence of students' Awareness level on their thinking skills.

5. DISCUSSION

5.1 Influence of motivation from teachers on student awareness

The results of this research show that motivation from teachers influences student awareness. if motivation from teachers increases, student Awareness also increases. The results of this study are based on previous research, which states that schools are an excellent place to strengthen communities and promote positive inclusion practices [54]. Structural solutions can also support motivation and inclusion. For example, the principal's priorities play a crucial role in realizing sustainable development within the school. In CCE, it is necessary to emphasize that humans build our society so we can also affect change [55]. The opinions of others can play a vital role in maintaining motivation. Therefore, it is essential to allow students to participate together in positive activities, fostering an environment and culture of sustainable development. They should also be encouraged to support one another's inclusion [56-58].

Referring to the SEM analysis results, it was found that motivation from teachers had a positive and significant influence on student awareness. In other words, the more motivation the teacher gives, the higher the student's awareness of CCE. Likewise, the continuation of climate action, motivation, and experiences of inclusion should be considered so that climate education becomes motivational [59].

In this case, school leaders, such as the principal, can establish policies to implement CCE in the curriculum. In its implementation, teachers can add environmental education content to each subject. As policymakers, school principals can promote student awareness through speeches at regularly organized school events.

5.2 Influence of motivation from teachers on thinking skills

The results of this research show that motivation from teachers influences thinking skills. If a teacher provides motivation, students' thinking skills are likely to improve. The thinking skills focus in CCE includes the scientific aspects of climate change and the need to be aware of uncertainty and differential impacts on individuals and regions. Developing critical, systematic, and creative thinking skills is essential for understanding and overcoming the complex challenges of climate change. In the context of CCE, knowledge is not only considered an end goal but must also be used critically for transformative thinking [60].

Referring to the results of the SEM analysis, it was found that motivation from teachers had a positive and significant

influence on thinking skills. In other words, the more motivation teachers provide, the greater the improvement in students' thinking skills. Climate-related information must be applied and evaluated critically; this model helps shape students into individuals who can positively influence their future and society [61]. In CCE, the focus on developing thinking skills and readiness for change is essential, considering the uncertainty of the future and the evolution of knowledge [62].

Students' skills regarding protecting the environment need to be strengthened. This can be done by teachers when implementing learning with a pedagogical approach. Teachers can deliver environmental education content broadly, or focus specifically on CCE. The implementation of this policy needs to be strengthened with an appeal by school principals regarding the application of CCE to learning.

5.3 Simultaneous effect of motivation from teacher on student awareness and thinking skills

This research demonstrates that teacher motivation simultaneously influences both student awareness and thinking skills. This means that when motivation from teachers is given, student awareness and thinking skills increase simultaneously. Environmental education has traditionally focused on everyday activities, such as responsible consumption and daily environmental activities at home [63, 64]. However, in climate education, action must be expanded to look at alternative approaches at personal, community, and social levels and implement new strategies.

Referring to the SEM analysis results, it was found that motivation from teachers influenced student awareness and thinking skills simultaneously. the difficulty of achieving sustainable behavior change should be considered in climate education, as there is a gap between knowledge and action, and increasing knowledge does not always lead to increased action [65]. Additionally, some argue that climate education should aim to foster a sustainable future. This requires a critical analysis of education's broader goals, considering the influence of individual choices and their impact on societal attitudes [66]. Integrating science and arts subjects is considered helpful because looking to the future requires creative thinking and evokes various emotions.

As policymakers, school principals can encourage teachers to implement CCE in learning. This policy is an effort to increase CCE's contribution to education. As facilitators of classroom learning, teachers can inspire and enhance students' awareness and thinking skills regarding environmental protection. Environmental protection culture and knowledge should be imparted to students from an early age, fostering a generation capable of safeguarding the environment.

6. CONCLUSIONS

The research indicates that teachers' motivation is crucial in enhancing students' awareness and thinking skills regarding Climate Change Education (CCE). The findings of the Structural Equation Modeling (SEM) analysis demonstrate that the greater the motivation provided by the teacher, the higher the level of student awareness of climate change. Additionally, the motivation provided by teachers positively contributes to the improvement of students' thinking skills. These results emphasize the importance of the teacher's role in providing motivation and shaping students' understanding and skills regarding environmental education and climate change issues.

The results of this research can be generalized to university students who have received environmental education at a previous level. This is based on the results of the analysis, which show that the resulting model is suitable for predicting the variables discussed. The results of this research are beneficial as an illustration of environmental education at the high school level, so it is hoped that it can strengthen Student awareness and thinking skills to protect the environment in the future.

The limitation of this research is that it is still limited to the three variables studied, namely motivation from teacher, student awareness, and thinking skills. This allows for the influence of variables other than the variables discussed. Apart from that, the limitations of the research also lie in the sampling technique, namely accidental sampling. Future researchers could consider using proportional sampling or other techniques for further study.

In light of this research, it is clear that motivating teachers can be an effective strategy for enhancing environmental learning in schools, particularly in the context of Climate Change Education (CCE). Further research could explore specific factors that increase motivation from teachers in this area and analyze effective teaching methods. Teachers can implement these motivational strategies and innovative learning approaches to enhance students' thinking skills regarding climate change.

Suggestions for future research include increasing the number of variables studied apart from the three variables that have been discussed. Alternative sampling techniques could also be explored, diversifying beyond the method employed in this study. The model produced by this research can be a starting point for developing models in further research related to CCE studies.

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