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# Investigating the Influence of Project-Based Learning on Beliefs About Global Warming in Relation to Academic Achievement

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***Abstract***
*Human communities and natural ecosystems confront an unprecedented challenge posed by the escalating global climate crisis, requiring urgent and transformative educational interventions. Conventional educational methods often fail to foster a deep understanding and genuine conviction about complex environmental issues. This paper seeks to investigate the influence of Project-Based Learning (PBL) on the beliefs of seventh-grade students regarding global warming in Panchkula, Haryana, India. Previous academic grades in science were also taken into consideration. 160 students were selected from both government and private CBSE (Central Board of Secondary Education) schools in Panchkula, Haryana, India, using a quasi-experimental research method. Students were assigned to either an experimental group (Project-Based Learning) or a control group (Lecture-Based Learning). Quantitative data were obtained using pre-and post-tests. Students' beliefs were evaluated using the tool constructed by Boyes et al. (2008). The results demonstrate that the experimental group's beliefs significantly increased as compared to the control group, with underscores exhibiting substantial gains. Additionally, the beliefs of students regarding global warming remained unaffected by the type of school. To evaluate the long-term impact of project-based learning, the sample size and the length of the intervention should be taken into account. The successful implementation of project-based learning also requires a significant investment of time, resources, and training for educators. Therefore, the study aims to contribute to the expanding body of literature supporting more dynamic and effective climate education models, equipping the next generation with the ability to confront the challenges of a changing climate.*
***Keywords:*** *Project-based learning, beliefs, Lecture-based learning, Global warming, climate change, Climate education*

## 1. INTRODUCTION

Global climate change has led to many devastating impacts, which the entire world is facing. There are numerous causes associated with global climate change, ranging from air pollution to ocean warming. Human societies and natural ecosystems confront an unparalleled challenge posed by the escalating global climate crisis, requiring urgent and transformative educational interventions. The repercussions of global warming are evident everywhere on this planet. A combined action led by everyone of us is required to mitigate the impact of global warming (Kurup et al., 2021), which can't be achieved readily. Hence, we need to transform this generation towards a better future by fostering their beliefs to reduce greenhouse emissions. The United Nations has recognised education as a weapon against the climate crisis as it empowers the knowledge, beliefs and attitudes of children. Education is empowering twenty-first-century skills among students. However, child-centred pedagogies, which are preferable to other traditional methods of teaching, have proved to be of great importance. Educating students on global warming and climate change is vital for cultivating comprehensive knowledge and addressing a significant shortfall in atmospheric science and climate education (Serafin et al., 1991). Conventional teaching methods, typically marked by knowledge delivery, often fail to promote the intricate cognitive, emotional, and behavioural changes required for successful action on climate change (Monroe et al., 2019). A study by Pruneau et al. (2003) demonstrated that experiential learning programs significantly influenced the views and behaviours of children and adolescents towards climate change. This emphasises the urgent necessity for novel educational approaches that overcome rote memorisation and promote authentic involvement, critical thinking, and a sense of responsibility in students. The insights and viewpoints of present students are particularly crucial, as their lives will be profoundly impacted by anticipated climate change (Varela et al., 2018). The impact of climate change is universally acknowledged; it is a significant issue that demands discussion among family and friends to shape their perspectives (Stevenson et al., 2018).

In this context, education is deemed vital for reducing greenhouse gas emissions and is a fundamental aspect of scientific literacy and public understanding of science (Kurup et al., 2021). The current research assesses the influence of project-based learning on beliefs of students about global warming with regard to academic achievement. The objectives of the study are:

- To assess the effect of Project-Based Learning on the beliefs of students about global warming.
- To compare the beliefs of Project-Based Learning and lecture-based learning of students about global warming in relation to their previous Academic Achievements.
- To compare the beliefs of Government and Private school students about global warming.

The following hypotheses were framed based on the objectives above:

- There is no significant interaction effect of Teaching Method (Project-Based Learning & Lecture-Based Learning) and Academic Achievement on mean gain scores of Beliefs about global warming.
- There is no significant effect of Teaching Method (Project-Based Learning & Lecture-Based Learning) on mean gain scores of Beliefs about global warming.
- There is no significant effect of Academic Achievement on the mean gain scores of Beliefs about global warming.
- There is no significant effect of the type of school (Government and Private) on the mean gain scores of Beliefs about global warming.

## 2. LITERATURE REVIEW

Project-based learning is a systematic pedagogical approach that emphasises learning through the execution of projects (Thomas, 2000). Educational institutions can substantially enhance awareness of critical knowledge and issues. They ought to provide the younger generation with comprehensive environmental education and encourage pro-environmental behaviours within an appropriate framework (Stevenson et al., 2018). Therefore, it is essential to implement specific reforms in the school curriculum that shape students' beliefs and understandings of global warming and climate change. Beliefs are defined as presumptions regarded as valid (Pajares, 1992). It is essential to examine the evolution of beliefs, attitudes, and intentions demonstrated by students across various educational levels (Skamp et al., 2009a). Learner-centered methodologies are optimal as they enable students to structure their educational materials (Shin, 2018). Project-based learning empowers students to independently identify practical and complex problems, devise solutions, and engage in collaborative research to address these issues (Lee et al., 2015). Project-based learning has a positive influence on children's proficiency in terms of environmental content and investigative skills. They show gains in achievement that are important to figure out big environmental issues (Chen & Yang, 2019). A study conducted by Karpudewan et al. (2016) showed that Project-based learning leads to enhanced understanding, mindset, ideas and actions of students on energy-related concepts. Consequently, PBL can improve the sustainable perspective of students towards mitigating the impact of global warming. Another study conducted by Bilgin et al. (2015) proved that students receiving instruction using project-based learning materials improve their performance in science and technology courses and have higher self-efficacy beliefs than those who receive instruction using the conventional method. In addition to this, PBL has a beneficial effect on students' motivation and can strengthen their beliefs and capacity for task completion (Shin, 2018). Kurup et al. (2021) established an inquiry intervention strategy utilising the 5E teaching framework (Engage, Explore, Explain, Elaborate, and Evaluate). The intervention affected students' perceptions of scientific facts and challenges related to global warming, indicating significant shifts in their beliefs and an understanding of the necessity for collective commitments and efforts. Hence, project-based learning positively influences the beliefs of students by improving their knowledge and environmental attitudes.

### Identified Research Gaps

According to the previous research studies conducted on students regarding the concept of global warming, middle school students reflect the knowledge perceived in a positive way (Celikler & Aksan,2015). Students' beliefs about the cause of global warming and its consequences need to be addressed. There is a lack of conceptual understanding of global warming among students (Lin,2016). Limited research has been done in India, involving a comparison of project-based learning and lecture-based learning methods of teaching to assess the beliefs of students about global warming. A few studies are comparing the impact of PBL on Indian government and private schools. It is required to evaluate the beliefs of the students towards mitigating global warming in a developing country like India, where

the impact has been devastating (Lehnert et al.,2020). This research seeks to address these gaps by concentrating on the effects of teaching methodologies (project-based and lecture-based) on students' beliefs about global warming.

## 3. METHODOLOGY

The current study used a quasi-experimental research method including pre-test and post-test (Mukaromah & Wusqo, 2020). The total number of participants in the current study was 160, studying in grade 7th in government and private CBSE schools of Panchkula, Haryana, India. The students were divided into a control and an experimental group using a stratified random sampling method. 80 students were selected from each school, which comprises mainly of two sections, and then classes were randomly assigned as control and experimental groups (Vidergor, 2022). The experimental group in the study received instruction using a project-based learning educational intervention, while the control group received instruction using a lecture-based learning (LBL) approach on the same material (Fadhil et al, 2021; Rehman et al, 2023). The questionnaire developed by Boyes et al. (2008) was used to assess the beliefs of students about global warming. The previous science scores of the students were considered.

At the beginning of the study, parental consents were taken to complete the questionnaire on beliefs about global warming. Everything was well informed beforehand that the participation in the study is voluntary and their responses to the questionnaires will not be revealed.

**Procedure**

The learning process included eight lesson plans, each for project-based learning and traditional learning, prepared by the researcher. The lesson plans included eight topics of global warming and were based on Bloom's taxonomy.

The current study was divided into 3 phases.

Phase 1: Pre-Test

Students of both control and experimental groups filled out the questionnaire for belief in the presence of the researcher. The approximate time taken for the pre-test was 50 minutes.

Phase 2: An Educational Intervention

Lesson plans prepared by the researcher were used to teach students in both groups. Project-based learning methodology was used for teaching the experimental group.

Phase 3: Post-Test

Furthermore, a post-test assessing their beliefs on global warming was administered using the same tool. The post-test took about 40 minutes to complete.

The researcher collected the completed questionnaires following the pre-test and post-test.

## 4. RESULTS

**Descriptive Findings**

Quantitative analysis depicted that the belief scores increased significantly in the PBL group (pre: M = 153.73; post: M = 165.92; gain: M = 12.16) compared to the LBL group (pre: M = 156.28; post: M = 162.42; gain: M = 6.14). This proves that the PBL group has shown significantly greater improvements in terms of Belief scores, as given in Table 1.

**Table 1: Belief scores for Teaching Method (PBL & LBL)**

| Group | Pre-test mean (SD) | Post-test mean (SD) |
|---|---|---|
| PBL | 153.73 (13.33) | 165.92 (13.68) |
| LBL | 156.28 (12.61) | 162 (12.25) |

Low achievers showed the highest relative gains (M=9.83, SD=3.12). Though, high achievement group maintained the highest overall scores, however lower achievement group has shown more consistent improvements, as given in Table 2.

**Table 2: Belief Scores for Academic achievement (High, average and low)**

| Scores | Academic Achievement | Mean | SD |
|---|---|---|---|
| Gain knowledge scores | A | 8.99 | 3.76 |
| | H | 8.54 | 3.78 |
| | L | 9.83 | 3.12 |

Though private and government schools showed an increase in belief score as given in Table 3, private school students exhibited higher mean gain scores (M=9.31, SD=3.63).

**Table 3: Belief Scores for Type of School**

| Scores | School Type | Mean | SD |
|---|---|---|---|
| Gain knowledge scores | Government | 8.76 | 3.69 |
| | Private | 9.31 | 3.63 |

**Inferential Findings**

ANOVA results revealed significant differences in belief gains ($F = 237.438$, $p < .001$). Low achievers and government school students benefited most from PBL, highlighting its potential for reducing achievement gaps. The four null hypotheses were tested using ANOVA.

The first hypothesis stated that there is no significant interaction effect of Teaching Method (Project-Based Learning & Lecture-Based Learning) and Academic Achievement on mean gain scores of Beliefs about global warming. This hypothesis was rejected. Table 4 indicates the F-value of 1.017 and a p-value of 0.364. Therefore, this suggests that the combined influence of teaching method and academic achievement does not affect beliefs about global warming. Figure 1 further supports the above result.

**Table 4: ANOVA - Gain Belief Scores**

| | Sum of Squares | df | Mean Square | F | P | $\eta^2p$ |
|---|---|---|---|---|---|---|
| Teaching Method (1= PBL, 2= LBL) | 1031.41 | 1 | 1031.41 | 237.438 | < .001 | 0.613 |
| Academic Achievement | 3.05 | 2 | 1.52 | 0.351 | 0.705 | 0.005 |
| Teaching Method (1= PBL, 2= LBL) ✻ Academic Achievement | 8.84 | 2 | 4.42 | 1.017 | 0.364 | 0.013 |
| Residuals | 651.59 | 150 | 4.34 | | | |

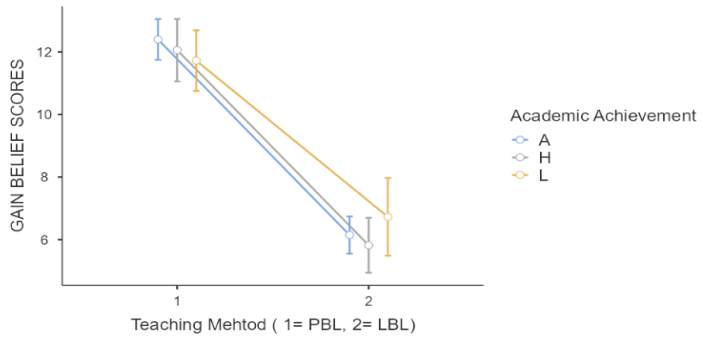


**Figure 1: Interaction graph (Teaching Method & Academic Achievement) for gain Belief scores for Academic Achievement (High, Average and Low)**

The second Hypothesis stated that there is no significant effect of Teaching Method (PBL vs. LBL) on mean gain scores of Beliefs about global warming. The null hypothesis was rejected. Table 5 indicates an F-value of 237.438 and a p-value of < 0.001. The significant result indicates that the teaching method does have a substantial effect on the mean gain scores of beliefs about global warming. The post hoc comparison given in Table 5 further supports this finding, showing a mean difference of 5.83 between PBL and LBL, with a Cohen's d of 2.8, which indicates a very large effect size. Further, Figure 2 shows a comparison graph for gain belief scores for Teaching Method (PBL & LBL).

**Table 5: Post Hoc Comparisons - Teaching Method (1= PBL, 2= LBL)**

| Teaching Mehtod (1= PBL, 2= LBL) | | Teaching Mehtod (1= PBL, 2= LBL) | Mean Difference | SE | df | t | $p_{tukey}$ | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| 1 | - | 2 | 5.83 | 0.378 | 150 | 15.4 | < .001 | 2.8 |

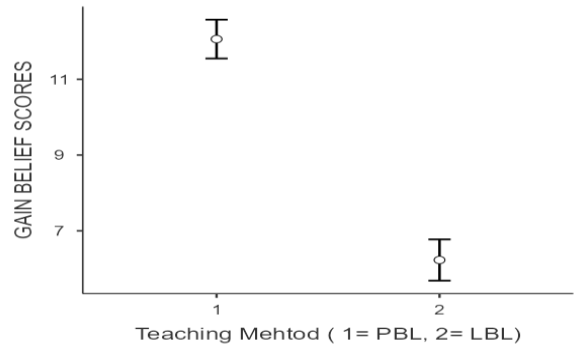


**Figure 2: Comparison graph for gain Belief scores for Teaching Method (PBL & LBL)**

The third hypothesis stated that there is no significant effect of Academic Achievement on the mean gain scores of Beliefs about global warming. The null hypothesis was not rejected. Table 6 gives an F-value of 0.351and a p-value of >0.05. This suggested that the type of Academic Achievement (High, average and low) does not significantly influence students' beliefs about global warming. The post hoc comparison given in Table 6 also aligns with this finding, that students with varying levels of academic achievement do not show differing mean gain scores. Further, it also indicated a small effect size. Additionally, Figure 3 shows a comparison graph for gain belief scores for Academic Achievement (High, Average and Low).

**Table 6: Post Hoc Comparisons - Academic Achievement**

| Academic Achievement | | Academic Achievement | Mean Difference | SE | df | T | $p_{tukey}$ | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| A | - | H | 0.3344 | 0.404 | 150 | 0.828 | 0.686 | 0.1605 |
| | - | L | 0.0482 | 0.457 | 150 | 0.105 | 0.994 | 0.0231 |
| H | - | L | -0.2862 | 0.522 | 150 | -0.549 | 0.847 | -0.1373 |

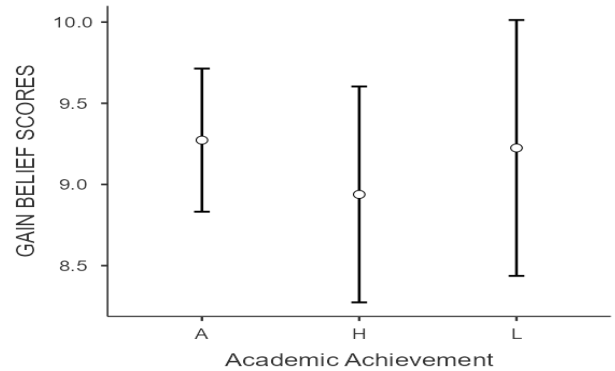


**Figure 3: Comparison graph for gain belief scores for Academic Achievement (High, Average and Low)**

The fourth hypothesis stated that there is no significant effect of the type of school (Government and Private) on mean gain scores of Beliefs about global warming. In government school, M=8.76, SD=3.69 and in private school, M=9.31, SD=3.63, as shown in Table 7. It concludes that the mean gain scores in private school are slightly higher than those in government school, and the standard deviation is similar, indicating similar variability within both groups.

**Table 7: Group Descriptives for Gain scores on Belief for Type of School (1= Govt., 2= Private)**

| | Group | N | Mean | Median | SD | SE |
|---|---|---|---|---|---|---|
| GAIN BELIEF SCORES | 1 | 79 | 8.76 | 7 | 3.69 | 0.415 |
| | 2 | 77 | 9.31 | 8 | 3.63 | 0.414 |

The independent samples t-test results in Table 8 showed that the t-value: 0.942, df (degrees of freedom): 154, p-value: 0.348, Mean difference: 0.552, SE (Standard Error) of difference: 0.586, and Cohen's d (Effect Size): 0.151. The mean difference of 0.552 indicated that students in private schools have a slightly higher mean score than students in government school; however, this difference is small and the effect size is small, suggesting that the difference is impractical. Hence, there is no significant effect of the type of school (Government vs. Private) on the mean gain scores of beliefs about global warming. The null hypothesis is not rejected, meaning that the type of school does not significantly influence the beliefs about global warming. Further, Figure 4 illustrates a comparison graph for gain belief scores for School type (Govt and Private).

**Table 8: Independent Samples T-Test**

| | Statistic (t value) | Df | P | Mean difference | SE difference | Effect Size (Cohen's d) |
|---|---|---|---|---|---|---|
| GAIN BELIEF SCORES | 0.942 | 154 | 0.348 | 0.552 | 0.586 | 0.151 |

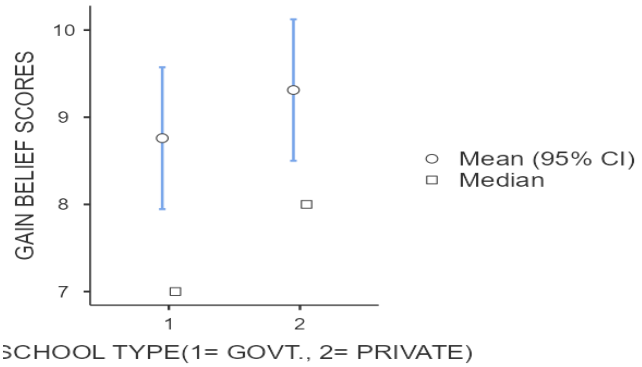


**Figure 4: Comparison graph for gain belief scores for School type (Govt and Private)**

## 5. DISCUSSION

The purpose of the study was to explore the influence of project-based learning on the beliefs of students about global warming. The quantitative findings of this study indicate that Project-Based Learning (PBL) substantially enhances beliefs of students about global warming. This is congruent with using PBL to improve students' viewpoint and emotional domains in terms of environmental awareness (Lopez & Palacios, 2024). Students exposed to the PBL intervention outperformed as compared to the one taught with the traditional method of teaching. PBL has been proven to be the main cause for gains in beliefs among the students in the experimental group as compared to the students in the control group (Rehman et al., 2023). Students in the experimental group depicted more emotional engagement and enthusiasm

as compared to the students in the control group. For instance, it has been proven that learners perceive a sense of excitement during their activities in project-based learning (Mukaromah & Wusqo, 2020).
The descriptive statistics and the ANOVA results emphasise that the improvements were particularly apparent among low-achieving students and those from government schools (Karpudewan & Khan, 2017; Sharma et al., 2020). PBL creates a nurturing environment in the classroom. Therefore, by creating tangible solutions to real-world problems, low-achieving students gain confidence and a sense of ownership, which gives them a sense of satisfaction. Further, it promotes collaboration, communication, teamwork, and problem-solving abilities (Rehman et al., 2023), facilitating the resolution of real-world challenges. Project-based learning promoted deeper shifts in beliefs towards pro-environmental views in the experimental group, which is consistent with earlier studies that emphasise the emotional impact of practical, hands-on projects (Chen & Yang, 2019). The study also highlights that there is no effect of government and private schools on the beliefs and gains of students about global warming. This proves that PBL is a student-centred teaching pedagogy that mainly focuses on hands-on, real-world projects with active involvement of learners (Rehman et al., 2023). The study also showed that academic achievement has no impact on the beliefs of students about global warming. PBL enables students to acquire knowledge through solution-seeking, inquiry, discourse, planning, and interaction with others. Therefore, students, when confronted with real-world difficulties, investigate and critically assess potential solutions. The gains were evident in low achievers, which proves that PBL leads to better communication that further fosters building ideas and beliefs. Project-based learning can transform students' responses to the entire learning process (Choi et al., 2019). Additionally, Chen and Yang (2019) mentioned that a team of students working together encourages social interaction and effective communication.
The combined influence of academic achievement and teaching methodology has no influence on ameliorating the beliefs of students regarding global warming. The improved beliefs of students about global warming in the intervention group indicate that project-based learning induces objective-oriented outcomes involving problem-solving, decision-making, and idea-generating processes (Karpudewan et al., 2016). Project-based learning has proven to build up beliefs about global warming among low scorers. The results are consistent with DeWaters and Powers (2011), where PBL endorses energy literacy by modifying attitudes, beliefs and behaviours. Hence, the educational intervention based on project-based learning contributed to shaping the mindset of students by enhancing their knowledge towards sustainability. Consequently, the current study concludes that PBL pedagogy fosters environmental conscious beliefs. When Project-Based Learning (PBL) is meticulously developed and executed, data indicate that it may surpass traditional instruction in teaching concepts (Walker & Leary, 2009).

## 6. CONCLUSION

The present study evaluated the effect of project-based learning on students' beliefs regarding global warming with regard to academic achievement. The study highlights that PBL significantly influences students' beliefs regarding global warming. The projects were particularly effective in fostering climate-conscious behaviour. The study highlights that PBL has significantly influenced students' beliefs about global warming. A favourable effect of the study is the advantages for low-achieving students. Henceforth, this pedagogical approach provided a conducive environment for these underachieving students. Nevertheless, it is important to take into account some of this study's limitations. The duration of the intervention and the sample size should be considered to assess the long-term effect of project-based learning. Additionally, a substantial amount of time, resources, and teacher training are needed for the success of project-based learning.

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**Disclosure Statements**

No potential conflict of interest was reported by the author.

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