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Knowledge Building for Climate Change Education: A case study of a Maldivian teacher

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Abstract. This study proposes the Knowledge Building (KB) pedagogy as a collaborative method for climate change education. Few studies have explored how teachers new to KB have used the approach involving students who are also new to KB in classrooms. This study explores how a grade seven science teacher used the KB approach for the first time to support student learning about climate change, specifically focusing on facilitating idea generation and the revision and refinement of ideas. The teacher implemented KB in two rounds with her class of 20 students. A qualitative case study design was employed to collect the data. Data was collected from classroom observations, teacher interviews, student interviews, and teacher reflections; it was coded, and categories were derived from the emergent data. The results show that the teacher attempted to facilitate the students' idea generation, revision and refinement of those ideas as a collaborative process. While brainstorming and reflective comparisons fostered the idea-generation process, structural guidance facilitated revising and refining ideas. This educational method is essential for teaching about complex issues like climate change because it enables students to apply their existing knowledge to explore better solutions. While this research contributes to the ongoing research works on understanding how teachers new to the approach apply knowledge building in practice, particularly in facilitating idea generation and idea improvement, teachers should assume the role of facilitators, work together with students as partners, and provide extra guidance required during the process, especially when they are unfamiliar with KB or similar approaches.

Keywords: climate change education; idea generation; idea improvement; knowledge building

1. Introduction

Global concern has been raised by the uncertainties around climate change, its scientific, economic, and social challenges, and the inconsistent outcomes of the proposed solutions (Lehtonen et al., 2019). Climate change is a global threat, particularly to small island nations as they are more vulnerable (Doorga, 2022;

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Martin et al., 2018). According to several studies, countries such as the Maldives might be underwater by the end of the century (Kapoor, 2020; Sakamoto et al., 2021). Ranked 117th in the Notre Dame Global Adaptation Initiative Country Index (ND-GAIN) (University of Notre Dame, 2025), the Maldives is among the nations that are vulnerable to climate change and its consequences such as sea level rise (Eckstein et al., 2019). The National Aeronautics and Space Administration and the United States Geological Survey has reported that rising sea levels are estimated to make about 80% of the low-lying small island state uninhabitable by 2050 (Ranjan, 2021).

Education is fundamental to addressing climate change (Reid et al., 2021) as people require climate literacy and understanding for up-to-date adaptations and mitigation actions (Fitzpatrick et al., 2024). Education can play a role in climate-related disaster preparedness through sturdy curricula, appropriate pedagogies and different learning resources by preparing people to make high-level and adaptive decisions related to climate change (Feinstein & Mach, 2020). Of the seventeen Sustainable Development Goals (SDGs) adopted by the United Nations, SDG 13, the climate action goal, is about improving education, increasing awareness and developing the personal and organisational capability to mitigate, adapt and reduce climate change's impact and initial risks (United Nations, 2022).

According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and Monitoring and Evaluating Climate Communication and Education (MECCE), to support climate mitigation, education can promote climate-related research and development to accelerate technological inventions for climate change solutions, along with intensifying the education for girls to help increase their independence related to fertility-related decisions (UNESCO & MECCE, 2024).

Studies focusing on sustainability, environmental issues and environmental awareness are on the rise among the public and schools, such as through environment clubs in schools (Mohamed & Mohamed, 2021) and green school projects (UNESCO, 2024a). For instance, Shiyama et al. (2023) conducted a small-scale, cross-cultural participatory study exploring how students expressed their understanding and views on local environmental challenges, their aspirations for future environments, and their role as global citizens through artistic and various written forms. Di Biase et al. (2021) actively engaged a small island school and the island community to collaborate on the "Playing with Solar" project, promoting awareness about renewable energies, particularly solar energy.

Although the Maldivian government frequently addresses climate change, there is still a gap in educating the youth about this issue. According to a recent survey by United Nations Children's Fund (UNICEF) in the Maldives, fewer than 47% of respondents could accurately explain climate change and global warming (Rello & Ackers, 2021). While many students (64%) report that they often learn about climate change in school, the current education methods and content may not adequately meet their needs. Additionally, around 93% of respondents wanted to learn more about climate change, encompassing its causes, effects, prevention

strategies, and local initiatives. Mohamed and Mohamed (2021) also identified that there is still a deficiency in pro-environmental behaviours among individuals, as public actions indicate a lack of fundamental environmental education that emphasises the connections between the natural ecosystem and the social and economic sectors.

This indicates the need for better approaches to climate change education, that emphasise collaboration and the active involvement of learners in addressing climate-related issues. The Maldivian National Curriculum Framework (NCF) does not directly address this issue (UNESCO, 2024b). Nevertheless, sustainable development has been incorporated into the curriculum (National Institute of Education, 2015), introducing a core competency of utilising sustainable practices. Issues related to climate change are covered in subjects such as Health and Physical Education, Science, and Social Studies. For instance, the grade seven science curriculum examines the effects of climate change and its impact on ecosystems.

While education is considered to be the foundation for social and environmental changes due to the climate crisis, teaching climate issues needs to use better strategies to address the complexities and controversies involving it (Monroe et al., 2017). They highlighted various strategies that could help students go further beyond the general knowledge about climate change including, (i) the use of intentional conversations and discussions, (ii) providing opportunities for students to interact with scientists and science, (iii) designing climate change education to focus on the misconceptions about CC and (iv) involving students in designing and implementing projects on climate change within the school or the community.

Creative and participatory approaches involving children and youth are needed (Corner et al., 2015; Jorgenson et al., 2019) as children are more vulnerable to climate change and hence should be empowered to understand and take action (Trott, 2019), as understanding and responding to climate warmings effectually depends on knowledge, stewardship and sustainability comprehensively across various domains (Reid et al., 2021). Rousell and Cutter-Mackenzie-Knowles (2019) called upon involving children in resolving the complex effects of climate change in their communities, as climate change education calls on the preparation of children for the uncertainty and rapidly changing future using innovative approaches (Stevenson et al., 2017).

Thus, to respond to the call for participatory and collaborative approaches involving children in climate change education, this study focuses on how a teacher used the knowledge building approach to help the students work collaboratively and actively address climate issues in their community.

2. Literature Review

2.1 Knowledge Building

Pioneered by Scardamalia and Bereiter in 2006, 'knowledge building' is an educational approach that promotes a collaborative culture of knowledge creation

in classrooms (Scardamalia & Bereiter, 2021). It involves students identifying realistic problems or issues they are interested in, verbalising their ideas and thoughts regarding the community problems, and developing, discussing and improving ideas that are significant to the community (Bereiter & Scardamalia, 2003).

Table 1: Knowledge Building Principles

KB principle	Definition
Real Ideas, Authentic Problems	The ideas created are as real as things that are touched and are usually different from textbook problems and puzzles.
Idea Diversity	Understanding similar and different ideas to create an environment where ideas can grow into new and better forms.
Improvable Ideas	All ideas can be improved in terms of quality, coherence and utility.
Epistemic Agency	Participants have individual or collective control over the whole range of components of knowledge building, including the goals, strategies, resources, and evaluation of the results.
Knowledge Building Discourse	Students use discursive community methods to improve their understanding, focusing on conversations led by students rather than those driven by teachers.
Constructive uses of Authentic Sources	Communication patterns and practices which students respect and understand critically, as well as examining authoritative sources of information (texts, experts).
Community Knowledge, Collective Responsibility	Everyone in the group shares equal responsibility for the success of the group, instead of depending on a leader.
Democratising Knowledge	All participants in a knowledge building community are legitimate contributors to the shared goals of said community.
Symmetric Knowledge Advancement	The distribution of expertise within and among the community results from knowledge exchange and the idea that giving knowledge is getting knowledge.
Pervasive knowledge building	Knowledge building is not confined to occasions or subjects but pervades mental life – in and out of school.
Embedded, Concurrent and Transformative Assessment	Identifying problems as the work continues, embedded in the everyday work of the community.
Rise Above	Learning to work with diversity and complexity to achieve new syntheses.

As a principled approach, knowledge building does not prescribe specific tasks or activities but articulates fundamental values and principles. The twelve KB principles (see Table 1) represent the conceptual framework of KB pedagogy and

technology. These principles foster student collaboration and enable students to think critically, interdisciplinarily, and globally about issues like climate change. Teachers can apply these principles at any point on a spectrum. As knowledge building remains open to new contexts, the underlying principles guide teachers in educational settings, exemplifying effective KB use and forming the foundation for a principle-based framework (Chen & Hong, 2016).

Considering the importance of the KB principles and conceptual framework, Chen and Hong (2016) identified four unique characteristics that differentiate knowledge building from various constructivist approaches:

- a) Supporting epistemic agency – learners are required to engage in higher levels of socio-cognitive responsibility through participation in knowledge transformation and the responsibilities of planning, monitoring, and evaluating their knowledge creation efforts (Oshima et al., 2006; Scardamalia & Bereiter, 2003; Zhang et al., 2022).
- b) Taking collective responsibility – responsibility is shared equally among the learners, who participate actively in advancing knowledge and promoting its fair dissemination within the community (Gutiérrez-Braojos, 2018). The participants in KB classrooms function like experts, supporting the community on an individual basis (Scardamalia, 2002), while seeking unique ideas and perspectives, assessing ideas that can be improved, analysing justifications and explanations, and reconsidering challenges and issues to enhance the collective knowledge further (Tan et al., 2021).
- c) Creating new knowledge – students are involved in the teamwork of expert groups and organisations that create knowledge as part of intricate social interactions, fostering the development of public knowledge that transcends individual understanding (Chen & Hong, 2016). Students can acquire knowledge and help create new knowledge during the process.
- d) Design-mode thinking – design thinking involves analysing and exploring products to improve them (Dam & Siang, 2018), which aligns with the design aspect of knowledge building, focusing on enhancing ideas (Scardamalia & Bereiter, 2017). Knowledge building encourages learners to participate in the practice of design-mode thinking, which includes a wide variety of activities related to the creating and refining of knowledge (Bereiter & Scardamalia, 2014).

2.2 Technology Supporting KB: Knowledge Forum

Knowledge Forum (KF) is a technology designed to support the knowledge building process (Scardamalia, 2004). The KF environment has extensive KB features and functionalities that empower students in their knowledge building journey (Tsai et al., 2014). The platform allows students to utilise a collaborative knowledge space to create and share their contributions, while the analysis tools in KF, enable teachers to evaluate the students' contributions (Tsai et al., 2014).

KB extends beyond digital environments or a specific knowledge building environment (Chen & Hong, 2016). For instance, the “knowledge wall” (Haneda & Wells, 2000) “flash cards” (Bielaczyc & Ow, 2014), the future learning

environment (Muukkonen et al., 2005) and wikis (Joubert & Wishart, 2012) have been developed in addition to KF to support KB. In the present study, we have used Padlet to facilitate the students' KB process.

2.3 The Present Study

The knowledge building approach fosters student collaboration in creating knowledge (Scardamalia & Bereiter, 2021) and empowers them to gain knowledge through collaborative problem-solving skills, idea development, and critical thinking, informed by credible sources, and collective responsibility for intellectual growth (Bereiter & Scardamalia, 2016). Teachers with no experience with KB struggle to apply this approach, as well as socially organise and pedagogically support the flexible, open, agency-driven inquiry processes in classroom teaching (Tao & Zhang, 2018).

However, the principled nature of KB enables teachers to collaborate with students to define the inquiry process concerning KB principles (Scardamalia & Bereiter, 2006). A less structured inquiry allows students to authentically test their ideas on real-world inquiries with a broader scope (Li et al., 2018). However, most KB studies involve experienced teachers facilitating the KB process (Chen & Hong, 2016).

Studies have also recorded collaborative and productive KB in different classroom communities facilitated by veteran teachers (Yang et al., 2021; Zhang et al., 2018). However, limited information is available on how teachers and students new to this method progress in knowledge creation, particularly regarding the role of teachers in knowledge building classrooms (Lai, 2019). Moreover, how teachers should implement and utilise knowledge building in classrooms to encourage student-led collective improvement of ideas remains insufficiently explored (Li et al., 2018).

Therefore, this study explores how a teacher applying the knowledge building approach for the first time in teaching and learning about climate change issues facilitated the students' knowledge building processes, specifically in idea generation, and the refinement and revision of ideas. The research question examined was:

'How does a teacher, learning to facilitate knowledge building for the first time, support students in the knowledge building process, particularly in idea generation and the refining and revising of ideas?'

3. Research Methodology

3.1 Research Design

This study adopted a qualitative case study approach (Merriam, 1998) to gain an in-depth and nuanced understanding of how a teacher facilitated her students' knowledge-building processes using the KB approach for the first time. The case study approach enabled the researchers to concentrate on the teacher's experiences in guiding the students' knowledge-building processes. Additionally,

it aimed to offer readers an in-depth account of the participant teacher's perspective on her experience while applying the knowledge-building method.

3.2 Participants and Research Setting

A purposive sampling method was employed to gain an in-depth understanding of the cases able to provide rich information (Nyimbili & Nyimbili, 2024; Patton, 2015), allowing researchers to explore issues that are central to the investigation through these information-rich sources. This study focuses on a teacher's first-time experience facilitating the knowledge-building process. Thus, a grade seven science teacher who has not experienced the KB approach was selected. It also involved her class of 20 students (13 girls and seven boys) of age 13.

The research took place in a Maldivian government school from October 2023 to February 2024. The school follows the National Curriculum Framework and follows the precise rules and regulations implemented by the Ministry and the National Institute of Education (NIE). Upon receiving approval from the Ministry of Education, the school appointed a gatekeeper who facilitated various processes, such as arranging meetings with the teacher, students, and parents, and arranging the computer lab. Informed consent was sought from the teacher and parents, and assent was sought from the students prior to the data collection.

3.3 Data Collection and Analysis

The data was collected in two rounds. The main data source was semi-structured interviews while observations, ongoing discussions, documents, the teacher's reflective journal, student interviews and Padlet were used to triangulate the data from the interviews. Semi-structured interviews allow researchers to have the flexibility to respond to the situation at hand, to develop an emerging understanding of the participants, and to develop new ideas on the issue (Merriam, 2009; Merriam & Tisdell, 2016). To triangulate the data collected from the teacher interviews, six students were also interviewed. The students were selected based on their participation during the knowledge building sessions.

For instance, two students were selected from those who participated well, two from those who least participated, and another two who were between the two groups. The students who participated well contributed real ideas, portrayed agency, contributed to community knowledge, and worked on improving ideas. The students who participated the least contributed the least to real ideas, portrayed the least agency, contributed the minimum to community knowledge, and worked the least on improving ideas. All interviews were audio-recorded and transcribed, translating words or phrases in the local language into English. The data was organised and managed using ATLAS. Ti 24.

This study utilised thematic analysis as the data analysis technique. This approach enabled the organised identification, examination, and interpretation of the recurring themes within the qualitative data obtained from the interviews with the teacher, classroom observations, student interviews, and reflections from the teacher (Merriam & Tisdell, 2016). The researcher created the initial open codes that were subsequently organised, concentrating on the significance of the codes and the accompanying quotations. The codes were further condensed by

recognising recurring themes or information and merging several of them. As categories emerged from the data, they were labelled and refined with an emphasis on the data and the codes.

3.4 Ethical Procedures

Several measures were taken to enhance the internal validity, reliability, and external validity (Merriam & Tisdell, 2016). For triangulation, multiple methods were used to collect the data, including interviews, observations, discussions, documents and Padlet. For member checks, the teacher checked the initial findings of the research for verification and confirmation and then provided additional information and clarification of some of the data collected.

For prolonged engagement in data collection, the researcher spent four months engaged in the data collection process, explicitly observing the KB sessions and interviewing, as well as working with the teacher before and after the implementation process. For the audit trail, the researcher used research journals including the questions, reflections, and decisions related to the issues or ideas that the researcher comes across during the data collection.

To address any ethical issues pre-emptively, the university's research review committee, the Ministry of Education, and the school approved the study. Prior to the data collection, the researchers obtained informed consent from the participants. When reporting the findings, the participants' names were replaced with pseudonyms to maintain their confidentiality and anonymity. To maintain the trustworthiness of the study, both positive and negative findings have been reported.

4. Findings

The study investigated how a teacher, for the first time, supported their students' knowledge-building process, particularly by facilitating idea generation and the refinement and revision of ideas. To respond to the research question, the researcher analysed the interview transcripts, discussions, reflections and classroom observations. The analysis revealed the following categories:

Category 1: Facilitating Idea Generation through Activating Thoughts and Student-Centred Prompts

The teacher used various techniques to spark the students' initial interest in climate change by using brainstorming and reflective comparison exercises. She initiated the process with the activity 'My Ideal Earth', allowing the students to conceptualise a vision for a better world and to reflect critically on the current environmental state. She described this visual and cognitive engagement as:

"... at the beginning, students were given the topic 'My Ideal Earth' and asked to draw their ideal Earth. They were given the choice of how to visualise it." (Teacher Interview 1)

She encouraged the students to connect their prior knowledge, personal experiences, and environmental observations to the topic:

"I asked them to think about what they have learnt over the years... their personal experiences and what they observe from their surroundings. "
(Teacher Interview 1)

While brainstorming and analysing the problem assisted the students in generating initial ideas, some students found it difficult as they lacked prior knowledge about the problem. The teacher highlighted this in her reflection as:

"I noticed that some students had difficulty generating ideas. They kept saying there was nothing more to add and could not think of anything else. " (Teacher Reflection 2)

She linked the students' lack of prior knowledge of the problem with the existing lecture-style teaching methods. She also believed that the lack of reading and research by the students were the reasons why they could not generate initial ideas:

"The students lacked sufficient content or knowledge related to prevalent topics; hence, they cannot come up with new (ideas) or connect the knowledge they learnt. Also, most Maldivian students are not avid readers, and those who do read rarely read non-fiction. They do not research topics on their own or are sadly curious about things. " (Teacher Interview 1)

Once the students had initiated idea generation, the teacher promoted the externalisation of those ideas through individual and group work. She transitioned from one-on-one activities to collaborative group tasks to foster communication and mutual critique. As she noted:

"They worked in small groups of three to four students to come up with any idea relevant to temperature rise... things that can be done. "
(Teacher Interview 2)

This process was reinforced using collaborative digital tools such as Padlet, which enabled idea sharing, commenting, and discussion.

"I gave them the authority to go through all the ideas and comment on them or expand on ideas of their own choice. " (Teacher Interview 2)

Category 2: Supporting the Refinement and Revision of Ideas through Guidelines and Collaboration

While idea improvement is the goal of knowledge building, the teacher acknowledged that her lack of knowledge about executing the process hindered the class from improving their ideas in the first round. She highlighted that the process was constrained as she needed more time to help the students understand the KB principles and did not know how to execute the process:

"Well, I was also not aware of how to carry out idea improvement well. I wanted more time to go through it and find easier and better ways to convey idea improvement for the students. " (Teacher Interview 1)

Therefore, she focused more on facilitating the revising and refining of the students' ideas in the second round. To enhance the students' ability to refine and revise their ideas, the teacher provided structural guidance. She designed and distributed a guideline to help the students organise their thoughts and evaluate their work:

"I asked the students to organise their ideas according to the guidelines I shared with them so that it will be easier for anyone who checks it to understand what the students have worked on. " (Teacher Interview 1)

While these efforts have facilitated systematic thinking, the teacher acknowledged that some students only partially followed the guidelines or struggled with tasks like identifying the relevance of ideas. For instance, she reported:

"They were reluctant to remove the ideas as the students who came up with them did not accept that they were not very related to the main topic. " (Teacher Interview 2)

Additionally, limited negotiations happened among the students and with the teacher. For instance, the following conversation from session 15 (second round), with Students C and B shows negotiation when connecting similar ideas:

Student C: *Our topic was greenhouse gases. We expanded it by adding greenhouse gas emissions and examining how similar global warming and climate change are.*

Student B: *Yeah, vehicles release gas, and they use fuel, and electricity is consumed as well. Those topics are related to fuel usage, and there is a connection because fuel usage is one of the main reasons the temperature rises.*

To facilitate the reviewing of ideas, the teacher reviewed ideas with the students by going through the ideas and details provided on Padlet:

"I opened the guideline sheet and reviewed their work with them. It was more about asking them if all the parts were there or if anything was missing. I did not specifically tell them what to add or how to find it. The students found this helpful, as they said it made them understand more and notice what they had missed. " (Teacher Discussion 2)

Lacking experience in inquiry-based methods, the teacher gave instructions by modelling how to comment on and review ideas. She modified her instructions according to the student's needs and understanding levels. By demonstrating how to comment on ideas, the teacher guided the students through one idea from the Padlet. She felt that modelling had beneficial effects on how the students responded to others' thoughts, as she observed a shift in their comments from using "why" or "how" to offering more effective comments. She explained:

"I also reviewed their work with them and asked them questions about what is included and what they think should be added to explain their ideas further... I explained each part to them separately, letting them know some of the missing parts from their work. For example, the crammed and crowded cities one: How do crammed and crowded cities

cause a temperature rise? How is this connected to the overuse of electricity? ” (Teacher Interview 2)

Padlet facilitated the KB process, particularly in expanding and developing ideas. It also allowed the students to learn to be independent, respect others' ideas and understand that there are different causes of and solutions to rise in temperature. The teacher mentioned that utilising Padlet made discussions more manageable for passive students since they favoured jotting down their thoughts and elaborating on their classmates' notes to participate. Allowing students to comment on others' ideas, ask questions and inquire about the ideas presented by their peers also empowered them to participate in the learning process actively:

“During the discussion time, I allowed other students to add to it [Padlet]. For example, group one presented an idea and group Two had something to add to the first group’s ideas, so they could add. Like that, there was this connection where everybody could contribute ideas from all the groups to achieve our primary goal of understanding what climate change was. ” (Teacher Interview 2)

Even with limited success in revising and refining ideas, some students expressed that their understanding of and views on climate change had changed. For example, Student E said:

“It helped me think more deeply about the environment and what we are doing, that caused this rise in temperature.... I learned that humans don't think the same at all, they have different mindsets, as one of our ideas, human mindset... Before joining this group, I didn't know what climate change was because I learned it and I forget it lots of times. But now I know what most of the definitions are which I didn't learn, and it helped me to become more responsible. ” (Student E, Interview 2)

5. Discussion

The findings of this study offered clearer insights into how the teacher facilitated knowledge-building in the classroom and how her understanding of the approach transformed its application. However, these findings must be interpreted with caution as the teacher in the present study has no experience with the KB approach, and the students lacked inquiry skills. For two reasons, facilitating knowledge building for the first time posed challenges for the teacher. First, student aspects such as a lack of prior knowledge from insufficient research skills and engagement with fictional content, complicated the process. Second, the teacher's limited understanding of implementing knowledge-building principles, particularly the idea-refining process, posed challenges.

Regarding idea generation, the study indicated that teachers can stimulate student thinking by using different brainstorming activities and helping them express their ideas and thoughts. In settings such as the Maldives, where students typically adhere to the teachers' instructions, encouraging students to share their ideas and thoughts may necessitate additional time and effort from the teacher.

The teacher facilitated idea generation through the “My Ideal Earth” activity, along with recalling the students’ prior knowledge, which enabled brainstorming

among the students and aided them in pinpointing real ideas, real problems, and the diversity of their ideas. While Scardamalia and Bereiter (2006) pointed out that idea generation is a natural process, especially for children, this study did not observe such a natural flow in the idea-generation process due to the relatively limited awareness of climate change issues among the students, as some students demonstrated a lack of prior knowledge. The prior knowledge of the students regarding the issue is identified as a key element in inquiry-based learning (de Jong et al., 2023).

It reinforces the need to teach students about the science of climate change and the complexity of the climate system, as underscored by the experts in the study by Perkins et al. (2018). Their research stresses that climate change education should encompass a thorough understanding of the topic, be centred on the learners, and effectively reveal the realities of climate change to them within both local and global contexts. Therefore, the teacher encouraged the students and supported them in researching the matter since some of them struggled to come up with initial ideas related to the problem.

In addition to the students' lack of prior knowledge of climate change, the NCF does not directly address climate change. To successfully teach children about climate change, it should be incorporated into the curriculum as a separate subject (Eilam, 2022). According to Shiyama et al. (2023), a thematic approach integrating environmental and sustainability education could lead to innovative curriculum development.

Even with the initial challenges in facilitating idea improvement process, the teacher experienced some success in facilitating idea improvement. She facilitated the process by participating in the knowledge-building community. Her providing a guideline initially for students to examine and enhance their ideas aligns with the notions of de Jong et al (2023), as initial support is crucial for effective inquiry. While the entire process was not solely entrusted to the students, this study partly aligned with Chai et al (2016) as the limited opportunities collaboratively given to the students have fostered some degree of epistemic agency.

Parker (2018) also affirmed that these changes indicate the teacher's effort to adjust her current practices as she started to comprehend the approach and recognise the significance of letting her students participate in KB. Moreover, Hong and Lin (2019) proposed that engaging students in KB can foster collaborative and inquiry-driven learning. Through careful planning and the use of various tools, it is feasible to implement inquiry-based activities that shift epistemic agency from teachers to students across different cultural and educational settings (Akgun & Sharma, 2023).

The analysis also showed that some negotiations happened while refining and revising ideas. Yet, the teacher controlled the process, limiting the students' ability to ask questions and negotiate. It could be due to her limited understanding of applying the KB principle, "improving ideas" during the process. This finding

contrasts with the students' collective questioning and improvement of ideas while engaged in Knowledge Forum discussions as identified by Ong et al. (2020). The focus and the ability to react coherently to each other's arguments (Pesaresi & Zhang, 2019) needed to be improved in these negotiations. Negotiations and discussions are crucial to initiate and sustain knowledge advancement as these enable students to share their ideas and negotiate a fit between their ideas and the ideas of the community through comparisons (Resendes & Dobbie, 2017). To engage students in argumentation, classroom interactions should facilitate interactions so then the students are willing to share their ideas, listen to others' ideas and attempt to work together to understand said ideas (van Aalst & Truong, 2011).

The teacher recognised that even with the guideline at hand, the students still could benefit from her help when it came to evaluating and refining their ideas. Hence, she supported their learning by reviewing their work on climate change and its effects on the nation. In this context, she encouraged students to participate in knowledge-building activities as the students in the study had limited inquiry skills. Such explicit directions could address the shortcomings of the inquiry process (de Jong et al., 2023).

Aligning with the knowledge-building research that stresses the importance of teachers explicitly guiding students to engage in KB (Chen et al., 2017), the teacher in this study demonstrated how to review and comment on the students' ideas while facilitating the knowledge-building process. Unlike the present study, the study by Ma et al. (2017) reported a teacher who has experience of knowledge building directly teaching the students how to formulate scientific explanations, while another study provided direct instruction to novice students (Dehghan-Chaleshtori & Zhang, 2020).

As the facilitator, the teacher aimed to enhance the students' epistemic agency using Padlet and established a collaborative environment to emphasise teamwork and active peer interaction. Consistent with Bielaczyc and Ow (2014) and Scardamalia (2004), she concentrated on making the students comfortable tackling challenges, posing questions, and engaging in critical thinking without fearing being mocked or intimidated by others. Bielaczyc and Ow (2014) and Scardamalia (2004) highlighted the importance of students feeling secure enough to take risks and engage in constructive criticism and acknowledging that they still have to learn. This manner of climate change-focused collaboration also helped the students address challenges, collaborate on tasks, share ideas, and build on each other's ideas.

It also aligns with the emphasis on employing inquiry and co-learning methods in climate change education (Stevenson et al., 2017). Despite the limited knowledge across the inquiry, the knowledge-building approach allowed students to engage with the scientific method personally, potentially enabling them to extend their understanding of climate change beyond basic concepts (Monroe et al., 2017).

6. Conclusion and Implications

This study demonstrated a teacher's first attempt at facilitating their students' knowledge building process, particularly focusing on idea generation and idea improvement about climate change. It indicates the crucial role of the teacher in assisting the students in recalling their prior knowledge related to the issue during the initial idea generation. It also showed the importance of scaffolding as the students developed and revised their ideas. While the teacher had constrained inquiry knowledge and skills, she tried to create a collaborative environment, allowing students to have autonomy as they collaboratively shared and expanded each other's ideas.

The collaborative nature of the study highlights the significance of teamwork in addressing complex issues like climate change. It also indicated that although enculturation can be lengthy, KB can still advance knowledge even in complex contexts, especially regarding idea generation, and idea improvement. The study also underscores the importance of the curriculum in addressing topics of importance, such as climate change. As it is necessary to have a well-informed society to address such complex challenges, climate change education ought to be introduced into the NCF so then these issues can be given due attention within the educational system.

It also intends to offer the pool of knowledge on training teachers to implement the knowledge-building method in the teaching of critical issues that require collaborative and up-to-date solutions, such as climate change. This study is limited to a single case study; future research can focus on a more extensive, longitudinal study with a more diverse population to trace the long-term impact of KB on student outcomes. The study also involved one teacher and her class; therefore, the findings may vary with teachers with different perspectives and facilitation styles as they would design different activities to facilitate the KB process.

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