

Strengthening capacities in Latin America by designing teacher professional development programmes for climate change education

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Abstract

Purpose – This study aims to describe the design process of two teacher professional development programmes on Climate Change Education in Chile and Mexico, their initial outcomes on teacher practices and feedback on course activities, content and format, and their expectations of future topics for deepening their understanding.

Design/methodology/approach – A systematization of the design and implementation process of both programmes was conducted. Subsequently, an online survey comprising 21 questions was administered to 115 teachers from both countries, representing 5% of the graduates from each programme. The survey evaluated their experiences, the impact on their teaching practices and the effects on their personal and professional lives. This non-experimental design relied on teachers' self-reported perceptions after completing the course.

Findings – Teachers rated their experience highly, particularly regarding content quality and relevance to their local environment. Most (97.4%) applied their learning in their classrooms, with 78.3% noting it helped raise student awareness of climate change and facilitate collaborative projects. Additionally, 92.2% reported personal sensitization to climate issues and 87% changed personal habits. The course influenced 91.3% to take daily actions to reduce CO₂ emissions. Some reflections are made on the design and implementation of the programmes, considering the survey results and the available literature.

Research limitations/implications – The study relied on self-reported data from teachers after they had completed the courses. This approach was chosen because it allowed for a direct assessment of teachers' understanding and experiences. However, it is important to acknowledge the limitations inherent in self-reported data, such as the potential for response bias.

Practical implications – Educators, scientists and healthcare professionals can explore innovative pedagogical approaches to make CCE engaging and relevant, ensuring that all students not only comprehend the content but also feel empowered to contribute to environmental sustainability and learn to regulate their eco-anxiety. Teachers would have the opportunity to attend professional development courses based on research, reflect on their personal and technical habits, transform them, be role models for their students and build professional learning communities. Schools are transformative with a high quality of climate change education.

Social implications – Climate change demands urgent transformations in our consumption, energy generation and the construction of resilient cities. Education is pivotal in empowering environmentally conscious citizens. It fosters environmental awareness, develops skills to tackle climate challenges, promotes active citizenship, advocates for sustainable lifestyles and encourages innovation in clean technologies. By connecting people with nature, education strengthens environmental responsibility. Additionally, it equips society to advocate for sustainable policies and take action for the environment. A comprehensive educational approach is essential to forge global consensus and effectively address climate change.

Originality/value – By systematically evaluating teacher experiences and the impact on their personal and professional lives through detailed survey data, the study provides valuable insights into effective educational



strategies for climate change awareness. Additionally, it highlights practical applications and behavioural changes among educators, contributing to the broader discourse on environmental education.

Keywords Teacher professional development, Climate change education, Inquiry-based pedagogy, Problem-solving learning

Paper type Case study

1. Introduction

The current circumstances facing the planet represent an unprecedented challenge for humanity. Latin America is a highly vulnerable region to the impacts of climate change, which are already evident and have consequences on food security, water quality, biodiversity, public health, and groups of people migrating between countries in search of a better quality of life, among other areas (Bárcena *et al.*, 2020).

Climate change education (CCE) is a key tool to address these challenges and prepare current and future generations to face a changing world. This relatively recent field of education has been designed “to equip students with the knowledge, skills, and competencies that will make them the agents of change much needed to deal with the climate change crisis” (Nepraš *et al.*, 2022). Education on climate change involves acquiring knowledge in the midst of risk, uncertainty, and swift transformations. It has been described as well to have the potential to stand out as one of the most potent and enduring measures for mitigation (Azevedo and Marques, 2017).

Unfortunately, it has been reported that the insufficient readiness and confidence of teachers to tackle CCE hinder the endeavours to introduce climate change education into K-12 schools (Wise, 2010). Research indicates that teachers often feel unprepared to cover the content, express concerns about potential political repercussions, and worry about presenting arguments for and against climate change in a balanced manner due to a lack of understanding of the scientific consensus (Hestness *et al.*, 2014; Plutzer *et al.*, 2016; Waldron *et al.*, 2019; Wise, 2010). In addition, teachers’ personal values and motivations influence their practices in CCE, creating a barrier to effective teaching (Henderson and Drewes, 2020).

For these reasons, an effective approach to unlocking the potential of climate change education in K-12 settings involves, among other strategies, implementing teacher professional development to alleviate hesitations and integrate climate change into their curricular standards. Working towards the empowerment of teachers in Latin America involves strengthening conceptual understandings of climate science, integrating inquiry-based pedagogy with problem-solving learning, promoting collaboration among teachers, and creating international dialogues to ensure the best implementation methods in their educational realities.

According to UNESCO (2023), in an increasingly complex and interconnected world with a real, existential threat such as climate change, there is a growing call for education to enable individuals, as agents of change, to acquire knowledge, skills, values, and attitudes that lead to a green transition of our societies, as enshrined in SDG Target 4.7, and, indeed, in the entire 2030 Agenda.

In this article, the process of design and implementation of two teacher professional development programmes, one in Chile and the other in Mexico are described. These programmes aim to build capacities in teachers, to educate students about climate change and foster critical questioning. It also aims to inspire authentic action within school communities related to mitigation, and adaptation to climate change. The initial impact on teachers’ personal and professional lives is also reported, through the analysis of the answers of a survey, aimed at collecting teachers’ experiences after completing the course. Also, their feedback on course activities, content and format, and their expectations of future topics for deepening their understanding was analysed.

2. Teacher professional development on climate change education (CCE)

The significance of teacher professional development in Climate Change Education (CCE) cannot be overstated, as it equips educators with the knowledge and skills necessary to address one of the most pressing global challenges. [Monroe *et al.* \(2017\)](#) conducted a systematic review to determine effective strategies for CCE, identifying key elements such as focusing on personally relevant information, engaging teaching methods, deliberative discussions, interactions with scientists, addressing misconceptions, and implementing school or community projects. These components highlight the need for CCE programmes to be both engaging and contextually relevant, ensuring that teachers can connect the material to their personal and professional contexts.

However, many K-12 teachers avoid teaching climate change due to discomfort with the subject or perceived irrelevance to their curriculum ([Wise, 2010](#); [Ennes *et al.*, 2021](#)). [Ennes *et al.* \(2021\)](#) study revealed that time constraints are the primary barrier to participating in professional development programmes. This suggests that integrating CCE into existing professional development frameworks and creating time-efficient opportunities are crucial for increasing teacher participation. Moreover, those confident in their knowledge of climate change were less likely to perceive administrative support and interest as barriers, indicating that enhancing teacher confidence through professional development can mitigate some participation obstacles.

[Li *et al.* \(2019\)](#) emphasizes the importance of professional development in enhancing teacher efficacy regarding climate change education. Their study applied educative curriculum guidelines and efficacy strategies to develop secondary instructional resources, demonstrating that targeted professional development can significantly boost teachers' confidence and pedagogical content knowledge. This approach is particularly beneficial for educators lacking prior experience in teaching climate change, providing them with both the content knowledge and teaching strategies needed to integrate this topic into their curriculum effectively.

[Tserej *et al.* \(2024\)](#) underscore the benefits of involving teachers in authentic research as part of their professional development. Their Shade our Schools—Leaves are Cool! citizen science project engaged teachers in real scientific research, enhancing their content knowledge and confidence to teach about climate change. This approach aligns with the idea that active participation in research can significantly improve teachers' instructional practices and student outcomes in CCE. This project, on the other hand, not only improved teachers' knowledge but also provided them with practical tools to engage their students in meaningful climate change education ([Shea *et al.*, 2016](#)), which confirms the importance of making CCE locally relevant, allowing teachers to see the direct impact of their instruction on their communities.

In synthesis, effective CCE professional development programmes should incorporate active participation, identification, and action on daily work challenges, and involve teachers in the inquiry and innovation process. Sharing knowledge and experiences among educators and community members fosters a collaborative learning environment. The availability of mentors or coaches is also crucial, providing guidance and support throughout the learning process and accompany them for implementation and build confidence with new contents and methodology. Immersing teachers in a coherent pedagogical framework that addresses local needs ensures that the professional development is relevant, practical and situated.

3. Climate change education and teacher training in Chile and Mexico

Climate change education (CCE) in Latin America is an evolving field characterized by a blend of participatory approaches and expert-driven literacy. [Prosser Bravo *et al.* \(2022\)](#)

highlight the tension between these traditions, underscoring the importance of including participant perspectives in educational interventions. Their study involving 145 participants in Chilean school programmes revealed predominant negative emotions towards climate change, yet also a significant degree of hope for the future. Participants exhibited confusion between climate and environmental actions, with a preference for local over national initiatives. The study concluded the necessity of integrating experiential expertise into CCE to actively incorporate participant opinions and perspectives.

One prominent initiative in the region is the International Conference on Climate Change Education, organized annually over the past six years among Latin American countries, including Chile, Mexico, and Colombia. This conference, involving a range of governmental and non-governmental organizations, facilitates the exchange of knowledge and best practices in CCE, promoting a collaborative approach to addressing climate change through education.

In Chile, CCE is not yet a formal part of the national curriculum set by the Ministry of Education, which instead emphasizes sustainability as a cross-cutting topic from early childhood through secondary education. The Ministry of the Environment supports this through the National System of Environmental Certification of Educational Establishments (SNAE), certifying schools that implement environmental education strategies. However, these efforts from different ministries lack integration. The Scientific Inquiry Program for Science Education (ICEC), launched in 2015, is another key initiative promoting scientific inquiry in education. This programme also includes elements of CCE, organizing international conferences and professional development activities to enhance science teaching. Despite these efforts, the impact remains fragmented, with various initiatives from other ministries and NGOs not fully integrated or evaluated.

In Mexico, the 2023 educational reform marked a significant shift by formally including climate change in the primary education curriculum, focusing on definitions, explanations, and student projects on climate adaptation and mitigation. Previously, the national curriculum prioritized environmental education over CCE. The private organization INNOVEC has been instrumental in advancing CCE through STEM + education based on the Sustainable Development Goals of Agenda (2030). INNOVEC's programmes aim to foster a deep understanding of scientific phenomena and develop skills and attitudes to address global challenges. Their Climate Change Education programmes, in collaboration with the Climate Education Office – OCE, and other international partners, have made significant strides in primary and secondary education, forming alliances with state governments and institutions for implementation and funding.

Despite these efforts, challenges remain in ensuring cohesive and comprehensive CCE across Latin America. The need for integration between various initiatives and consistent evaluation of their impact is evident. Educational leaders and stakeholders play a crucial role in motivating and supporting teachers in their professional learning, ensuring that CCE is effectively incorporated into educational practices. By fostering collaboration, providing mentorship, and developing locally relevant pedagogical frameworks, CCE can be more effectively integrated into the educational landscape, empowering teachers and students to address climate change proactively.

Considering the diverse initiatives and ongoing efforts to integrate climate change education across Latin America, this study aims to contribute to the field by describing the design process of two teacher professional development programmes on Climate Change Education in Chile and Mexico. By examining their initial outcomes on teacher practices, the study seeks to provide insights into the effectiveness of these programmes and offer recommendations for enhancing CCE efforts.

4. Methods

The methodology of this study involved a systematization of the design and implementation processes of two teacher professional development programmes focused on Climate Change Education in Chile and Mexico. The initial phase documented the design process, which encompassed identifying the educational needs related to climate change in both countries, developing the curriculum, and implementing the courses. This phase included collaboration with educational experts, curriculum developers, and climate change specialists to ensure contextual relevance and scientific accuracy of the programmes.

The programmes were structured using a variety of pedagogical strategies aimed at enhancing teachers' understanding of climate change and equipping them with the necessary tools to effectively teach the subject. Key components of the curriculum included interactive lectures, hands-on activities, collaborative projects, and the integration of local and global case studies on climate change. Emphasis was placed on active learning and critical thinking to foster a deep understanding of climate science and its implications for both the environment and society.

Following the design and implementation of the courses, an evaluation phase was conducted. This phase involved surveying a sample of 115 teachers from both Chile and Mexico, representing 5% of the total number of graduates from each programme. The sampling strategy aimed that the findings would be generalizable to the larger population of programme participants.

The survey was administered online, ensuring accessibility to teachers regardless of their geographical location. The questionnaire comprised 21 questions, designed to capture a comprehensive evaluation of the teachers' experiences with the professional development programmes. The questions were divided into overall satisfaction with the programme, perceived improvements in climate change knowledge, the impact of the programme on teaching practices, and broader effects on personal and professional lives. It also included two open questions about their general feedback to the programme and topics for further exploration.

To gather both qualitative and quantitative data, the survey included a mix of closed-ended questions (using Likert scales) and open-ended questions. Closed-ended questions provided measurable data on specific aspects of the programme, such as the clarity of instructional materials, the relevance of the content, and the effectiveness of the teaching strategies employed. Open-ended questions allowed respondents to provide more detailed feedback, offering insights into their personal experiences and any unanticipated outcomes of the programme.

Data analysis involved descriptive statistics to summarize the survey responses, providing an overview of the teachers' evaluations, and the constant comparative method (Bogdan and Biklen, 2003) for the qualitative responses.

The study relied on self-reported data from teachers after they had completed the courses. This approach was chosen because it allowed for a direct assessment of teachers' understanding and experiences. However, it is important to acknowledge the limitations inherent in self-reported data, such as the potential for response bias.

The findings are intended to inform future iterations of the professional development courses, with the goal of enhancing the quality of Climate Change Education in Latin America, and empowering teachers to effectively educate their students on this critical global issue.

5. Findings

5.1 Systematization of the design and implementation processes of two teacher professional development programmes focused on Climate change Education in Chile and Mexico

5.1.1 Systematization of the course in Mexico: ALEC project. In Mexico, INNOVEC and the Office for Climate Education (OCE) initiated a collaboration in 2020 to promote Climate

Change Education through the *América Latina para la Educación Climática*–ALEC project. This alliance includes national and international institutions, such as the Education Secretariats of several states, Science and Technology Councils, companies, and international foundations like Siemens Stiftung, as well as NGOs like the Mario Molina Centre. In 2023, INNOVEC, in collaboration with OCE specialists and the University of Chile, conducted both in-person and virtual training for teachers and trainers. The project was implemented in schools between 2023 and 2024 in various states.

The hybrid course consists of 16 h of in-person training and 4 h of virtual masterclasses. They cover topics such as Introduction to Climate Change, Oceans and Cryosphere and Climate Change, and Soils and Climate Change.

Since 2023, the course has been conducted in various states of Mexico, training 1,089 teachers in “Introduction to Climate Change,” 901 teachers in “Oceans and Cryosphere,” and 37 teachers in “Soils and Climate Change.” Additionally, virtual masterclasses with international participation have engaged thousands of teachers and educational figures.

5.1.1.1 Objective. The objective of the course was to provide teachers and students with the tools to understand climate change, strengthening their capacity for action in adaptation and mitigation strategies. A systemic model is employed, allowing its application in schools across Mexico. This model includes the development of educational materials, course design, teacher training, coordination and monitoring, project management, dissemination, and the creation of a community of teachers and climate change education specialists.

5.1.1.2 Principles. The course aims to generate a clear understanding of climate change within the educational community and society, empowering students to become agents of change in their communities and transforming schools into engines of community change. It trains teachers to address climate change from a scientific perspective, creating networks of committed teachers and students, and developing responsible citizens who are aware of their social and natural environments.

5.1.1.3 Course design. Educational resources for the ALEC project, developed by the Office for Climate Education specialist on Intergovernmental Panel on Climate Change (IPCC) reports, were adapted to the Mexican context by INNOVEC and the Mario Molina Centre. Two manuals were developed: “Introduction to Climate Change” and “Oceans and Cryosphere.” These resources incorporate the 5E learning cycle to structure lessons.

Initial training involved face-to-face and virtual workshops. Training protocols were designed for the modules “Introduction to Climate Change” and “Oceans and Cryosphere,” with 16 h of in-person and 4 h of virtual sessions, focusing on inquiry methodology and project-based learning.

Local programme organization and monitoring were carried out by Education Departments and Science and Technology Councils, with occasional support from INNOVEC and OCE. Resulting projects included school gardens, solar heaters, biodigester stoves, and chemical-free fertilizers.

The training workshops are conducted in collaboration with local institutions, addressing regional climate change issues. Adaptation and mitigation projects developed by students and teachers aim to address and contribute to solving community problems.

Active methodologies such as inquiry and project-based learning are incorporated to facilitate the understanding of climate phenomena and promote the active participation of students and teachers in the educational process.

Training includes a session on “what we can do” for climate action, analysing CO₂ emissions, and proposing sustainable alternatives. Community-involved projects for awareness, adaptation, and mitigation are encouraged, fostering responsible societal change.

The ALEC project is implemented in six Mexican states, involving 341 trainers and 2,027 teachers, and impacting 66,601 students. Local partnerships have facilitated the adaptation, financing, and scaling of the project, enhancing awareness through social and local media.

5.1.2 The Climate change education – CCE programme in Chile. The design and initial implementation of the Climate Change and Sustainable Development Education Program in Chile took place between 2020 and 2021 and keeps going on, spearheaded by the Inquiry-based science education programme (ECBI) and the Inquiry Science for Science Education – ICEC programme from Chilean Ministry of Education. This initiative, known as the “Climate Change Education Project–CCE” was a cooperation project involving Siemens Stiftung and the University of Chile. The project was structured into four phases. In the first phase, five countries from the RED STEM LATAM network participated, with 125 teachers sharing their interests and projects on waste management and the environment. The second phase involved the analysis of documents, videos, and an international discussion to identify six thematic areas and 30 subtopics related to climate change and sustainability. The third phase focused on creating and validating a prototype of educational resources, resulting in 18 new modules for teachers and students.

The fourth phase implemented a 12-week online learning course, involving 25 pilot teachers. The programme also emphasized collaboration with institutions such as INNOVEC-Mexico, Universidad La Sabana – Colombia, and Universidad San Francisco de Quito – Ecuador to ensure a broad Latin American reach a professional development programme and to enhance and share new pieces of educational materials.

5.1.2.1 Objective. The primary objective of the programme was to develop the necessary capacities in natural science teachers and educators from other subjects who wished to join. These educators, in turn, were expected to convey these skills to their students and the broader community to address the escalating climate crisis.

5.1.2.2 Principles. The programme operated under the assumption that collaboration is crucial for addressing the climate crisis and environmental protection. It was developed through cooperation between pedagogical teams from Mexico, Chile, Colombia, Ecuador, and Peru. This co-construction was led by a committee composed of members from the Institute of the University of Chile’s Advanced Studies in Education (CIAE), the ECBI Program, the Centre for Climate and Resilience Research (CR2) from the University of Chile, the Chilean Ministry of Education, OCE-Paris, Siemens Stiftung, and Siemens Caring Hands.

5.1.2.3 Design process. The first step involved diagnosing and analysing environmental situations from the teachers’ perspectives. A closed-question questionnaire was distributed to 50 educators from five countries, identifying the main environmental issues affecting their local contexts. Teachers also reported on climate action initiatives in their schools and the tools and instruments used for their projects. This data led to an international roundtable discussion with pedagogical coordinators and climate change specialists, identifying key concepts such as social responsibility for the environment, climate politics, and local environmental knowledge.

Based on the territorial and document analysis, six thematic core axes for the professional development programme were identified: Climatic Systems, Climates, Ecology, Human Ecology, Climate Change/Global Warming, and How to Mitigate Climate Change. These axes were enriched with audio-visual materials from international conferences and validated through collaborative discussions.

A prototype of educational resources was created and validated to support climate change and sustainable development education. These resources, designed for both synchronous and asynchronous use, integrated scientific inquiry and project-based learning methodologies. The educational resources, covering levels from preschool to secondary education, were validated by 25 teachers and made available under a Creative Commons license.

The e-learning course was structured with a total of 90 h, divided into modules on climate change and sustainable development and pedagogical tools. The course utilized tutors who supported teachers in their learning process by participating in forums and organizing

individual tutoring sessions. These tutors guided teachers in developing final projects tailored to their local contexts. The course aimed to equip educators with the skills to design and implement climate change lessons using inquiry-based and project-based learning methodologies. A pilot course was conducted, with subsequent implementations for Chilean and Colombian teachers.

The course has been implemented twice after piloting, involving teachers from Chile and Colombia. To address different contexts, the programme adopted a systemic approach, forming partnerships with various actors and ensuring clear, shared goals. Teacher collaboration was emphasized to align educational levels and promote interdisciplinary learning, enabling students to address local environmental issues. The course also aimed to influence participants' personal habits through inquiry-based activities and project presentations, fostering new understanding of conversations and actions in their communities.

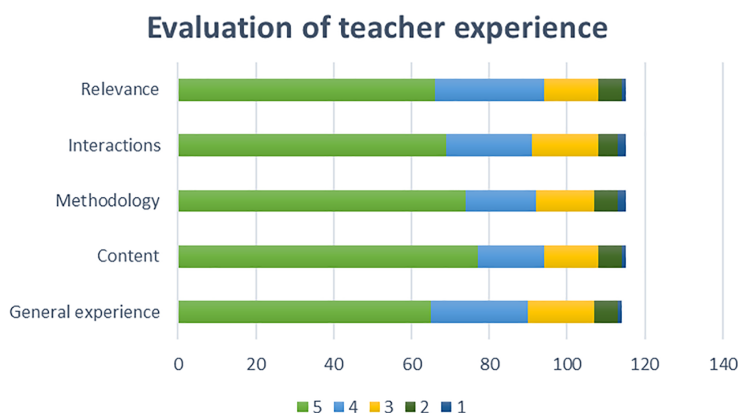
5.2 Survey responses and analysis

The survey was answered by 115 respondents, representing 5% of the course graduates in each country. Among the participants, 64.4% completed the course in 2023, 27.8% in 2024, and the rest between 2023 and 2020. Participants were mostly high school teachers (60%), and then primary school teachers (23.5%), and other roles (16.5%). The teaching experience of participants ranges from 1 to 40 years.

Participants rated their experience in the programme, on a scale from 1 (very bad) to 5 (very good). They evaluated the quality of content, methodologies used, peer and facilitator interactions, and the alignment of content with the local context. Results can be seen in [Graph 1](#).

Overall, the ratings across all categories were predominantly positive, with the majority of participants rating their experiences as 4 or 5. This suggests that the course was well-received and seemed effective by most participants. Participants valued its content, methodology, interactions with peers and tutors, and relevance. The less valued area was relevance to their context, and the most valued was scientific content.

Regarding the application of course learning in their school classes, 97.4% of the participants reported implementing the knowledge gained, while 2.6% did not. Additionally, 78.3% stated that the course effectively raised students' awareness about climate change and



Source(s): Authors' own work

Graphic 1.
Evaluation of the
teacher experience in
the programme

facilitated collaborative projects focused on mitigation, adaptation, or regeneration. Meanwhile, 20.9% partially agreed, and 0.9% did not find the course helpful in this regard.

Examples of how the course influenced teaching practices or the development of climate-related projects include educational activities for children aged 6 to 12, monthly scientific experiments, and learning experiences promoting the scientific method. Sustainable innovation projects with a focus on sustainability were also noted. Efforts to raise awareness about the water cycle and conservation, adaptation to climate change through reforestation and energy efficiency projects, and school gardens and composting were highlighted. Interdisciplinary and community programmes promoting collaboration and holistic education were significant, along with the use of technology and educational materials to enhance learning.

The course personally sensitized 92.2% of teachers, with 7.1% partially affected and 1.7% not influenced. It increased climate change knowledge for 94.8% of teachers, while 5.2% found it partially helpful. Post-course, 87% of participants reported changes in personal habits, such as consumption and transportation, due to heightened climate change awareness, with 11.3% partially changing and 1.7% not changing. The course influenced 91.3% of teachers to take at least one daily action to reduce CO₂ emissions, while 8.7% were not influenced. Actions included reducing car use, carpooling, cycling, walking, conserving water, recycling, rainwater harvesting, reducing energy consumption, using renewable energy, consuming local products, creating home gardens, reducing meat consumption, avoiding disposable products, donating clothes, and recycling waste.

A significant 93% of participants indicated that the course helped them develop critical thinking about climate change and its implications, with 7% partially agreeing. Post-course, 17.4% of teachers formed or joined communities of educators from their cohort, 50.4% connected with colleagues at work, and 40% did not join any climate education-focused groups. The course influenced 82.6% of teachers' attitudes towards professional development, with 17.4% partially influenced.

In terms of personal actions taken to reduce CO₂ emissions, 91.3% of teachers declared they were involved in at least one action. The most mentioned action was the reduction in the use of their car. Most of the teachers declared changing from car to bicycle, and others sharing rides with colleagues. Other actions were related to reduction of meat consumption and being more conscious about other kinds of consumption such as plastic or single-use products.

The qualitative feedback from teachers regarding the course reveals a diverse set of responses, focusing primarily on the course's duration, format, content, and post-course support. A significant number of participants emphasized the need for extending the course duration, as they felt the current timeframe was too rushed, especially for in-depth exploration and practical experiments (mostly teachers from Mexico). Many suggested that the course should be conducted during favourable weather conditions to facilitate outdoor activities with students.

There was a call for more frequent sessions to reach a broader audience of educators, with recommendations for involving other stakeholders such as school directors, supervisors, and parents. Teachers also highlighted the importance of clearer communication about the post-course programme and commitments, as some participants were still uncertain about their responsibilities.

The preference for in-person classes and practical workshops was strongly voiced, with suggestions to include more hands-on activities like soap making from recycled oil, organic pest control, and sustainable energy device creation. Participants appreciated the content but requested broader and more specialized material, including linking with experts for better implementation of strategies such as clean energy and urban gardening.

Suggestions for improving the course's impact included fostering collaboration with NGOs and experts to enrich the course with diverse perspectives and experiences, enhancing follow-up on teachers' activities with students, and tailoring the content to local contexts. Additionally, participants expressed a need for more structured sharing of materials, systematic follow-up, and official validation of the course to ensure its recognition and support for continuous professional development. Overall, teachers found the course valuable but sought more duration, practical engagement, and comprehensive support to maximize its effectiveness in promoting climate change awareness and action within educational communities.

Finally, based on the feedback from participants regarding future topics for deepening their understanding of climate change education, several key areas have been identified for further exploration. Teachers expressed a keen interest in learning strategies to adapt to the inevitable effects of climate change and enhancing community resilience. There is a strong demand for knowledge of alternative energy sources and comprehensive strategies to combat pollution in the hydrosphere, lithosphere, and atmosphere.

Participants highlighted the importance of understanding water conservation and hydroponics, utilizing technology to mitigate climate change, and developing projects focused on environmental and water care. They expressed a need for practical examples and new project development, particularly in agro-food production and the sustainable use of clean energy. Specific topics such as river and reef conservation, food security, and the impact of climate change on natural resources were also noted.

Further interests include the integration of organic pest control, sustainable wastewater treatment, and the use of compost in school gardens. Teachers emphasized the need for region-specific examples and the application of ecosystem care based on local contexts. They also suggested workshops on constructing water harvesting systems and cultivating fruits and vegetables at home, with a focus on minimizing water usage.

Additionally, there is a call for addressing emotional responses to climate change, carbon footprint reduction, and actionable measures to combat climate change at home.

Recycling and composting directed at parents and teachers, forest formation projects, and the STEAM methodology were highlighted as crucial areas. Teachers requested in-depth exploration of recyclable materials management, waste-burning elimination, and reef conservation. There is a significant interest in the effects of clouds, the collateral damage of technology use, and the pros and cons of alternative energy.

The importance of reforestation, preservation of endemic species, waste management, natural fertilizers, and the broader context of clean energy, sustainable development, and innovative projects were reiterated.

The feedback included requests for practical workshops on the 3 Rs (reduce, reuse, recycle), understanding water and carbon cycles, addressing increasing droughts and species extinction, and initiating climate action in schools. Innovative solutions such as green roofs and solar panels, as well as tackling deforestation and the impact of industrial pollution, were mentioned. Teachers emphasized the importance of activism, sustainable art, and integrating climate change topics into classroom activities through playful and interactive platforms.

The feedback from teachers reveals a strong commitment to deepening their understanding of climate change education, highlighting their desire to learn about strategies for adaptation, alternative energy sources, pollution combatting, water conservation, and sustainable practices. They expressed interest in practical projects, region-specific examples, and innovative solutions. This demonstrates a dedicated and proactive approach among teachers, eager to expand their knowledge and implement effective climate action in their communities and classrooms.

6. Discussion and implications

The reviewed literature highlights the crucial importance of Climate Change Education and teacher professional development in this field to address current climate challenges. The findings of this study, which describe the implementation of teacher professional development programmes in Mexico and Chile, provide valuable insights into the effectiveness and relevance of such initiatives.

Firstly, the analysed teacher professional development programmes address concerns raised in the literature, such as teachers' lack of preparation and confidence to teach about climate change. Both programmes focus on strengthening teachers' scientific understanding of climate change, as well as providing innovative pedagogical strategies to effectively integrate the topic into the curriculum. This reflects the emphasis on teacher training as agents of change in climate education, as suggested in the literature (Monroe *et al.*, 2017; Li *et al.*, 2019).

The teacher professional development programmes on Climate Change Education in Mexico and Chile have showcased comprehensive approaches, entailing collaboration among diverse stakeholders and the amalgamation of scientific content with pedagogical methodologies. In Mexico, the ALEC Project adopts a hybrid approach, blending in-person training with virtual masterclasses, whereas in Chile, the CEE Program employs a 12-week online course format. Both initiatives underscore active learning methodologies and the contextualization of content to local settings.

The structure and design of the courses in Mexico and Chile also reflect best practices identified in the literature. For instance, both programmes incorporate active learning approaches, such as inquiry-based and project-based learning, which have been identified as effective in engaging students in climate education (Tserej *et al.*, 2024). Additionally, the programmes are tailored to local and contextual needs, resonating with the call for contextual relevance in the literature (Prosser Bravo *et al.*, 2022).

Libertad Secondary School, for example, is in the town of Jesus, in Tlaxcala, Mexico. It was established in the year 2000 and currently has an enrolment of over 200 students, most of whom come from the surrounding areas near Jesus. The main occupations of the local community include agricultural work, construction, commerce, and factory employment. The ALEC Project began at Libertad Secondary School in 2023. Initially, the "Introduction to Climate Change" module was implemented, and in 2024, the "Soils and Climate Change" module followed. With the training received, the teachers from different disciplines integrated the course topics into their respective subjects and encouraged third-grade students to teach first and second-graders. The first-grade geography teacher also joined the project, covering soil types in Tlaxcala and Mexico. One of the topics was the impact of consuming processed foods or foods produced in regions far from where the students live. Understanding the importance of local food consumption in reducing carbon emissions, the students continued to promote the use of fruit gardens at the school.

In Chile, teachers enrolled in the e-learning course "Education on Climate Change and Sustainable Development" were encouraged to design and document projects in a logbook that addressed a local issue specific to their school, as a requirement for passing the course. Projects included topics such as water conservation, green spaces, renewable energy generation, and recycling waste and clothing. Upon completing the course, teachers could voluntarily register for a second phase that provided support in implementing these projects.

A significant finding of this study is the high rate of teacher participation in implementing the acquired knowledge in their classrooms and promoting collaborative projects focused on climate change mitigation and adaptation among students and families around their local situations observed by students. Developing curiosity, critical thinking, collaboration, and communication, as well as building character in each student and promoting action to achieve a sustainable life for each family involved in the project, became the main aim for

teachers. This direct classroom action reflects the potentially transformative impact of professional development programmes on teaching practice (Wise, 2010; Ennes *et al.*, 2021; Henderson and Drewes, 2020).

Participants from both programmes have reported the immediate implementation of acquired knowledge in their classroom settings, signifying the direct and practical application of course insights. Teachers in both countries have observed a heightened awareness among students concerning climate change, coupled with successful executions of collaborative projects focused on mitigation, adaptation, and environmental rejuvenation. Furthermore, participants have provided valuable feedback regarding various facets of the courses, encompassing duration, format, content, and post-course support.

Recommendations for enhancement include extending course durations, incorporating more hands-on activities, and bolstering collaboration with local stakeholders. The process of implementation in schools of the inquiry methodology to understand the causes and effects of climate change gives a clue, as well as the design of interdisciplinary pedagogical innovation and climate action projects by socio-scientific problems observed by students and teachers around schools promote engagement in other actors from the community which allows relating climate education globally with SDG-2030. Educating people about climate change is the responsibility of all. Scientists and educators must work together to provide new methodologies as well as research-based resources and materials to help teachers K-12 implement this new approach in the classroom, and stakeholders must take action to introduce the topic into the school curriculum.

7. Conclusions

While the ALEC Project in Mexico and the ECC Program in Chile have received positive feedback from participants regarding their perceived effectiveness, it's essential to acknowledge that these assessments are based on self-reports from teachers. As such, they provide valuable insights into the initial outcomes and perceived impact of the programmes. However, these self-reports also represent a limitation of the study, as they rely on subjective perceptions rather than objective measures of effectiveness. Therefore, while the feedback from participants highlights areas for improvement and suggests promising outcomes, further research utilizing experimental evaluation methods would be beneficial to corroborate these findings and provide a more comprehensive assessment of the programme's impact on Climate Change Education. Addressing these suggestions for improvement and conducting future research to evaluate the programmes' effectiveness more rigorously will be crucial in advancing Climate Change Education Professional Development in the Region.

Additionally, it is necessary to expand participation throughout the Latin American territory and interact with other countries and research institutions to ensure the inclusion of all interested parties in training on Climate Change Education and Sustainable Development, from early childhood to adulthood. Collaboration is key to addressing the climate crisis and environmental care and protection. Therefore, positioning effective cooperation in the Latin American region is a significant exercise in improving sustainable human development.

References

- Azevedo, J. and Marques, M. (2017), "Climate literacy: a systematic review and model integration", *International Journal of Global Warming*, Vol. 12 Nos 3/4, pp. 414-430, doi: [10.1504/ijgw.2017.10005893](https://doi.org/10.1504/ijgw.2017.10005893).

- Bárcena, A., et al. (2020), *The Climate Emergency in Latin America and the Caribbean: The Path Ahead – Resignation or Action?* ECLAC Books, No. 160 (LC/PUB.2019/23-P), Economic Commission for Latin America and the Caribbean (ECLAC), Santiago.
- Bogdan, R.C. and Biklen, S.K. (2003), *Qualitative Research for Education: an Introduction to Theories and Methods*, 4th ed., Pearson, New York, NY.
- Ennes, M., Lawson, D.F., Stevenson, K.T., Peterson, M.N. and Jones, M.G. (2021), “It’s about time: perceived barriers to in-service teacher climate change professional development”, *Environmental Education Research*, Vol. 27 No. 5, pp. 762-778, doi: [10.1080/13504622.2021.1909708](https://doi.org/10.1080/13504622.2021.1909708).
- Henderson, J. and Drewes, A. (2020), *Teaching Climate Change in the United States*, Routledge, London.
- Hestness, E., McDonald, R.C., Breslyn, W., McGinnis, J.R. and Mouza, C. (2014), “Science teacher professional development in climate change education informed by the next generation science standards”, *Journal of Geoscience Education*, Vol. 62 No. 3, pp. 319-329, doi: [10.5408/13-049.1](https://doi.org/10.5408/13-049.1).
- Li, C.J., Monroe, M.C., Oxarart, A. and Ritchie, T. (2019), “Building teachers’ self-efficacy in teaching about climate change through educative curriculum and professional development”, *Applied Environmental Education and Communication*, Vol. 20 No. 1, pp. 34-48, doi: [10.1080/1533015X.2019.1617806](https://doi.org/10.1080/1533015X.2019.1617806).
- Monroe, M.C., Plate, R.R., Oxarart, A., Bowers, A. and Chaves, W.A. (2017), “Identifying effective climate change education strategies: a systematic review of the research”, *Environmental Education Research*, Vol. 25 No. 6, pp. 791-812, doi: [10.1080/13504622.2017.1360842](https://doi.org/10.1080/13504622.2017.1360842).
- Nepraš, K., Strejčková, T. and Kroufek, R. (2022), “Climate change education in primary and lower secondary education: systematic review results”, *Sustainability*, Vol. 14 No. 22, 14913, doi: [10.3390/su142214913](https://doi.org/10.3390/su142214913).
- Plutzer, E., McCaffrey, M., Hannah, A.L., Rosenau, J., Berbeco, M. and Reid, A.H. (2016), “Climate confusion among US teachers”, *Science*, Vol. 351 No. 6274, pp. 664-665, doi: [10.1126/science.aab3907](https://doi.org/10.1126/science.aab3907).
- Prosser Bravo, G., Bonilla, N., Prosser González, C. and Romo-Medina, I. (2022), “Expertos por experiencia en la educación para el cambio climático: emociones, acciones y estrategias desde la perspectiva de participantes de tres programas escolares chilenos”, *Revista de estudios y experiencias en educación*, Vol. 21 No. 45, pp. 232-251, doi: [10.21703/0718-5162.v21.n45.2022.012](https://doi.org/10.21703/0718-5162.v21.n45.2022.012).
- Shea, N.A., Mouza, C. and Drewes, A. (2016), “Climate change professional development: design, implementation, and initial outcomes on teacher learning, practice, and student beliefs”, *Journal of Science Teacher Education*, Vol. 27 No. 3, pp. 235-258, doi: [10.1007/s10972-016-9456-5](https://doi.org/10.1007/s10972-016-9456-5).
- Tserej, O., Sidoti, B., Assael, S., Padolf, A., Bistrain, M., Shen, J. and Feeley, K.J. (2024), “How do teachers learn and engage with climate change? An examination of the shade our schools—leaves are Cool! Citizen science program”, *Citizen Science: Theory and Practice*, Vol. 9 No. 1, pp. 1-14, 2 doi: [10.5334/cstp.619](https://doi.org/10.5334/cstp.619).
- UNESCO (2023), “Climate change education for social transformation: whole-institution approach to greening every school”, available at: <https://www.unesco.org/en/sustainable-development/education/cop28-cce-webinars>
- Waldron, F., Ruane, B., Oberman, R. and Morris, S. (2019), “Geographical process or global injustice? Contrasting educational perspectives on climate change”, *Environmental Education Research*, Vol. 25 No. 6, pp. 895-911, doi: [10.1080/13504622.2016.1255876](https://doi.org/10.1080/13504622.2016.1255876).
- Wise, S. (2010), “Climate change in the classroom: patterns, motivations, and barriers to instruction among Colorado science teachers”, *Journal of Geoscience Education*, Vol. 58 No. 5, pp. 297-309, doi: [10.5408/1.3559695](https://doi.org/10.5408/1.3559695).

Further reading

Gaudiano, E.J.G. and Cartea, P.Á.M. (2020), "Educación para el cambio climático: ¿educar sobre el clima o para el cambio?", *Perfiles Educativos*, Vol. 42 No. 168, pp. 157-174, doi: [10.22201/iisue.24486167e.2020.168.59464](https://doi.org/10.22201/iisue.24486167e.2020.168.59464).

OCE (2020), "El clima en nuestras manos. Océanos y Criosfera", available at: <https://www.oce.global/es/resources/actividades-para-la-clase/el-clima-en-nuestras-manos-oceano-y-criosfera>

UNESCO (2019), "Cambiemos las mentalidades, no el clima. La función de la educación", p. 1, available at: https://unesdoc.unesco.org/ark:/48223/pf0000266203_spa.locale=es

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