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Indigenous educational methods for teaching natural sciences from an intercultural perspective

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ABSTRACT

The article presents research results on Indigenous educational methods that can be integrated into school content, moving towards a didactic approach with an intercultural perspective that favours the teaching and learning processes of natural sciences, which have historically been monocultural and hegemonic. The incorporation of Indigenous educational methods into school education could enable the contextualisation of knowledge within diverse social and cultural contexts. The study adopts a qualitative approach, which, through semi-structured interviews with three Mapuche sages and three traditional educators, inquires about the ways of learning used in Indigenous family and community education. The information was analysed using the content analysis technique. The main results show two educational methods that can be linked to natural science teaching: 1) *Inatuzugu*, which is learning mediated by observation and experimentation; and 2) Experiential learning, which is related to learning in real situations. The main conclusions emphasise the importance of integrating Indigenous educational methods into natural science teaching, thereby enabling teaching and learning processes with an intercultural perspective. This approach offers pedagogical practices with cultural significance that are relevant to Indigenous educational contexts.

Keywords: natural sciences; cultural diversity; teaching method; sciences didactics; interculturality.

Métodos educativos indígenas para una didáctica de las ciencias naturales en perspectiva intercultural

RESUMO

O artigo apresenta resultados de investigação sobre os métodos educativos indígenas que podem ser articulados com os conteúdos escolares, para a transição para

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a didática numa perspetiva intercultural, que favorece os processos de ensino e aprendizagem das ciências da natureza, que historicamente foram monoculturais e hegemónicos. A incorporação de métodos educativos indígenas na educação escolar permitiria contextualizar o conhecimento em contextos de diversidade social e cultural. O estudo adota uma abordagem qualitativa que, através de entrevistas semiestruturadas aplicadas a três sábios Mapuche e a três educadores tradicionais, consulta sobre as formas de aprendizagem utilizadas na educação familiar e comunitária indígena. A informação foi analisada com a técnica de análise de conteúdo. Os principais resultados mostram dois métodos educativos que podem ser articulados com a didática das ciências naturais: 1) Inatuzugu, refere-se à aprendizagem mediada pela observação e experimentação; e 2) Aprendizagem experiencial, relacionada com a aprendizagem em situações reais. As principais conclusões destacam a urgência de articular os métodos educativos indígenas à didática das ciências da natureza, para viabilizar processos de ensino e aprendizagem com uma perspetiva intercultural, oferecendo práticas pedagógicas com significado cultural territorialmente relevante em contextos educativos indígenas.

Palavras-chave: ciências naturais; diversidade cultural; método de ensino; didática das ciências; interculturalidade.

INTRODUCTION

Currently, both globally and locally, school education systems have highlighted the importance of natural science education, especially in the context of the environmental crisis affecting the planet (Castillo-Retamal & Cordero-Tapia, 2019). Thus, the teaching of these sciences has been consolidated in educational discourses as a key tool for educating new generations with conscious and responsible approaches to the environment (Chadwick & Bonan, 2018). This teaching is proposed as a strategy that, in the short, medium, and long term, can contribute to mitigating environmental crises and promoting ecological awareness in children and young people in Indigenous and intercultural contexts (Crespo, 2020). This overview highlights the importance of natural science education in promoting effective actions for environmental sustainability through school education. Etymologically, taken from the Greek, didactics (*didaskein*) refers to the art of teaching, instructing, explaining, and demonstrating knowledge of another subject. At the same time, taken from Latin, the word didactic (*discere* and *docere*) refers to the art of teaching and learning (Casasola, 2020). In this context, didactics in teaching and learning processes is defined as the set of procedures and strategies used by teachers to facilitate the construction of knowledge around a particular school content, which, in theory, should be contextualised and respond to the educational realities of the territories in which the schooling process takes place.

In this sense, school educational contexts have historically been characterized by being monocultural and hegemonic, with a Western Eurocentric bias, and have been rooted in pedagogical practices in general and the teaching of natural sciences in particular. This didactic has been characterized as traditional in nature, drawing from a banking education approach (Freire, 2021). In other words, the teacher plays the role of presenter, and the students adopt a passive role in the educational process, where the focus is centred on transferring information from fragmented disciplinary content that is foreign to the students' sociocultural context. This is how new generations of Indigenous and non-Indigenous children and young people must memorise this school content without giving them a useful and practical meaning for their development in society. In this way, these practices and the use of hegemonic didactics that assign students with a lower social value increase in Indigenous educational contexts without considering that, in these territorial spaces, there is *per se* ancestral knowledge about the relationship between humans and their natural environment, for the protection and conservation of tangible and intangible beings that coexist in a given physical and spiritual space (Arias-Ortega & Previl, 2023). However, in the school environment, these Indigenous spaces and knowledge are often denied and made invisible by teachers, who employ a hegemonic Eurocentric-Western didactic approach (Villarroel, Arias-Ortega, & Quintriqueo, 2022). Thus, problems associated with how school knowledge and skills are taught emerge, which, in the school setting, are based on monocultural teaching methods that are alien to the ways of learning in Indigenous contexts. We maintain that Indigenous teaching and its incorporation into the school environment can contribute to the protection and care of the natural environment from a culturally relevant perspective that can be enriched by incorporating teaching strategies present in Indigenous family education into the teaching of natural sciences.

From this perspective, we argue that offering decontextualised natural science teaching that fails to consider students' prior knowledge has a negative impact on their learning. This happens because the hegemonic and decontextualizing approach generates disinterest in the topics addressed in the subject, as they are perceived as alien to reality. As a result, superficial and rote learning are favoured, lacking meaning and connection to their environment (Villarroel, Arias-Ortega, & Quintriqueo, 2022). This is a consequence of the epistemological tensions generated by the epistemic hierarchy, which places Western, Eurocentric knowledge above local and/or Indigenous knowledge in schools' natural science curricula. In the case of Chile, the Chilean school education system has historically been based on Western Eurocentric

knowledge (Dietz, 2018; Sartorello, 2021; Battiste, 2022); therefore, it has denied, made invisible, and omitted Indigenous knowledge and wisdom. The above resulted from the civilising processes carried out through the establishment of the school (Mansilla, 2020), whose primary objective was to consolidate the nation-state project by eliminating the Indigenous element from the population. Thus, the use of the vernacular language was forbidden, and the Indigenous episteme was delegitimised (Arias-Ortega, Villarroel, & Sanhueza-Estay, 2023) to consolidate monolingual Western Eurocentric thinking as universal knowledge, resulting in a progressive loss of Indigenous knowledge and wisdom.

The objective of this article is to present research results that identify Mapuche educational methods that can be integrated into the teaching of natural sciences in school education.

DIDACTICS OF NATURAL SCIENCES IN THE CHILEAN SCHOOL CURRICULUM

The teaching of natural sciences in the Chilean school curriculum follows the guidelines issued by the Chilean Ministry of Education (MINEDUC, 2023). These teaching guidelines aim to strengthen curriculum appropriation and deepen the knowledge of the topics of each subject. It states that the natural sciences aim to understand nature and its related phenomena, declaring that this fundamental knowledge would enable scientific literacy in new generations upon completion of compulsory school education. Regarding scientific literacy, it is defined as the acquisition of knowledge that enables students to develop the necessary capacities to understand and solve everyday problems (Shen, 1975). Thus, to respond to the educational objective stipulated in the school curriculum for natural sciences, teachers should reflect on what, why, and how they teach it, as well as what they expect to achieve through their instruction. These questions can be addressed through didactics that, in Indigenous and intercultural educational contexts, should consider the social, cultural, political, territorial, and spiritual realities that converge in the sociocultural environment and impact the learning of the human-nature relationship (Villarroel, Arias-Ortega, & Quintriqueo, 2022).

From this perspective, didactics is a field in permanent reconstruction that enables reflection on the pedagogical practices teachers implement in teaching and learning processes, particularly around how students construct learning (Iraria & Fuentes, 2023). Thus, didactics becomes a tool for teachers to transform their pedagogical practices to benefit their students' learning. This is especially relevant in educational settings with social and cultural diversity,

such as the Indigenous context in the case of the Mapuche in Chile, because this context demands the development of contextualised educational experiences that respond to a socially, culturally, and territorially relevant education. Hence, through didactics, Indigenous educational knowledge and understanding can be articulated with the school curriculum of natural sciences, positioning the teacher as an active and responsible entity in the teaching and learning processes that they develop (Iraria & Fuentes, 2023). The above is possible to the extent that teachers adopt an epistemological pluralism that enables them to connect the teaching and knowledge of the natural sciences with the contents, methods, and purposes of Mapuche education.

From this perspective, rethinking the teaching of natural sciences in conjunction with Indigenous knowledge implies starting from the premise of an intercultural didactic approach capable of recognising that some Mapuche educational methods could enrich the teaching of natural sciences and their connection with the environment, to establish a relationship of respect and reciprocity with the natural world from diverse epistemic frameworks that go beyond scientific knowledge as the only valid one. In the particular case of Chile, we refer to Mapuche educational methods that are part of the epistemic basis of this Indigenous people, sustained in social memory and expressed in the wisdom of wise men and women, Indigenous authorities, and parents who transmit Mapuche educational, social, cultural, and spiritual knowledge through family education (Quilaqueo, Quintriqueo, Catriquir, & Llanquinao, 2004; Quilaqueo, Quintriqueo, & Cárdenas, 2005; Quilaqueo & Quintriqueo, 2017).

In this sense, Mapuche family education refers to the educational action where children and young people develop teaching and learning experiences based on educational content that is grounded in the knowledge historically constructed by the community, which is available for learning and teaching (Beillerot & Mosconi, 2006). Hence, Mapuche family education encompasses a set of content, methods, and educational purposes that are taught to Indigenous children and young people to preserve the vitality and epistemic frameworks of future generations (Quintriqueo et al., 2022). In this way, we evidence from the scientific literature in authors such as Quilaqueo and Quintriqueo (2017), Arias-Ortega (2019), and Quintriqueo, Arias-Ortega, and Muñoz (2024) a set of Mapuche educational contents, methods, and purposes that could be integrated into school content to promote learning with cultural and territorial relevance (see Table 1).

Table 1

Mapuche educational contents, methods, and purposes for an intercultural natural science

Concept	Definition	Some examples
Mapuche educational content	These refer to the knowledge and skills that should be taught to new generations to ensure the survival and transmission of one's own culture from a dynamic perspective of constructing and reconstructing knowledge. This involves individual and collective processes, procedures, and attitudes for the construction of shared knowledge. These contents can be understood from a conceptual and a value perspective.	Conceptual contents associated with the *küpan* family ancestry and the *tuwün* referring to the territorial origin Value contents associated with education regarding the basis of the process of interaction between people (*yamuwün*) and the natural environment (*ekuwün*) Harmony to build and preserve a form of relationship with the tangible and intangible beings that coexist in the world. Possibilities of articulation with the recognition of the history, geography, and social organization of the territory Contents associated with the classification of plants, the *wajontu mapu* (universe), and *ixofij mogen* (biodiversity).
Mapuche educational methods	They refer to pedagogical practices present in Mapuche education, which are used consciously and intentionally to transmit intergenerational knowledge and educational skills that are desirable to teach to new generations, both at the cognitive,	*Gübam* is an educational method that, through advice and teaching practices based on learning and error, seeks to help children and young people become aware of their actions and modify their behavior on both the cultural, natural, and spiritual levels. *Mumülkan* is a method that enables us to understand the

	attitudinal, and spiritual levels.	processes of knowledge construction, organizing one's own (previous) knowledge and new knowledge to advance in a person's education. Possibilities for articulation with scientific skills, such as listening and experimentation, that enable the building of knowledge through practice.
Purposes	Personal development based on principles specific to the education of new generations, based on the Mapuche reference frameworks. This would enable people to be educated in achieving the ideal of being a good person, characterized by an attitude of respect, developing self-esteem, sound thinking, wisdom, fidelity to their ideals, and being a good listener.	*Kümeche* means to be a correct person who, due to feelings of empathy towards others, be wise (*kimchi*), and learn about the social, cultural, and religious practices that support Mapuche knowledge. Possibilities for articulation with cross-curriculum learning objectives that seek to develop children's relationships based on empathy, respect, and global citizenship.

Table 1 demonstrates the existence of a set of Mapuche educational contents, methods, and purposes that can be incorporated into the teaching of natural sciences.

As the focus of this study, we concentrate on Mapuche educational methods that relate to the forms of experimentation children and young people can develop within the learning context. In this way, they can generate actions that promote teaching and learning processes based on cognitive structures constructed and preserved in social memory, directly in contact with ecological-cultural spaces and the community environment. In this context, the ways of learning and teaching are dynamic and depend on the social, cultural, and linguistic transformations of each territory, as well as the search for social and cultural development within the family and community (Quilaqueo & Quintriqueo, 2017; Quintriqueo et al., 2022). This is how Mapuche educational

methods, in general, remain current in the social memory that is continuously reconstructed to respond to the shaping and construction of Mapuche social, cultural, and spiritual identity (Quilaqueo & Quintriqueo, 2017). However, these Mapuche educational methods have generally been preserved in the family and community environment. In the school context, they have been put at risk due to the invisibility, denial, and omission that school education has historically exhibited concerning Mapuche education. Thus, through this study, we seek to identify some methods in the Mapuche context in La Araucanía that could be incorporated into pedagogical practices from the voices of traditional Mapuche sages and educators who, through their incorporation into school education, could mediate their articulation with school knowledge in the teaching of natural sciences to form new generations committed to the natural environment and its preservation.

METHODOLOGY

The research methodology employed a qualitative approach, which enabled us to gain insight into the subjective and intersubjective perspectives of sages and traditional Mapuche educators regarding educational methods that can be integrated with the teaching of natural sciences (Bisquerra, 2004). The study's context is La Araucanía, Chile, the country's second-largest region and home to the largest Mapuche population. The study was conducted in the Lafkenche (sea people) area of the commune of Saavedra, with the participation of three Mapuche sages (*kimchi*) and three traditional educators, all of whom were aged between 40 and 65 years and fluent speakers of Mapunzugun (the Mapuche vernacular language). The inclusion criteria are: 1) People knowledgeable in Mapuche educational knowledge; 2) Active participants in their community; 3) Speakers of the vernacular language (*Mapudungun*); and 4) Have a link with a school in the territory.

The technique used for data collection was the semi-structured interview, as it allows for a deeper understanding of the knowledge that participants have regarding the object of study (Bisquerra, 2004). The interview asked about the teaching methods used at the family and community levels to educate Mapuche children and youth. For the analysis of the information, inductive content analysis was employed, which enables the identification of both explicit and implicit aspects that emerge from the participants' testimony regarding educational methods specific to Mapuche family education, thereby enriching the teaching of science. In this way, patterns are identified, and key themes are derived from the participants' voices. We rely on the use of Atlas Ti 9.2 software, which allows us to view the code, its repetitions, and densities,

among other features (Bisquerra, 2004). Operationally, inductive content analysis involved: 1) familiarising ourselves with the data from the interview transcripts, for a critical and in-depth reading of the data to capture their explicit and latent content and context; 2) systematic coding, a process that involved labelling the relevant characteristics of the participants' testimonies, to answer the research question, which allowed the organisation of the data into manageable fragments; 3) repetitive patterns emerging from the participants' testimonies were sought, which were grouped into similar codes, giving way to the identification of themes that capture broader meanings in relation to the research question; 4) a process of reviewing the emerging themes, to ensure that the data support them and are coherent throughout the data; 5) Decision-making involved refining the themes as needed. We defined the themes, analysed them in detail, and assigned definitive names that accurately represented their essence, ensuring coherence and consistency with the participants' testimonies. 6) A results report was prepared, presenting an analytical narrative that interconnects the themes with the testimonies, triangulating research findings and existing theories. This report was supported by representative illustrations of each theme based on the testimonies. The coding of the testimonies employed the following nomenclature: TE refers to the traditional educator, and MS refers to the Mapuche sage. The numbers that appear in parentheses, for example [08:67], refer to the location of the testimony in the hermeneutic unit of Atlas Ti. Regarding the ethical safeguards of the research, informed consent was obtained to protect the rights of the participants (Bisquerra, 2004). The consent form clarified that the research does not entail any harm or financial compensation, that participants' anonymity will be maintained, and that participants may withdraw from the research at any time. We also employed the Mapuche sociocultural protocols associated with the *pentukuwün* (Mapuche protocol greeting) and the *mañumtun* (thank you) that were handed to the participants as a gesture of appreciation and gratitude for sharing their ancestral knowledge. The research has been approved by the Ethics Committee of the researchers' higher education institution.

RESULTS

The results emerging from the testimony of traditional scholars and educators reveal two recurring Mapuche educational methods used in the education of children and young people in community and family contexts. These methods refer to the *inatuzugu* (inquiry) and experiential intelligence as educational methods that can be applied in conjunction with the teaching of natural sciences. This refers to the way Mapuche educational methods approach the education of Mapuche children and young people in family education,

where an adult is responsible for educating children based on their own educational content, from their own reference frame (Arias-Ortega, 2019).

DIDACTICS IN THE TEACHING OF NATURAL SCIENCES THROUGH *INATUZUGU*

The *inatuzugu*, as a Mapuche family educational method, relates to learning through observation and experimentation, which is essentially a hands-on approach to learning. Both actions complement each other, highlighting a method that enables the development of educational experiences for children and young people within family and community contexts. In this way, the *inatuzugu* develops in direct contact with the environment; therefore, it is a means by which children and young people can establish a connection with the natural environment from an early age. Thus, children and young people observe the daily routine activities performed by adults, ranging from household chores to the development of spiritual practices. In this regard, a testimony states that: "*I lived that knowledge, we grew up like that, we went to the* geykurewen *(*rewe *change celebrations), we lived and experienced our knowledge, that's how we learned it. Nobody taught us, but we watched and learned*" (TE 1; 62:62). The testimony of the traditional educator raises the need for students to exercise detailed observation of the activities specific to their social, natural, and cultural environment. This could be feasible in the educational field, which would facilitate teaching and learning processes situated in the context of life. This enables children and young people to learn, on-site and intergenerationally, not only how to behave but also about the implications of each activity performed within the community and family. Another testimony adds: "*From a young age, one watches what one's elders do. I learned household chores, farming tasks, and community ceremonies from my grandfather and father. From a young age, one is taken to different ceremonies and places so that one learns to know, behave, and do things*" (SM1; 03:20). The testimony shows that children and young people develop observation skills in real-life, everyday situations within family and community education, enabling meaningful learning and promoting educational experiences that contribute to comprehensive development, from knowledge to social norms.

In that sense, the *inatuzugu* could be key to the intercultural teaching of natural sciences, since it emphasises the importance of linking student learning with their cultural, social, and natural contexts. Thus, science education would not only be limited to transmitting knowledge but would also foster the development of skills that allow students to learn from their

environment, everyday practices, and interactions with their community. In this way, the act of observing, as mentioned in the testimonies, becomes a fundamental tool for children and young people to understand and appropriate ancestral knowledge. Thus, rather than teaching theory in isolation, intercultural teaching allows students to have concrete, direct experiences, which significantly enhances their understanding of the natural world. Furthermore, learning through observation of activities ranging from everyday tasks to spiritual practices promotes a holistic view of the environment, integrating both scientific and cultural knowledge. In this type of teaching, students can also learn intergenerationally, a practice that is particularly crucial in Indigenous and rural communities. This is because knowledge is not transmitted exclusively in school but is shared through observation and participation in the activities of adults. This approach facilitates learning that is not only academic, but also practical and relational, helping students internalise both social norms and knowledge of natural resources and their implications for community life.

Regarding experimentation as part of the educational method *inatuzugu*, a traditional educator reports that: *"The first learning a child acquires is done in the family context, observing everyday life, accompanying adults in field work, in ceremonies. In this way, they learn in real-life situations that later enable the child to remember and know how to act in a given situation"* (TE2; 05:20). Thus, in Mapuche family education, learning through experimentation is of vital importance, as children and young people apply the knowledge they have acquired through observation to real-life situations. This is a possibility in the educational field, as teaching natural sciences involves experimentation. From an intercultural perspective, this experimentation should be conducted with a sense of sociocultural relevance, in accordance with the specific sociocultural norms and patterns, while respecting the tangible and intangible beings that inhabit the world. In this regard, a traditional educator states that: "*As an adult, one knows when the child is ready to perform activities or tasks and accordingly one assigns responsibilities and tasks according to their age and development and as we have observed in the different activities in which they have accompanied us*" (TE1; 11:32). From an intercultural didactic perspective, Mapuche educational methods can be incorporated into the teaching of natural sciences in the formal education system. This includes not only the content but also the ethical approach to the tangible and intangible elements of the environment, promoting a respectful relationship with nature. For example, instead of conducting decontextualised experiments, teachers could work on activities that connect scientific knowledge with traditional

practices, such as sustainable natural resource management or interpreting climate phenomena based on local observations. According to the testimonies of traditional educators, they emphasise that this process requires close support from adults, who act as learning mediators. In this way, continuous observation of children's development allows them to identify key moments when they are ready to take on new responsibilities, resulting in a progressive transition toward independent experimentation. This principle can be adapted to the classroom through formative assessment and the design of activities that take into account students' abilities and cultural context.

The convergence of Indigenous experimentation and formal natural science education not only promotes understanding of scientific concepts but also fosters values such as respect, responsibility, and interconnectedness with the environment. In this way, intercultural didactics can be built that enhance meaningful learning and contribute to the recognition of diverse knowledge in a globalised world, but one deeply rooted in cultural particularities.

DIDACTICS IN THE TEACHING OF NATURAL SCIENCES THROUGH EXPERIENTIAL LEARNING

Experiential learning refers to educational methods that emphasise the creation of real learning spaces, thereby promoting teaching and learning processes linked to the everyday family and/or community environment. In this regard, a sage says: "*One develops the connection with the environment from a very young age, because our ancestors have always taught us the important things in each activity, whether in a prayer or when we go out to collect firewood, and then we replicate what we have learned*" (MS2; 22:11). According to the testimony, it is possible to infer that children and young people at an early age become involved, following the advice of their elders, in the various activities carried out both at the family and community levels. Thus, from the perspective of Mapuche family education, the experiential learning method highlights the comprehensive interrelationship between learning, the environment, and the transmission of ancestral knowings, which can be incorporated into the teaching of natural sciences from an intercultural perspective, capable of articulating the Indigenous and school episteme. This would contribute to the development of new environmentally sensitive citizens capable of establishing a connection with the natural environment, not just as something occasional or instrumental, as has been taught in school education, when nature is considered an exploitable natural resource. Rather, from an intercultural perspective, it could foster the establishment of a deeply rooted relationship with the natural environment from an early age. In which the

relationship takes place within the framework of a learning process of interdependence with the environment, where each element, be it a tree, a river, or an activity, has a symbolic and practical meaning. Everyday activities, such as collecting firewood or participating in prayer, are spaces for interaction that strengthen this relational connection with the natural and spiritual world. Likewise, it constitutes a possibility of going beyond books and study materials, since intercultural didactics would allow us to delve deeper into oral tradition as a practice of knowledge transmission that can be incorporated into teaching and learning processes. This is because learning is not structured around abstract texts or theories, but is transmitted through active participation and repetition in meaningful activities. This experiential and pragmatic approach to intercultural teaching connects the learner directly with ancestral knowings, allowing it not only to be understood but also internalised by being integrated into everyday life. Prayer, as a spiritual act, and firewood gathering, as a practical task, illustrate how the symbolic and the functional are intertwined.

In this sense, a traditional educator explains that: "*Children are constantly learning because from a very young age, you talk to them about what they should be, how they should do things, when they should ask permission, how to talk to adults, what their role is in ceremonies. In reality, you are always teaching them how they should behave in every activity in which they are present*" (TE3; 21:14). The testimony demonstrates that learning is a continuous process, and that spaces are created for it in every activity where children and young people participate. They are taught elements that are important for their development as individuals, enabling them to function independently within their family and community settings. In this way, the articulation of Indigenous and school educational methods would enable us to move towards a cyclical view of learning about the natural environment, demonstrating that learning is circular and ascending, with human beings continually learning. On the contrary, knowledge becomes increasingly complex every day, as it is complemented, learned, and relearned to the extent that there is openness to the epistemological pluralism characteristic of socially and culturally diverse societies. In this way, learning the natural sciences from diverse perspectives constitutes an opportunity for the intergenerational transmission of knowledge and wisdom, in which what is learned is not simply received but replicated and becomes a living legacy. This circularity is central to the Indigenous episteme, where knowledge is not perceived as a static product, but as a dynamic process that evolves across generations, respecting and adapting learning to the context. In this way, the experiential learning method becomes a co-constructive and comprehensive space that, in

Indigenous and intercultural educational contexts, articulates the physical, emotional, and spiritual aspects. Therefore, considering intercultural didactics for learning natural sciences not only begins by questioning the fragmentation of knowledge promoted by Western paradigms, but also proposes a pedagogical alternative based on relationality, continuity, and cultural significance.

A sage explains: *"I meet with them several times a year, and I explain to them what things mean and how they should face them and also how they should behave towards them. For example, now the time to perform the* guillatún *is approaching. We prepare months in advance and there are specific moments where I meet with children and young people to explain everything necessary to perform the ceremony"* (MS3; 26:04). The testimony demonstrates the learning methods employed in Mapuche family education, which are brought into contact with real-life situations, and which children and young people should learn about both their social norms and the meaning and relevance of such learning. In this way, it is possible to verify that Mapuche family education employs experiential intelligence as an educational method that promotes meaningful teaching and learning processes, allowing children and young people to experience real-life situations and apply what they have learned. In short, both *inatuzugu* and experiential intelligence are educational methods of Mapuche family education that can be linked to the teaching of natural sciences, making it possible to develop teaching and learning processes from an intercultural perspective. This would promote socially, culturally, and territorially relevant educational experiences in educational settings developed within an Indigenous context, where both Indigenous and non-Indigenous students would learn in a meaningful way. This would enable the reaffirmation of identity processes, the reevaluation of culture, and learning to coexist in intercultural societies.

DISCUSSION AND CONCLUSION

The articulation of Indigenous educational methods with the didactics of the teaching and learning processes in the natural sciences is based on the need to sustain educational experiences constructed from an intercultural perspective and epistemological pluralism, within the framework of school processes for Indigenous and non-Indigenous children and young people (MINEDUC, 2012), which helps establishing intercultural teaching that enables socially, culturally, and territorially relevant learning. The research results confirm that in the social and historical memory of the Mapuche sages, a base of contents, methods, and educational purposes present in Indigenous family education that are susceptible to articulation with the teaching of natural

sciences emerges (Quintriqueo et al., 2022). Specifically, the educational methods themselves support the foundations for thinking about intercultural didactics in the natural sciences, which promotes situated learning and responds to the needs and interests of Indigenous families and communities, as this would favour the academic and educational success of all students (Arias-Ortega, 2019). The above is consistent with the scientific literature reviewed (Quilaqueo & Sartorello, 2018; Arias-Ortega, 2019), which highlights the urgency of thinking about situated educational processes that allow the revitalisation of one's own knowings and sociocultural identity. In this regard, Campeau (2021) argues that students' learning and academic and educational success are directly related to the school curriculum and the teaching-learning processes, in which the incorporation of the cultural, epistemic, linguistic, and territorial aspects of the students' culture of origin would favour the improvement of the quality of school education in an Indigenous context. Likewise, we argue that education must be respectful of Indigenous epistemic frameworks to promote the development and implementation of intercultural teaching in the natural sciences from an intercultural perspective, allowing for the construction of a sense of education in Indigenous territories.

In this sense, the results of research conducted by Mapuche scholars and traditional educators reveal educational methods that are adaptable to the teaching of natural sciences, which are relevant for incorporating natural sciences into school teaching in Indigenous territories. The first is associated with the *inatuzugu* educational method, based on the processes of observation and exploration, both essential elements for the development of scientific education. Traditional scholars and educators report that this Mapuche educational method would be desirable to incorporate into the teaching and learning processes of natural sciences, to strengthen school education in the procedural area since, thanks to this educational method, Mapuche educational content and purposes are transmitted at the family and community levels. However, scientific literature reveals that educational knowledge and methods have been historically denied and rendered invisible in school education for decades (Arias-Ortega & Velosa, 2022; Burgess, Bishop, & Lowe, 2022). This is how, in school education in general, and in the teaching of natural sciences in particular, new generations of children and young people have been educated from a Eurocentric-Western monocultural perspective. This is due to the ways of constructing knowledge, which are based on the view of the positivist scientific method that separates the human being from the spirit, so that sociocultural reality is understood in a separate and fragmented way as a knowing subject (Beltrán-Véliz et al., 2022). This contradicts the logic of

Indigenous knowing, which posits that there is no separation between the subject and its material and immaterial aspects (Quintriqueo et al., 2022; Bermejo-Bermejo & Maquera-Maquera, 2022). It is also evident that observation allows children and young people not only to develop their own knowings, but also to learn relationships based on interconnected environmental levels as ways to achieve development and well-being through learning. From this approach, observation enables children and youth in Indigenous communities to consider complete ecologies, fostering their comprehensive health, which extends throughout the entire ecosystem and promotes community well-being (Sartorello, 2018). In this way, observation becomes an epistemic practice specific to family education, allowing the child to discover and characterise in a detailed and profound manner specific facts, objects, and phenomena that interact with and are part of the environment.

In this sense, teaching natural sciences through the development of observation would allow students to understand natural phenomena from an intercultural perspective, which involves observing these events in relation to their own worldview, in which there is an intrinsic network of connections. According to research by Carihuentro (2007) and Arias-Ortega and Quintriqueo (2021), Indigenous educational methods facilitate a process of acquiring knowledge in a systematic and ongoing manner. The above implies the development of skills such as observation through their involvement in the practices of their daily lives. In this way, teaching natural sciences from an intercultural perspective would allow for the development of teaching and learning processes through unique educational methods. However, in general, the teaching and learning processes in the school educational environment often do not incorporate Indigenous educational methods, making Indigenous knowledge invisible in pedagogical practices (Arias-Ortega, Quintriqueo, & Valdebenito, 2018). Likewise, in schools, educational methods often fail to situate the construction of knowledge within the local context, instead relying on unidirectional educational practices that prioritise writing and classroom space, overlooking the benefits generated by connections with the natural environment in which the school is situated (Villarroel, 2023).

From this perspective, the results of this research show that observation allows Indigenous children and young people to develop a sense of place and belonging with the tangible and intangible objects present in their territory. This poses challenges in the teaching of natural sciences from an intercultural perspective: 1) incorporating children and young people into learning that promotes observation and experimentation to develop emotional and experiential intelligence. This is a way to contribute to the autonomous

development of children and young people, since observation is an Indigenous epistemic practice that has historically enabled multigenerational learning that is transmitted and achieved through observation. This is how indigenous children and young people are motivated to develop the art of observation, achieving a sense of alignment toward a common purpose. For example, observing the forms, behaviours, and attitudes they should adopt when participating in the sociocultural and socioreligious practices they need to learn to ensure their preservation in society; and 2) incorporating the art of observing the natural environment to understand, experience, connect with, and interpret nature and the messages it transmits through the wind, water, and birds, which may keep balanced and reciprocal relationships with nature. With this, children and young people can establish a connection with their natural environment and develop behaviours that care for, preserve, and protect it.

Regarding the learning-through-experience educational method, it focuses on teaching and learning mechanisms specific to Indigenous family education, involving children and young people in everyday life activities related to the natural environment. In this way, the educational experiences of children and young people from Indigenous family education are linked to learning through real-life activities. In this way, from Indigenous epistemic frameworks, children and young people, through experimentation, manage to build a community that seeks the common good. Thus, together, they value experience, the collective, creativity, narrative, justice, and the ways of knowing and responding to the sensitive and lively places that their family education has taught them to respect and value in nature. This allows the natural environment surrounding the educational institution to become a living laboratory, enabling students to experiment in familiar settings. The above promotes teaching and learning processes that are socially, culturally, and territorially relevant.

This Indigenous educational principle implies the development of an ethical attitude that responds to the ontological and epistemological frameworks in the process of experimentation in sociocultural reality. Within the framework of intercultural natural science teaching, this opens up possibilities for deepening transdisciplinary collaboration, enabling new regenerative approaches that overcome the limitations present in science teaching (Wooltorton et al., 2022).

Vergara and Ibañez (2020) have developed research that reveals that the teaching and learning processes specifically in the natural sciences still operate from a logic of scientific racism, which impacts the teaching processes

that are still developed from a traditional perspective, positioning the teacher in the role of transmitter of knowledge and the students as receivers of educational content. These hegemonic pedagogical practices limit learning through experimentation, which creates tension with the educational methods present in Indigenous family education.

Because experimentation in the school education system is often conceived from the perspective of work that can be carried out in a laboratory, it does not consider other possible educational scenarios for experimental work. Furthermore, Vergara and Albanese (2017) report that the pedagogical planning of the subject of natural sciences is structured from a Western scientific perspective on the conception of nature and does not consider other knowings. In this way, the power relations and domination of hegemonic knowledge superimposed on any other knowings are evident through pedagogical knowing. Likewise, it is noted that the imposition of modern science, proposed by European colonialism, remains in effect in the Chilean school education system, establishing it as the sole criterion of truth and suppressing any other forms of knowledge (Santos, 2010). In this way, the teaching of natural sciences from an intercultural perspective poses the challenge of establishing a school curriculum contextualised to local society, culture, and territory, allowing for the decolonisation of knowledge in the sciences, incorporating and recognising social memory, respect for and inclusion of Indigenous peoples, their content, methods, and educational purposes in the teaching of natural sciences from an intercultural perspective. This implies that students' own cultures and knowledge systems, values, and ways of being must be validated. In this way, to counteract hegemonic sciences, it is vitally important to develop policies that respond to the calls to heal and restore ecosystems and social systems from a local perspective for the global world (Wooltorton et al., 2022).

Regarding the second Indigenous educational method relevant to the intercultural teaching of natural sciences, it refers to experiential learning. This educational method involves developing teaching and learning processes within the framework of one's own culture based on educational content, methods, and purposes related to the territory, kinship, and environment (Quilaqueo & Quintriqueo, 2017; Quintriqueo et al., 2022). From this, it is possible to design and implement educational experiences that guide situated and meaningful learning, based on connections with everyday activities within the community and family. Thus, the voices of Mapuche scholars and traditional educators underscore the importance of employing this educational method to enhance students' educational and academic outcomes.

Regarding the incorporation of specific educational methods for teaching natural sciences, they are highlighted as a possibility for considering intercultural didactics that integrate Indigenous and academic knowing, enabling the positioning of epistemological pluralism in science teaching, while also facilitating situated learning for Indigenous children and young people in school education, as those methods are embedded in their social memory and developed within Mapuche family and community education.

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DECLARATION OF DATA AVAILABILITY

Data supporting the results of this study will be made available by the corresponding author, Viviana Marcela Villarroel Cárdenas, upon reasonable request.

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