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Research Article

Climate Change and Geography Education: A Qualitative Study of Expert and Novice Teachers' Conceptions and Geographical Thinking

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Abstract: Climate change education represents a significant challenge for geographical education and educators. While there is a a large body of research focused on students' alternative conceptions, in contrast there is little attention paid to how teachers construct geographical reasoning about climate change. This study aims to analyse how expert and non-expert teachers articulate geographical thinking in relation to climate change education. An interpretative qualitative design was adopted, based on the analysis of two focus groups differentiated by teaching expertise, conducted in the context of the evaluation and discussion of a teacher training course on climate change and GIS. Qualitative data were analysed using a combination of deductive categories derived from the literature and inductively emerging codes due to the thematic analysis. The results reveal clear differences between the two groups. Expert teachers generate a higher density of qualitative data, mobilise systemic and multiscalar reasoning more consistently, and display explicit strategies of epistemic regulation, particularly through theoretical prudence and evidence-based argumentation. In contrast, non-expert teachers tend to frame complexity as a problem to be reduced, relying more frequently on linear or axiological explanations. Importantly, axiological elements are not absent from expert discourse but coexist in tension with non-axiological approaches.

Keywords: Climate Change Education; Geographical Thinking; Discourse Analysis; Systems Thinking; Complexity Education; Qualitative Case Study

Highlights:

- Expert teachers mobilize systemic and multiscalar reasoning more consistently.
- Theoretical prudence emerges as an exclusive feature of expert discourse.
- Axiological and non-axiological registers coexist within expert reasoning.
- Non-experts frame complexity as a problem to be reduced or simplified.
- Climate change education benefits from powerful geographical knowledge.

1. Introduction

In recent decades, climate change has become established as one of the most critical global challenges. This complex phenomenon, characterised by rising temperatures, changes in precipitation patterns, and an increase in extreme weather events, poses significant risks to ecosystems, human health, and the global economy (Intergovernmental Panel on Climate Change [IPCC], 2021). Various sectors and institutions, such as UNESCO (2025), emphasise that climate change is not and should not be treated as an isolated problem, but rather one that affects all aspects of life on the planet. It is therefore imperative that populations understand its causes, consequences and the actions required to address the social problems that accompany it.

In this context, climate change education is increasingly recognised as a key tool for both mitigation and adaptation. Beyond providing information about causes and impacts, it also aims to foster citizens who are committed to sustainability (Roussell & Cutter-Mackenzie-Knowles, 2020; Sterman & Sweeney, 2007). Current policy frameworks highlight the need to integrate climate change into educational curricula in order to promote environmental responsibility and a culture of sustainability from an early age (Spain, 2022a; Spain, 2022b; OECD, 2019; UNESCO, 2025). Accordingly, climate change education should not only support the acquisition of knowledge, but also develop and promote critical thinking and problem-solving skills that enable them to contribute to innovative and sustainable solutions (Zummo et al., 2020; Leininger-Frézal et al., 2023). In this regard, several published studies highlight the central role of geographical education in understanding global change. Geography provides key conceptual tools and competences, such as spatial reasoning, scale, and the analysis of socio-environmental interactions (Leininger-Frézal et al., 2023; Puertas-Aguilar et al., 2023) that are essential for addressing climate change in a meaningful way.

However, beyond students, society as a whole is increasingly exposed to sceptical, simplified, or post-truth discourses in relation to geographical and environmental phenomena, amplified through the media and social networks (Libarkin et al., 2005; Chang & Pascua, 2016). This situation becomes particularly visible in the context of extreme events such as summer wildfires, floods, or heatwaves, which entail risks to health, loss of human life, and material damage. However, these events also reveal important socio-political and educational shortcomings. This can be observed in poor planning and communication and, at another scale of analysis, in educational problems related to the concept of natural risk (Renn, 2008), content and competences attributable to geographical education (Morote & Olcina, 2024). Recent events in southern Europe, such as high-intensity Mediterranean storms (commonly referred to as cold-drop events in Spain), have also been accompanied by an increase in misinformation, hoaxes, and fake news circulating through media and digital platforms (López Carrión & Lorca-Abad, 2025).

In this sense, alternative conceptions (Posner et al., 1982; Vosniadou, 1994; Carrascosa, 2022) about sciences (and Geography) can have significant negative implications for contemporary societies. A substantial body of research has examined students' alternative conceptions of climate change (Conde Nuñez et al., 2013; Carrascosa et al., 2022; Olcina et al., 2023; Schubatzky et al., 2024). However, the majority of these studies are related to the teaching of natural or experimental sciences, with very few developed from perspectives rooted in geography or geographical education (Havelková & Hanus, 2022). Similarly, as detailed by Lundholm and Davies (2013), there are few studies addressing conceptual change from a social sciences perspective.

Moreover, much of the existing literature has focused on students' initial or alternative ideas (Škodová et al., 2025), implicitly assuming that teachers possess consolidated expert conceptions. However, expert conceptions are not defined solely by the absence of conceptual errors. Rather, they involve the construction of coherent and hierarchically organised explanations, aligned with scientific knowledge and developed through theoretical depth, professional experience, and reflective practice (Driver et al., 1994). These conceptions should be understood as situated constructions, shaped by specific epistemological–scientific positions. Therefore, they are ideas characterised by: structured reasoning, following scientific methods and argumentation, and the capacity to address abstract and complex phenomena (Chi et al., 1981).

Against this background, this study examines the conceptions of two groups of geography teachers—novice and experienced—regarding the teaching of climate change. The study adopts a fundamentally deductive analytical design, as it is grounded in a prior theoretical framework concerning the characteristics of expert thinking in geography—geographical thinking, systems thinking and non-axiological thinking—which are widely recognised in the specialised literature (Catling & Martin, 2011; Lambert, 2014; Jacobson & Wilensky, 2006; Dearden, 1981). At the same time, this approach remains open to the emergence of new categories and meanings, allowing the empirical data to introduce nuances, tensions, or novel elements into the understanding of how teachers construct and articulate their expert reasoning about climate change education in contemporary educational contexts, particularly within the European framework.

2. Objectives and Research Questions

Although research in didactics has extensively addressed conceptual change both in the field of geography (Havelková & Hanus, 2022) and in climate change education (Carrascosa et al., 2022; Schubatzky et al., 2024), the present study does not focus on defining conceptual change nor on analysing the processes through which erroneous conceptions are replaced by scientific explanations. Instead, this study adopts an interpretative perspective aimed at understanding how different professionals and experts in climate and geographical education construct educational

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meaning around climate change, situating this process in relation to the concept of Powerful Geographical Knowledge (Catling & Martin, 2011; Lambert, 2014; De Miguel, 2024).

From this perspective, the focus of the study shifts from the identification of conceptual errors towards the analysis of expert geographical reasoning, understood as a form of professional knowledge that integrates geographical thinking, systems thinking, and non-axiological approaches. This approach is particularly relevant in the context of current debates on geographical education in Europe, which emphasise the need to address global change through curricular and pedagogical frameworks capable of articulating rigorous knowledge, critical thinking and an understanding of socio-environmental complexity (Leininger-Frézal et al., 2023; Puertas-Aguilar, 2023).

In coherence with this approach, the main objective of this article is to analyse and understand expert reasoning in the field of geographical education, focusing on the role of geographical thinking through systems thinking and non-axiological thinking as structuring components of such reasoning.

To achieve this objective, the following research questions are posed:

- **RQ 1:** How do expert and non-expert teachers conceptualise the teaching of climate change within the field of geographical education?
- **RQ 2:** In what ways do forms of expert geographical thinking emerge in the proposals shared by these teachers?
- **RQ 3:** Which elements of expert thinking are identified as necessary for rigorous climate change education, and how do these vary in relation to elements of non-expert thinking?
- **RQ 4:** What tensions, divergences, or consensuses emerge between expert discourse and the theoretical frameworks of reference in geographical education?

In this sense, and as will be discussed in the methodological section, the study seeks to adjust didactic–pedagogical theories to specific contexts of geographical learning through the analysis of two focus groups, one composed of experts and the other of non-expert teachers.

Although qualitative research does not always require predefined hypotheses, exploratory hypotheses can serve a heuristic function as analytical orientation tools (Charmaz, 2006; Maxwell, 2012; Miles et al., 2014; Corbin & Strauss, 2015). In line with the theoretically informed and comparative design of this study, a set of exploratory hypotheses is proposed to clarify the analytical expectations guiding the comparison of the focus groups:

- **H1.** Expert teachers are expected to demonstrate a higher presence of systems thinking through geographical thinking in their discourse, characterised by the recognition of complexity, multicausality, and interdependence between socio-environmental factors, compared to non-expert teachers.
- **H2.** Expert teachers are expected to display a greater degree of non-axiological thinking, reflected in the differentiation between scientific evidence, explanatory interpretations, and value judgements, as well as in the use of evidence-based argumentation.
- **H3.** Non-expert teachers are expected to show a higher prevalence of axiological and linear reasoning, including moralising discourses and simplified cause–effect explanations, particularly when addressing the complexity of climate change.
- **H4.** The discourse of expert teachers is expected to present greater density, coherence and interconnection of conceptual elements, reflecting a more structured form of geographical reasoning.

3. Literature Review

The need to understand how teachers (both novice and experienced) construct and articulate their discourse around the teaching of climate and climate change from geographical perspectives requires a conceptual framework that brings together different dimensions: the systemic dimension, understood through the geographical nature of phenomena as complex, multifactorial, and multiscalar; the epistemological particularities of geographical knowledge (Catling & Martin, 2011; Lambert, 2014); and the cognitive and discursive processes associated with expert, scientific, and non-axiological thinking.

Geographical thinking is not limited to the accumulation of spatial data, but rather involves the ability to analyse complex spatial relationships, understand scales and processes, and establish connections between multiple geo-environmental variables (Jo & Bednarz, 2009). In turn, research on teachers' professional competence suggests that teachers' professional knowledge functions as a mediating resource between their dispositions (knowledge, beliefs and attitudes) and their effective practices in real teaching contexts (Scholten et al., 2019; Smit, 2023). These cognitive and didactic dimensions converge in the notion of expert reasoning, understood as a form of professional knowledge that

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integrates content knowledge, specific pedagogical knowledge, and situational judgement skills, which are progressively shaped through experience and critical reflection.

The state of the art in geographical education and general and subject-specific didactics has developed theoretical frameworks over recent decades that help to conceptualise this type of professional knowledge. A fruitful approach for understanding the nature of expert reasoning is that of Pedagogical Content Knowledge (Rickles et al., 2017), originally proposed by Shulman to describe the "special amalgam of content and pedagogy" that enables teachers to transform disciplinary knowledge into forms that are accessible and meaningful for students (Shulman, 1986; Smit, 2023). In geography, this framework has been used to analyse how teachers integrate their knowledge of space, geographical processes, and ways of teaching these contents in complex contexts, where students' prior conceptions and socio-environmental experiences play an active role in the construction of learning (Scholten et al., 2019). From this perspective, teachers' expert reasoning reflects not only what they know about climate change, but also how they organise, interpret, and communicate this knowledge within real educational situations, interconnecting scientific data, spatial interpretations, and reasoned, coherent, and logical discourses.

In summary, the conceptual foundations of the methodological inquiry process undertaken do not focus solely on what ideas or content are expressed by participants, but also on how these ideas are articulated and related to one another. It is assumed that expert conceptions are not merely collections of isolated propositions, but rather interconnected cognitive structures that emerge through teachers' language, justification, and argumentation when they design and implement learning situations involving the complex tasks inherent to climate change education. Based on these assumptions, three conceptual axes are identified that deductively guide the thematic categories of the focus group analysis: (i) geographical thinking as a way of organising and relating interdisciplinary knowledge; (ii) systems thinking as an approach to understanding complex interactions between environmental and social factors; and (iii) non-axiological thinking as a dimension that enables the separation of empirical explanations from value judgements, thereby fostering a scientific understanding of phenomena.

3.1. Teaching Climate Change as a Complex and Systemic Content: Geographical Thinking

Geographical thinking and the concept of Powerful Geographical Knowledge (Catling & Martin, 2011; Lambert, 2014) refer to a set of cognitive and epistemological processes that shape a specific way of understanding, interpreting, and acting upon spatial reality. This type of thinking is characterised by the ability to identify spatial patterns and relationships, analyse processes at different scales, and understand the territorial organisation of phenomena from an integrated perspective. Far from being limited to a descriptive view of space, geographical thinking involves a form of reasoning oriented towards explaining how and why phenomena occur where they do, and what social, environmental, and territorial implications they have or entail. At the same time, from contemporary geographical perspectives, concepts such as place or landscape constitute fundamental epistemological categories that make it possible to articulate the material, symbolic, and experiential dimensions of space, as well as approaches oriented towards problem solving or socio-environmental analysis. As noted by De Miguel-González (2024), geographical analysis not only incorporates material dimensions (physical and economic), but also subjective experiences and meanings linked to social practices, which shows that this type of thinking is not strictly limited to a structuralist mode of reasoning, but rather integrates, as previously highlighted, analytical, interpretative, and experiential components inherent to the understanding of geographical space.

With regard to the operationalisation of this approach in the present study, geographical thinking is synthesised, for analytical purposes, into the following elements: (i) the identification of spatial reasoning (distributions, patterns, and inequalities); (ii) the explicit use of multiscalar relations (local, regional, global, and "glocal"); (iii) the analysis of physical–social interactions; and (iv) the use of epistemologically relevant geographical concepts to interpret climate change as a territorially differentiated and socially mediated phenomenon. These elements constitute key indicators for identifying forms of expert reasoning in the discourse of the participating teachers.

From these perspectives on complexity, systems thinking (Jacobson & Wilensky, 2006; Mambrey et al., 2020; Hmelo-Silver et al., 2007) is defined as the ability to understand phenomena—in this case climate change—as dynamic, interdependent systems governed by non-linear feedbacks, where cause–effect relationships are multiple and complex (Sterman & Sweeney, 2007), focusing not only on the elements that constitute them but also on the relationships that occur among them. From a geographical perspective, systems thinking is articulated in connection with the notion of multiscalarity and with an understanding of territory as a network of interrelated subsystems.

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In this study, this type of reasoning is identified through teachers' discursive capacity to recognise interdependencies between factors (physical, biological, economic, etc.), conceiving climate change as a socio-ecological entity, understand multiple causalities (non-linearity), as well as recognised reinforcing feedback loops, discursively include explanatory perspectives of the model through cause–effect relationships, which may be indirect, delayed, or uncertain; and generate discursive shifts in relation to scale—both temporal and spatial—understanding territory (or reality) as a set of subsystems with complex relationships. These elements make it possible to analyse the extent to which teachers promote systemic explanations when addressing climate change education and constitute a central component of expert reasoning from geographical perspectives, as they foster an integrated and non-fragmented understanding of phenomena.

3.2. Non-Axiological Thinking

Is educating in environmental values a moral duty of teachers? Non-axiological thinking, conceptualised by Weber (1949) as value neutrality, refers to the discursive or cognitive capacity to interpret socially complex or controversial phenomena by distinguishing between empirical facts, explanatory models, interpretations, and value judgements, thereby avoiding indoctrination while fostering informed and rigorous deliberation (Dearden, 1981). Although facts and values interact with one another, they should not be conflated. In this respect, Jasanoff (2004) and Miller (2004) analyse how science and values—climate science in the case of Miller (2004)—are co-produced and mutually reinforcing; however, both authors insist on the need for epistemological transparency throughout the scientific process. This principle of "scientific–value" uncertainty may be particularly useful for a topic such as climate change when approached from socio-scientific or eco-social perspectives characteristic of geographical approaches, as it allows values to be acknowledged without dissolving the boundaries between science and normativity. From this perspective, a non-axiological approach does not imply discourse, thinking or education devoid of intrinsic values, but rather the capacity to recognise them, make them explicit, and distinguish between them (facts/evidence vs. interpretations vs. value judgements/opinions), thus avoiding moralisation, alarmism, or discursive simplifications.

Applied to the teaching of climate change, non-axiological thinking translates into the teacher's role as a critical facilitator of learning rather than as an activist, promoting students' critical and argumentative thinking. This involves addressing cognitive conflict with rigour, distinguishing between education about climate and education for climate, and fostering informed reflection without prescribing closed normative responses. In this article, this dimension is analysed as a key component of expert reasoning, as it enables an understanding of how teachers manage the complex relationship between scientific knowledge, ethical implications, and educational responsibility when teaching a highly politicised socio-environmental issue. With regard to the operationalisation of this approach in the present study, non-axiological thinking is synthesised into the following analytical indicators: (i) explicit differentiation of discursive levels, identifying in teachers' discourse the capacity to distinguish between scientific facts and evidence, explanatory interpretations, and value judgements or normative opinions about climate change; (ii) the use of arguments grounded in evidence and well-established scientific sources, avoiding exclusively moral or emotional appeals and prioritising reasoned, coherent, and verifiable forms of argumentation; (iii) reflective management of uncertainty and the limits of knowledge, recognising complexity, the provisional nature of explanatory models, and the absence of absolute truths, without resorting to alarmist or oversimplified discourses; and (iv) epistemic self-regulation of teachers' discourse, observable through attitudes of theoretical prudence, metacognition, and awareness of the educational impact of their own discursive decisions when addressing a socio-environmental issue that is highly politicised.

These elements make it possible to analyse the extent to which teachers reflexively manage the relationship between scientific knowledge, values, and educational responsibility, constituting a central component of expert reasoning in geographical education. Far from being understood as passive neutrality, non-axiological thinking thus emerges as a cognitive and discursive strategy oriented towards epistemic control of discourse and the fostering of critical and informed citizenship.

4. Materials and Methods

The methodology of the present study is situated within interpretative qualitative research in the field of geographical education, aimed at understanding processes of meaning construction in complex educational contexts. This ap-

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proach is particularly suitable for addressing the teaching of climate change, a phenomenon in which cognitive, epistemological, and socio-political dimensions converge, and which can hardly be captured through experimental or causal explanatory designs (Miles et al., 2014).

From this perspective, the analysis focuses on teachers' discourse as a privileged space for observing how forms of expert reasoning are articulated, how meanings are negotiated, and how epistemological tensions are managed in authentic professional situations. In coherence with the principles of rigour inherent to qualitative research, the study adopts the criteria of trustworthiness proposed by Lincoln and Guba (1985), aimed at ensuring the credibility, analytical coherence and transparency of the research process. Based on this general methodological framework, the research decisions adopted for the study are outlined below.

4.1. Research Design

In accordance with the methodological approach described above, and in order to achieve the proposed objectives and address the research questions, a thematic analysis was conducted with the aim of analysing and identifying different types of thinking and their associated processes in relation to climate change, always from a geographical, axiological, and systemic analytical perspective.

To this end, a qualitative case-study design was adopted through a thematic–comparative analysis of discourse, following a deductive approach while allowing space for openness and emergence. This approach makes it possible to understand meanings, interpret discourses, and compare patterns of reasoning between groups (Miles et al., 2014), without seeking to assume causal hypotheses, recognising from the outset that expert knowledge derives from a situated construction that emerges through interaction with other experts. From this perspective, expert knowledge is not conceived as a set of prior and stable attributes, but as a situated construction that emerges through discursive interaction among participants in shared professional contexts.

4.2. Instrument and Context of the Study

For the analysis of the different discourses, a focus group was deliberately selected as the research instrument. The focus group was oriented towards the evaluation of the design of an online course for secondary school geography teachers on climate change and Geographic Information Systems. This course is part of the Erasmus+ KA2 project "GIS for GIST of Europe" (available at: https://gis-t.eu/). The online course is aimed at secondary school teachers from different European countries. It adopts a transdisciplinary approach, integrating scientific content on climate change, geographical competences, active learning methodologies, and digital tools. Its design is grounded in the TPACK model (Mishra and Koehler, 2006) and the principles of Rosenshine (2012), and is complemented by a repository of learning scenarios in which the use of GIS plays a particularly relevant role.

In this sense, the focus group is understood as enabling the construction of shared knowledge through argumentation and the negotiation of meanings regarding what should characterise specific knowledge. Transferring this principle to the expert domain, what experts "know" about how climate change should be taught is not a pre-existing product, but rather a phenomenon that becomes visible when they engage in meaningful discursive activities. This methodological choice is grounded in the critique by Jakobsson et al. (2009) of studies that conceive knowledge as a stable entity that can be measured through questionnaires. These authors argue that inquiry into this type of task emerges in communicative practices where interaction with "others" takes place through cultural, professional, or scientific tools embedded in disciplinary activities. The focus group precisely reproduces this discursive "action": experts' debate, question, validate, reject, or nuance ideas through direct interaction in an authentic professional context, thereby providing rich material for analysing how they conceptualise the teaching of climate change from systems thinking and non-axiological perspectives. This focus group was conducted using semi-structured questions. Although the session was organised around four open-ended questions, the development of the focus group did not follow a rigid order, but rather adapted to the interactions and discourses of the participants. The questions posed were:

1. *If you teach climate change, how do you teach it?*
2. *Do you miss any specific content in any of the five sections of the course? Which ones, and why?*
3. *Do you consider the teaching materials, learning methodologies, and proposed activities to be appropriate?*
4. *What would you add or change to improve this first part of the training course?*

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The role of the moderators and researchers was fundamentally that of facilitators, with their interventions limited to introducing the questions, requesting clarifications, or specific elaborations, and redirecting the discussion, when necessary, in order to keep it aligned with the objectives of the study.

Taken together, and without assuming a complete emergence of the data given that the study starts from clearly defined questions grounded in specific prior theoretical frameworks, the aim is to derive interpretative conclusions from the diverse perspectives shared among the experts that may (or may not) be immediately evident. In this sense, and following Jakobsson et al. (2009), using a focus group that addresses something as specific as a MOOC for secondary school teachers on climate change as an analytical element allows us to: (i) foster the emergence of specialised forms of reasoning; (ii) contrast different disciplinary perspectives (didactic, climatological, sociological, and historical, educational, or geographical); (iii) make visible the tensions between different educational approaches; and (iv) stimulate processes of metacognitive and epistemological reflection.

4.3. Participants

Participant selection was carried out based on the convenience of the study, taking into account the participants' level of expertise. In this regard, the first group was considered an expert group due to its members' professional experience and academic training in fields related to geography, geographical education, and climate change (see Table 1). The second group was composed of novice teachers (trainee secondary school geography teachers from the United Kingdom), all of whom were graduates in Geography and had also completed a Professional Studies module in Education.

In total, two focus groups were constituted, comprising 14 participants in the first group and 8 participants in the second group, excluding the researchers, who adopted the role of participant observers. The first focus group was conducted online, with the session recorded for organisational and logistical reasons, while the second was conducted face-to-face, with the session also being recorded. The professional profile of the informants in the expert group was distributed as follows (Table 1):

Table 1. Expert Focus Froup Composition (Source: Authors' own elaboration)

Number of participants	Profile of the participants
2	Climatology professor / doctor
3	Geography professor / doctor
3	Geography Education professor / doctor
2	Geography Teacher, Secondary Education
3	Social Sciences Education Doctor / Professor
1	Geology and Experimental Sciences Education Doctor / Professor

4.4. Procedure

The process of data collection and analysis was developed in a sequential and systematic manner through the following phases (Figure 1):

Recording and transcription of both focus groups, in order to obtain a complete textual corpus for analysis.

1. Pre-coding and initial coding of the discourses, aimed at identifying relevant units of meaning, combining prior theoretical categories with emergent open codes (Saldaña, 2009; Charmaz, 2006; Corbin & Strauss, 2015).

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2. Progressive categorisation through the "Categorization Cycle", in which the initial codes were reviewed, refined, and grouped into higher-order categories, according to their conceptual coherence and their relationship with the reference theoretical framework (Charmaz, 2006; Saldaña, 2009).
3. Identification of patterns, themes and relationships through the examination of categories, pre-established and emergent concepts, as well as the relationships between these codes, patterns, themes, and concepts, with particular attention to convergences and divergences between the discourses of both participant groups.

To ensure the quality and rigour of the qualitative analysis, the criteria of trustworthiness proposed by Lincoln and Guba (1985) were adopted, including credibility, transferability, dependability, and confirmability. Credibilitywas strengthened through triangulation and iterative checks; transferability through detailed contextual descriptions; and confirmability through reflexivity and peer review. The reflexivity of the research team was explicitly addressed as a practice to make underlying assumptions and analytical decisions transparent.

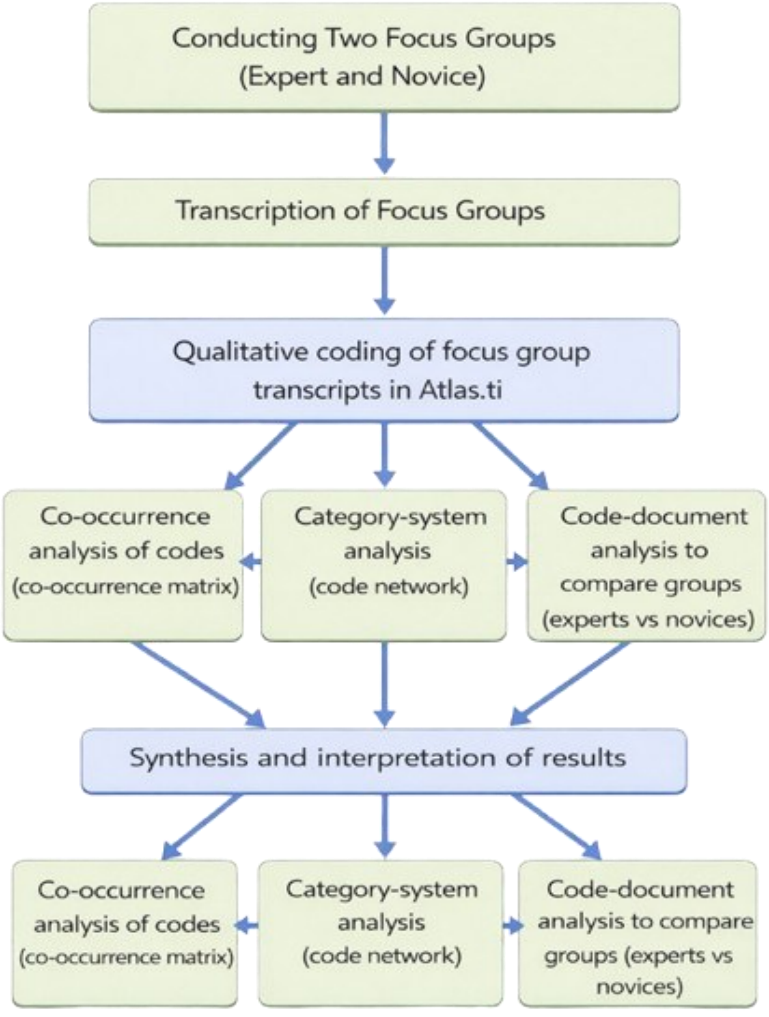

Figure 1. Methodological Process Scheme (Source: Authors' own elaboration)

The qualitative data analysis was supported by ATLAS.ti 25, a computer-assisted qualitative data analysis software (CAQDAS) designed to facilitate the systematic organisation, coding, and interpretation of textual data. The software was used to manage the corpus, assign codes to meaningful units, and progressively develop code groups and higher-order categories. Analytical tools such as code–document tables and co-occurrence matrices were employed to explore patterns and relationships between codes and categories. In addition, network views and analytical memos were used to support the iterative process of categorisation, enhance interpretative synthesis, and ensure transparency and trace-ability throughout the qualitative inquiry process.

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4.5. Limitations of the Study

This study adopts an interpretative qualitative design in which the comparison between expert and non-expert groups is intended as an analytical contrast rather than a statistically equivalent comparison. The aim is not to generalise results or measure differences in performance, but to explore how different forms of reasoning about climate change education are constructed across contrasting profiles. From this perspective, the unit of analysis is the discourse generated through group interaction. Consequently, variations in group composition or size are understood as consistent with the exploratory nature of the study and do not compromise the interpretative validity of the findings.

5. Results

Once the thematic analysis of the discourses generated in the two focus groups had been completed, different patterns of reasoning, perceptions, and discursive tensions in relation to climate change education were identified. The results are presented below in a series of progressively organised subsections, in accordance with the structure of the emergent coding and category system and their comparative distribution across both participant groups, with the aim of facilitating an interpretative understanding of the findings.

5.1. Resulting Codes and Categories about Experts' Way of "Geothinking"

The initial coding process generated a total of 65 codes, which were progressively refined and regrouped into 21 codes integrated within central categories (see Figure 2).

Figure 2 should not be interpreted as a simple hierarchical classification of codes, but rather as a relational network that represents the conceptual organisation of the analysed discourse. It visually distinguishes, on the one hand, core meanings associated with an expert-like geographical reasoning, and on the other, a set of discourses that tend to simplify or moralise climate change education. In this sense, the network highlights the centrality of categories such as *systems thinking*, *multiscale*, *non-axiological approach*, and *scientific perspectives/expert methods*, which are connected to codes such as complexity, cause–effect relationships, local scale, scale shifting, glocal perspective, use of evidence, use of official sources, metacognition, and theoretical caution. These associations suggest that, in more elaborate discourses, climate change is conceptualised as a complex, relational, and multiscalar socio-environmental issue that requires evidence-based reasoning and epistemological control of discourse.

In contrast, the same network also brings together categories and codes that reflect less complex forms of reasoning, such as *simplistic-linear*, *axiological discourse*, or *theoretical complexity (as problem)*. Within this pole, codes such as linear description, absence of multiscalar reasoning, theoretical oversimplification, moralisation of actions, ethnocentric perspectives, or the presentation of the SDGs as a single solution pathway can be identified. Therefore, the figure reveals that discourse on climate change education is not structured homogeneously, but rather through epistemological tensions between a systemic and critical understanding of the phenomenon and a more prescriptive, reductionist, or normatively driven approach.

Furthermore, the network suggests that some categories play a mediating role between both poles, particularly those related to the didactic dimension, such as *teaching science approach*, *active learning methodologies*, *GIS use*, *meaningful learning*, or *knowledge of students' beliefs*. This indicates that the construction of expert geographical thinking does not rely solely on conceptual knowledge, but also on how such knowledge is translated into teaching practices capable of addressing complexity without reducing it. In this regard, the figure visually synthesises the main analytical contribution of this phase of the study: identifying which discursive features bring climate change education closer to expert geographical thinking and which, on the contrary, distance it from it.

The analysis of the coding and category system reveals a complex discursive structure that extends beyond a mere aggregation of themes, reflecting instead a relational organisation of meanings. As illustrated in Figure 2, this structure is articulated around several interconnected conceptual cores. On the one hand, categories such as systems thinking, multiscale, non-axiological approach, and scientific perspectives/expert methods are closely associated with codes including complexity, cause–effect relationships, scale shifting, the use of evidence, and metacognitive awareness. These configurations point to forms of reasoning aligned with expert geographical thinking, in which climate change is conceptualised as a complex, relational, and multiscalar socio-environmental phenomenon that requires evidence-based reasoning and epistemic regulation of discourse.

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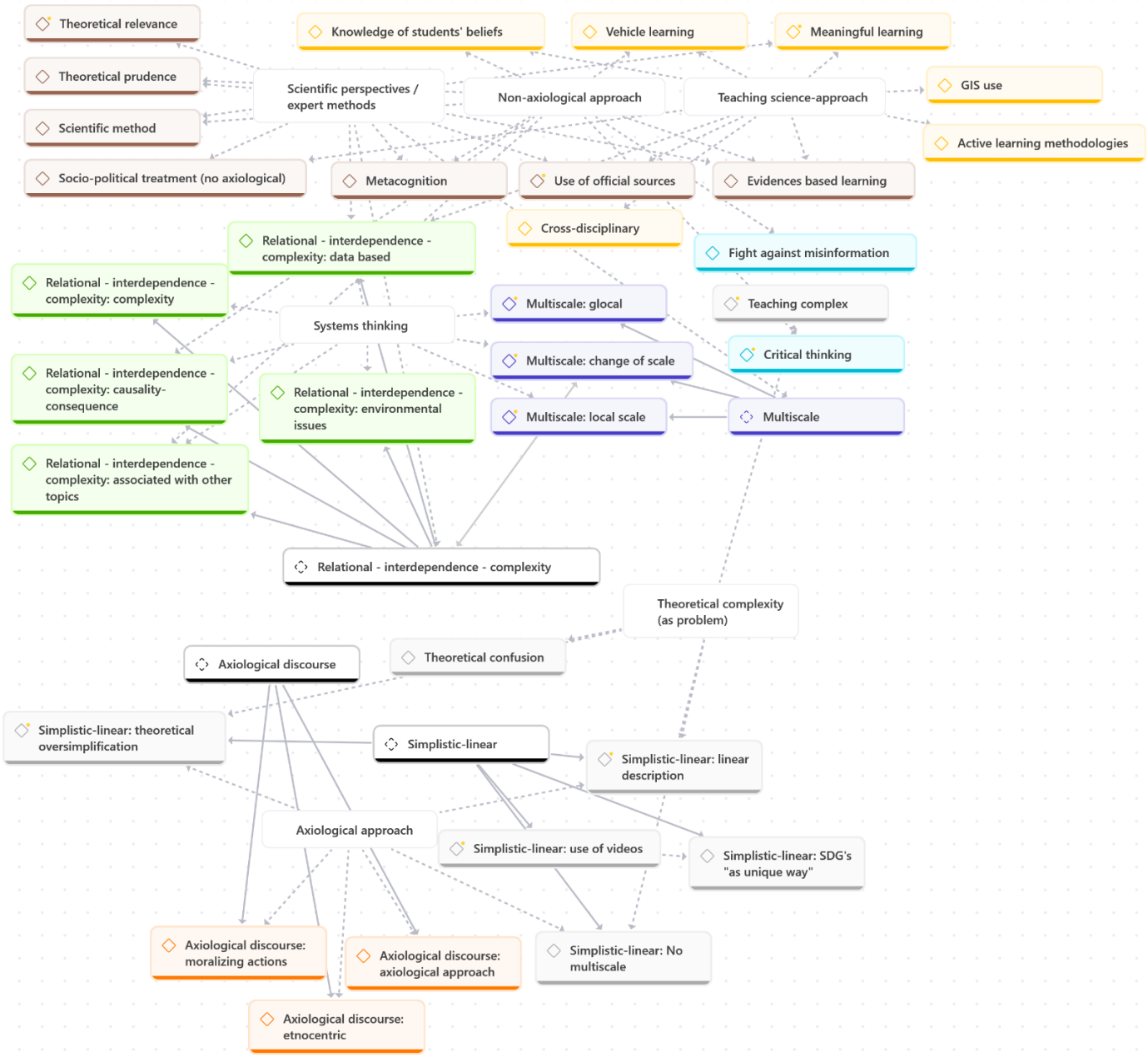

Figure 2. Network of Codes and Categories (Source: Authors' Own Elaboration)

On the other hand, the network also comprises clusters structured around categories such as simplistic-linear, axiological discourse, and theoretical complexity (as problem), which are linked to codes such as linear description, absence of multiscalar reasoning, theoretical oversimplification, and the moralisation of actions. These patterns reflect alternative modes of reasoning characterised by reductionist or normatively driven interpretations of climate change education.

The coexistence of these contrasting clusters within the same network underscores the presence of internal epistemological tensions in participants' discourse. These tensions are not merely conceptual but are structurally embedded in the relationships between codes and categories, with certain elements—particularly those related to didactic approaches (e.g., *teaching science approach*, *active learning methodologies*, or *GIS use*)—acting as mediating nodes between both poles. Thus, the network does not simply classify codes but reveals patterns of coherence, divergence, and contradiction that are essential for understanding how climate change education is conceptualised. The main categories can be grouped as follows:

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A. Centrality of Systems Thinking

One of the most consistent results of the analysis is the high density of the two categories that, in our analysis of expert discourse, encompass categories associated with geographical systems thinking (Figure 3). These are the category *Relational–interdependence–complexity* and the category *Multiscalarity*. The former category is articulated through various codes such as *complexity*, *causality–consequence*, or *associated with other topics*, where the participants in the study conceive climate change and its teaching as complex phenomena that are non-linear and that they address (or would address) through multi-causality, relationality, and from different perspectives (social, natural, philosophical, political, or ethical). This first category has a direct connection with the central category *Systems thinking*, reinforcing the idea that expert reasoning is grounded in systemic frameworks that seek to avoid reductive explanations and understandings of climate change.

On the other hand, the category *multiscale* also emerges strongly within expert discourse. Grouped under the codes *local scale*, *glocal*, or *change of scale*, it not only addresses explanations related to the concept of scale within geographical thinking, but also how this scale-based model articulates relationships and interdependencies within systems thinking. In this sense, scale functions as a dynamic analytical tool that is necessary for understanding the spatial distributions of the issue addressed and its teaching.

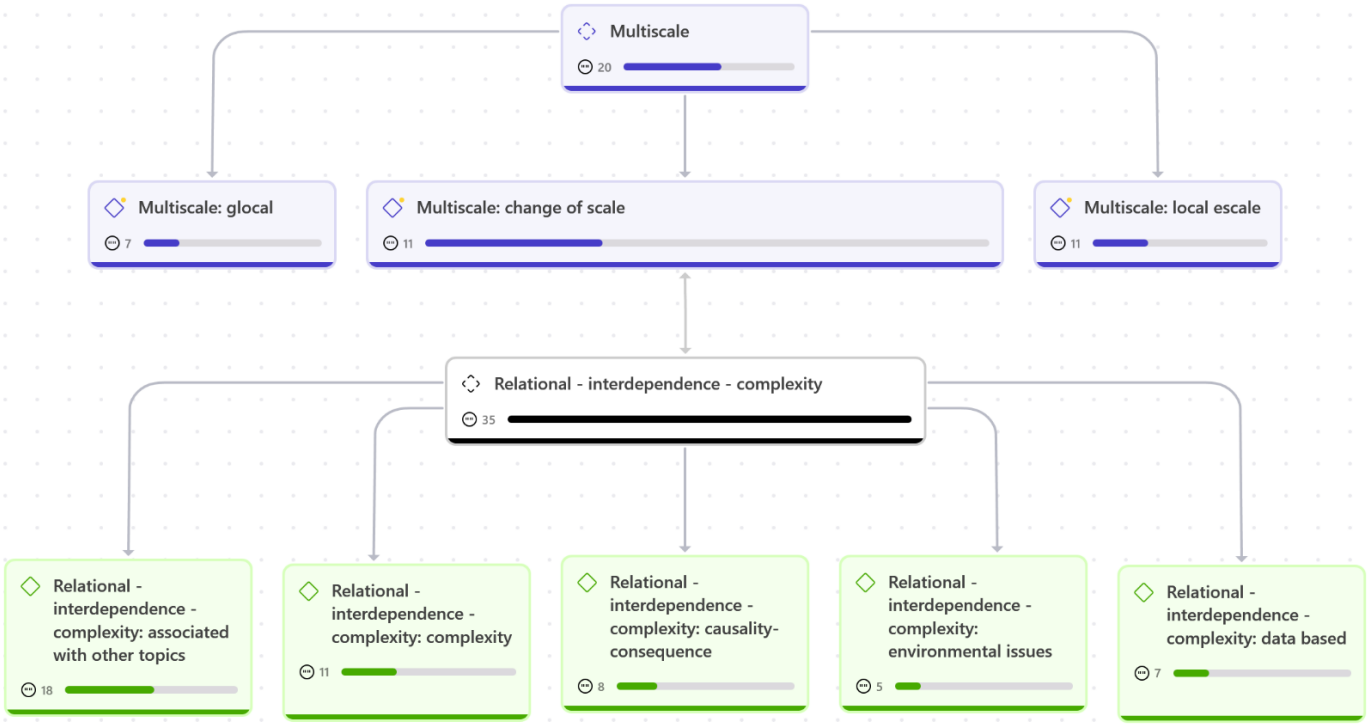

Figure 3. Geographic-System Thinking. Codes and Categories (Source: Authors' own elaboration)

B. Non-Axiological Thinking and Epistemic Control of Discourse.

Another relevant core of the coding and category system is articulated around the *non-axiological approach*. This is linked and structured around codes such as *use of official sources*, *evidence-based argumentation*, *metacognition*, *knowledge of students' ideas,* and *theoretical prudence*, and shows close connections with codes associated with systems thinking, such as *multiscalarity* or those related to relationality, interdependence, and complexity.

On the other hand, as can be observed in Figure 4, emergent codes such as *fight against misinformation* and *critical thinking* suggest, as noted in the theoretical section through Dearden (1981) and Miller (2004), that non-axiological thinking does not imply "passive neutrality", but rather a discursive strategy on the part of the teacher or expert oriented towards delimiting different levels of discourse (facts, values, and interpretations). In this sense, *theoretical relevance* and *theoretical prudence* also gain prominence, as they imply a reflexive self-regulation of the participant, ac-

knowledging uncertainties in which absolute truths are not assumed (in the case of prudence), or even assigning different degrees of importance to different elements or topics within scientific discourse, accepting the "non-neutrality" of education and its curriculum (in the case of relevance).

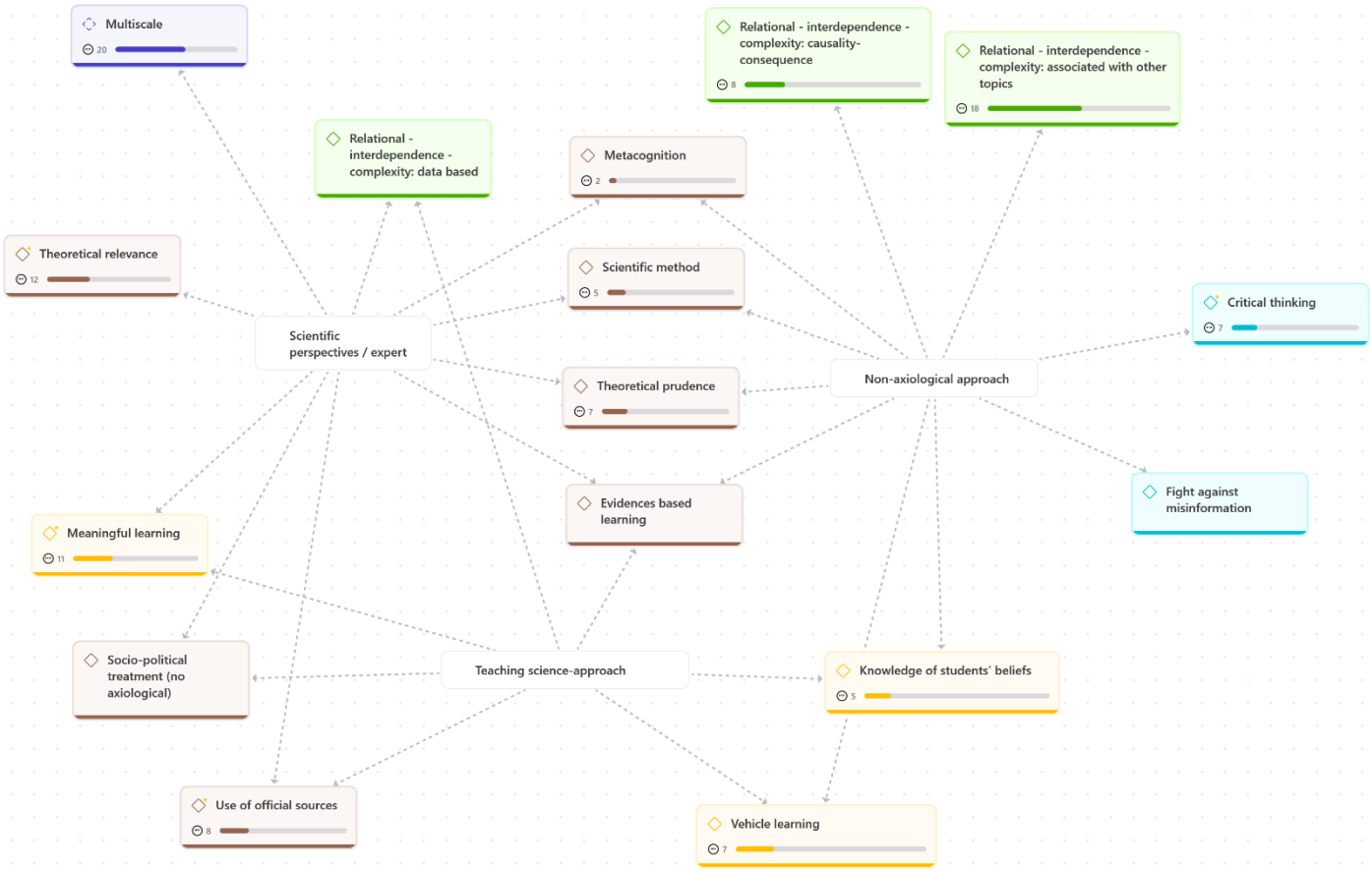

Figure 4. Non-Axiological Thinking. Codes and Categories (Source: Authors' wwn elaboration)

Finally, it is worth highlighting that the relationship between *non-axiological approaches* and *scientific perspectives / expert methods* reinforces the idea that this type of reasoning about educational issues from expert perspectives is grounded in practices inherent to scientific and geographical knowledge as modes of engagement. This includes the use of official sources, a socio-political treatment of climate change from non-moralising perspectives, and the application of techniques or theories from educational sciences (*vehicle learning*, *knowledge of students' beliefs*, *critical thinking,* or *meaningful learning*), as well as from subject-specific didactics (*GIS activities*, *use of official sources,* or *evidence-based*).

5.2. Tensions and Divergences Identified in the Discourses

In contrast to the two previous results, the system also reveals a set of categories and groups of emergent codes associated with axiological discourses (*axiological discourse* or *simplistic–linear*), which run counter to the approaches described above (Figure 5). Examples of these categories include *moralising actions*, *ethnocentric approaches*, *absence of multiscalar reasoning*, or their translation into climate change didactics (*use of videos* or *SDGs as unique way*).

In this regard, it is also worth highlighting a strong presence of codes that constitute axiological thinking through the absence or lack of theoretical grounding (*theoretical confusion*, *theoretical oversimplification,* or *theoretical complexity*). In general, these discourses appear in tension and in opposition to systems thinking and non-axiological thinking. As shown in the following paragraph, this is evidenced not so much as an epistemological rupture between approaches, but rather as the coexistence and combination of both paradigms within individuals' and groups' narratives.

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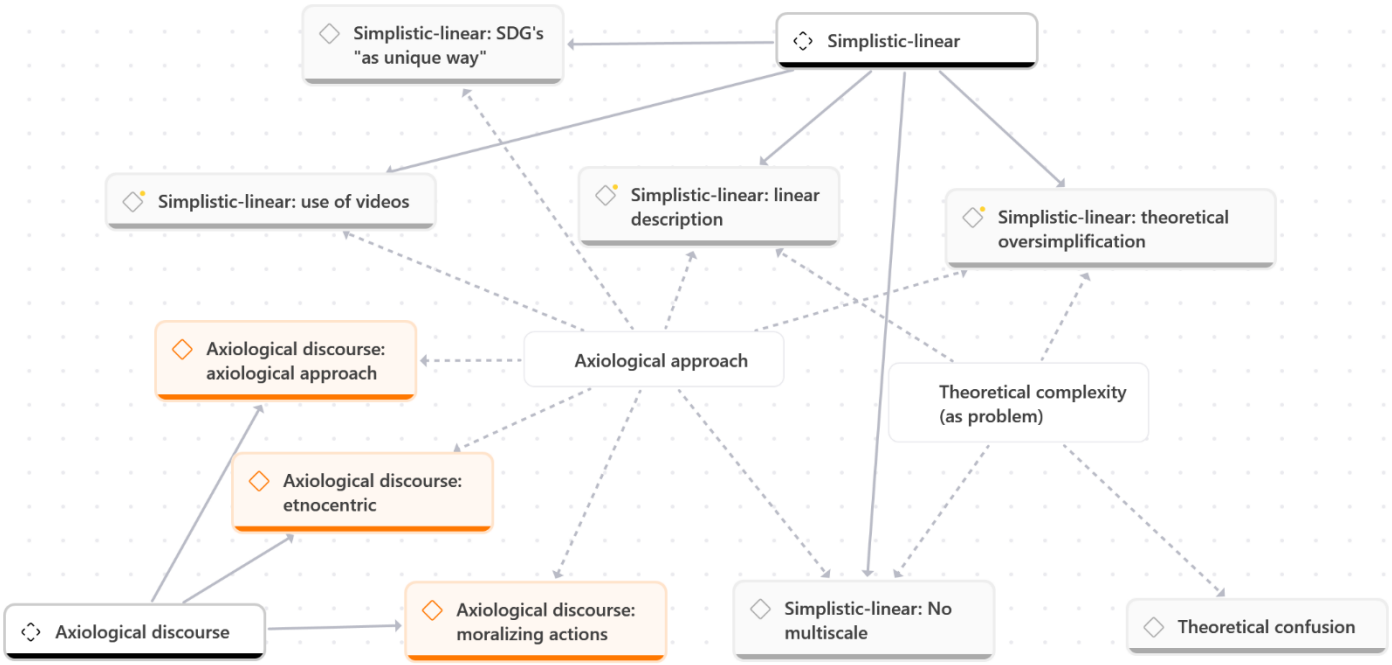

Figure 5. Emergence of Axiological Thinking: Categories and Codes (Source: Authors' own elaboration)

5.3. Comparison between Expert and Non-Expert Focus Groups

From a comparative perspective, the presence of categories and codes in both groups and their comparison allow us to observe certain similarities and differences in patterns of reasoning. Although in most cases, the different codes tend to align with what would be expected within an expert–novice thinking dualism—such as a greater prevalence of systems thinking, geographical thinking, or non-axiological thinking among experts—it is worth highlighting the following results (see Table 2).

The first result to be highlighted is that the volume of qualitative information related to the interactions established by participants in the focus group is greater in the expert group. There are notable differences in coding density between the expert group (n = 232) and the non-expert group (n = 116). This difference is particularly relevant when considering that the duration of both focus groups was relatively similar (45 minutes for the expert focus group compared to 32 minutes for the non-expert group). In addition to a higher number of codifications, the expert group also displays a higher frequency of interactions among participants, as well as greater length of these interactions. This pattern suggests a more detailed collective construction of meaning, likely due to a stronger theoretical command of the topic under discussion.

Although systems thinking appears, as expected, much more frequently in the expert group than in the non-expert group, this difference is particularly pronounced when considering the dimension of *multiscalarity*. In the expert group (Table 3), codes that associate climate change education with the concept of geographical scale appear recurrently: *change of scale* (n = 10) in experts compared to (n = 1) in non-experts; *local scale* (n = 10) in experts compared to (n = 1) in non-experts; and *glocal* (n = 7) in experts, while it does not appear in the non-expert group (0).

Table 2. Comparison of Categories between Expert and Non-Expert Groups (Source: Authors' own elaboration)

Expert teachers		**Non expert teachers**		
(%)	**Codes (sum)**	**(%)**	**Codes (sum)**	**Categories**
31.68%	17	68.32%	37	Axiological approach
66.33%	38	33.67%	19	Non-axiological approach

64.47%	63	35.53%	35	Scientific perspectives / expert methods
19.61%	8	80.39%	33	Simplistic linearity
60.19%	35	39.81%	23	Systems thinking
59.77%	43	40.23%	29	Teaching science approach
24.80%	14	75.20%	42	Theoretical complexity (as problem)

Table 3. Comparison of Codes "Multiscale" between Expert and Non-Expert Group (Source: Authors' own elaboration)

Expert teachers	**Non-Expert teachers**	
10	1	Multiscale: change of scale
7	0	Multiscale: glocal
10	1	Multiscale: local scale
27	**2**	**Multiscale (totals)**

Some examples extracted from the focus group transcripts that illustrate this set of results from expert perspectives are presented in Table 4.

Table 4. Examples of Expert Discourse Related to Multiscalarity (Source: Authors' own elaboration. Extracted from focus group interviews)

(…) I mean, starting from the local level seemed a bit like a joke at first, but I think that acting locally and its global consequences is what is interesting and what relates to activism. So, the topic works well. (...)
(…) I think climate change needs to be addressed, first of all, from a multiscale perspective, because it is a problem that affects multiple scales, and I also think that this very multiscalarity of the issue can help to organise the course, because I believe it is positive to start from the most general perspective of how climate change affects us as a global phenomenon, and then gradually become more specific (…) And then, another aspect that I think also needs to be transversal to this multiscalarity is the multidimensionality of the issue (...)

On the other hand, the comparative analysis of the focus groups shows a differentiated presence of *theoretical prudence* between the two groups. In the group of expert teachers, narratives explicitly associated with the delimitation of theoretical scope, the recognition of the limits of explanatory models, and the cautious use of concepts employed to address the teaching of climate change clearly emerge. These narratives are found exclusively in the discourse of the expert group and are absent from the non-expert group. In contrast, the group of non-expert teachers shows a higher recurrence of categories associated with *theoretical complexity understood as a problem*, but no narratives are identified that are coded as *theoretical prudence*. That is, although complexity appears recurrently in their discourse, it is not accompanied by discursive strategies aimed at regulating or problematising their discourse or the theoretical–scientific frameworks employed. This pattern reveals a clear difference in the ways in which both groups conceptually address the complexity of climate change.

Table 5. Examples of Expert Discourse Related to Theoretical Prudence (Source: Authors' own elaboration. Extracted from focus group interviews)

(...) I find it very difficult, a very complex question. I am not a specialist to… I can say what I do, and that already gives a clue (...)

> *(…) the issue in question 1 was whether we address it in class… and it makes me very uneasy. I think it is a very complex topic (…)*

Finally, within the expert focus group, codes close to axiological thinking are also identified. The data show that, although the expert group presents a high recurrence of categories linked to the use of scientific perspectives, systems thinking, non-axiological approaches, theoretical prudence, and epistemic control of discourse, codes such as *axiological approach* and *moralising actions* also emerge explicitly. The presence of these codes is neither isolated nor anecdotal, but rather integrated into moments of the discourse in which participants reflect on the educational meaning, the social responsibility of teaching, or the limits of teacher neutrality. These are concentrated in codes such as *moralising actions* or the *use of the SDGs as simplistic perspectives*. Although not predominant—since, as can be observed in Figure 6, there is a greater number of non-axiological approaches than axiological ones in the expert group—these findings reveal the coexistence of both forms of reasoning within expert discourse.

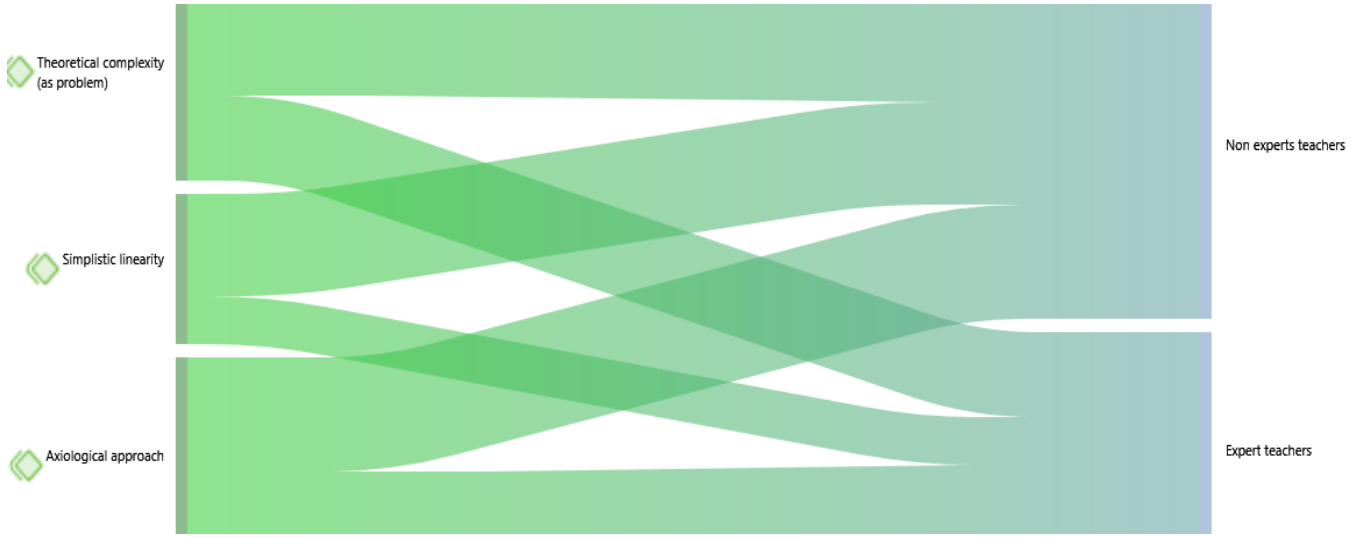

Figure 6. Flow Diagram of Axiological Categories by Focus Group Type (Source: Authors' own elaboration)

6. Discussion

Throughout the methodological process and the theoretical framework developed, this study contributes to achieving its main objective: to analyse and understand expert reasoning in geographical education through the teaching of climate change. In this context, the increasing complexity observed in the discourse is interpreted as a reflection of the cognitive and epistemological features associated with expert geographical thinking. Although the social sciences do not operate within the same paradigms as experimental or exact sciences, they do employ scientific features such as the use of scientific methods, the formulation of complex social problems, the use of empirical evidence and refutability, critical review, and the sources verification. The findings of this study support the idea that expert geographical reasoning is grounded in these principles. Importantly, the absence of absolute truths does not imply a lack of scientific rigour.

From the perspective of geography education, relatively few studies address climate change through the lens of expert and alternative conceptions. However, this approach is particularly relevant given the interdisciplinary nature of both conceptual change (Amin & Levrini, 2017; Guzzetti & Hynd, 2013) and climate change itself (Carrascosa et al., 2022; Schubatzky et al., 2024).

Findings from the expert focus group suggest that climate change education should be conceived as a complex and multiscalar formative process. This not only involves integrating scientific, geographical, and social knowledge, but also managing uncertainty and avoiding reductionist or overly simplified explanations. In this sense, these expert conceptions should not be separated from transdisciplinary frameworks that consider the cognitive, affective, and social

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dimensions of learning (Murphy, 2007). Such a holistic approach is particularly useful for understanding intersubjectivity within the multiperspectivity paradigm in geography and history.

An effective approach to geographical teaching should, therefore, be focused on identifying students' misconceptions and deliberately addressing them through targeted instruction (Havelková and Hanus, 2022). However, traditionally, geography teaching has been—and likely still is—far from these approaches, applying isolated and descriptive knowledge of "capes and bays" (Butt, 2010). Learning based solely on passive and encyclopedic knowledge can hinder the development of situated learning and metacognitive skills in students. In contrast, working with data, maps, and information sources is more consistent with active methodologies in geography education.

In addition, incorporating key geographical concepts such as scale, together with place-based learning (Smith, 2002), can support the transformation of students' alternative conceptions by connecting learning to local and everyday knowledge (Danaher, 2016). From a geographical perspective, climate change should be treated as a social science issue, without excluding other disciplinary perspectives. Its causes, consequences, and possible responses are deeply rooted in human activity and decision-making. Moreover, climate change is a spatially unequal phenomenon affecting territories differently depending on socio-economic or cultural factors. This includes ethical, social, and geopolitical dimensions. If we move beyond purely scientific conceptions, these causes are linked to human decisions and therefore require spatial, territorial, political, and lifestyle-based explanatory frameworks.

The discourse of the expert focus group reveals the coexistence of different categories and codes, including both approaches aligned with non-axiological thinking and the non-marginal presence of categories associated with axiological elements. Although axiological reasoning is often associated to non-expert geographical reasoning, in this study it should not be interpreted as a methodological inconsistency. Rather, it reflects a constitutive tension within expert reasoning, which is neither binary nor internally uniform. Within both groups and individuals, different forms of reasoning can coexist, particularly when addressing complex and socially controversial issues such as climate change education (Keller et al., 2019; Jasanoff, 2004).

From this perspective, axiological thinking does not function as the central organising principle of expert discourse. Instead, it operates as a complementary register that interacts with dominant evidence-based frameworks. Experts appear to navigate between the need to maintain rigorous, evidence-based, and non-prescriptive teaching, and the recognition that climate change, as a socio-environmental phenomenon, inevitably calls upon values, decisions, and positional standpoints. This tension is reflected in the alternation between moral, ethical, and scientific registers, without any of them completely cancelling out the others.

In addition, the emergence of *theoretical prudence* as a feature exclusive to expert discourse can be interpreted as a key indicator of expert reasoning, rather than simply a difference in content or discursive volume. Notably, although non-expert teachers frequently refer to the complexity of climate change, they do not articulate narratives of theoretical prudence. This may suggest that complexity is managed through strategies that simplify or reduce the scope of the explanation. By contrast, in the expert group, theoretical prudence functions as a way of regulating discourse and engaging with uncertainty.

The findings also highlight multiscalarity as a central feature of geographical reasoning. In the expert group, participants' changes in scale operate as a cognitive tool that enables the reorganisation of explanations of climate change, the connection between global processes and local manifestations, and the avoidance of overly simplified interpretations of the phenomenon.

This study also presents several limitations that should be considered when interpreting the results. First, the number of groups and participants limits the transferability of the findings to other contexts, although the methodology and research design employed are consistent with an interpretative–comparative thematic analysis approach (Miles et al., 2014). Second, the role of the research team in the coding and interpretation process must also be considered, as it entails an inevitable mediation of meaning and interaction with the qualitative data. This limitation has been addressed through procedures aimed at analytical transparency, internal coherence, and reflexivity, in line with the criteria of rigour and credibility proposed in interpretative qualitative research (Miles et al., 2014; Lincoln and Guba, 1985).

Overall, the results support the main objective of the study by identifying and characterising key features of expert geographical reasoning in climate change education through the teaching of climate change. In addition to the greater discursive volume observed in the expert focus group, the findings reveal differences in the organisation of reasoning, including a stronger presence of systems thinking, greater theoretical prudence, and enhanced epistemic control, as well as a more nuanced balance between non-axiological and axiological perspectives. In contrast, non-expert reasoning

tends to approach complexity as a problem to be reduced, more frequently resorting to linear or axiological explanations. These differences suggest that expert reasoning should not be interpreted as the accumulation of knowledge, but as a specific way of structuring, regulating, and communicating geographical knowledge in complex educational contexts. This provides a solid empirical basis for the notion of *Powerful Geographical Knowledge* applied to climate change education.

Finally, the findings open new lines for future research on alternative ideas and conceptual change from geographical perspectives. Further research could explore expert reasoning using the Structure–Behavior–Function (SBF) framework, widely used in systems thinking research in other disciplines (Hmelo-Silver, 2007). Expanding the study to a larger number of focus groups and to other educational contexts would also help to examine the stability of the identified categories and strengthen the transferability of the results. Moreover, the findings provide a basis for the development of instruments to assess dimensions of expert geographical thinking, as well as for the design of didactic and curricular proposals in geographical education.

7. Conclusions

Investigating expert geographical reasoning through the lens of climate change makes it possible to identify substantive differences in the ways knowledge is organised, regulated and communicated across different educational contexts. The results of this study show that this type of reasoning is characterised by greater discursive density, a more complex articulation of concepts, and a consistent integration of metaconcepts inherent to geographical thinking, such as scale from systemic perspectives, or epistemic control when addressing socially relevant and/or contested issues.

From an empirical standpoint, these differences are reflected not only in a greater volume and density of discourse within the expert group, but, above all, in the nature of the reasoning mobilised. Whereas expert teachers recurrently integrate systems thinking, multiscalarity, and theoretical prudence as strategies for addressing the complexity of climate change, the non-expert group tends to perceive such complexity as an obstacle, more frequently resorting to linear or simplifying explanations or to axiological approaches with weaker epistemic regulation. In this sense, the findings reinforce the idea that expert reasoning does not equate to greater declarative knowledge, but rather to a specific capacity to structure, hierarchies, and control discourse when engaging with complex and uncertain socio-environmental phenomena.

However, in our teaching practice, through this epistemic control, we must be aware that axiological thinking is not absent; it emerges not only in non-expert discourses but also in discourses considered expert. The coexistence of both types of discourse within the same individual or group should not be understood as a contradiction, but rather as a reflection of intrinsic characteristics of human reasoning and of complex and controversial issues such as climate change. In expert discourse, axiological elements do not function as the central organising axis, but rather as a complementary register that enters into tension and dialogue with evidence-based explanatory frameworks, whereas in non-expert reasoning they tend to occupy a more dominant position.

Teaching a topic laden with complexity within the social sciences (such as education or geography) necessarily entails negotiation between scientific explanations, curricular decisions, and eco-social responsibilities. Self-regulation through non-axiological thinking and an understanding of systemic perspectives—both key components of geographical thinking—may serve as ways of managing complexity. In this sense, understanding complexity, in most cases, involves accepting uncertainty. From this perspective, climate change education is not conceived as the transmission of closed answers, but rather as a formative space in which teachers articulate rigorous knowledge, geographical thinking, and educational responsibility in response to one of the main contemporary socio-environmental challenges.

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Contribution to the Special Issue Topics: This study contributes to the Special Issue by addressing powerful geographical knowledge and spatial thinking through the lens of climate change education. By comparing expert and novice teachers' reasoning, the article engages with critical, future-oriented pedagogies and explores how systems thinking, multiscalarity, and non-axiological reasoning can support geography teaching in uncertain times marked by socio-environmental complexity and contested knowledge.

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