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Uncertainty and its significance in geographical education: a comprehensive analysis

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ABSTRACT

Uncertainty is a phrase that is used in geography education, however its meaning and conceptualization differ. The word "uncertainty" is employed in several settings within the field of geography education, and this article provides an overview of those definitions and ideas. Because of the close relationship between their knowledge and their work in the classroom and in the lab, scientists and geography educators will find this review particularly useful. To achieve this goal, a comprehensive literature study was carried out. A total of sixty-three articles were chosen for this qualitative content analysis, and they were all published in English. It was clear from reading most of the articles that the word "uncertainty" does not have a single, definitive meaning; rather, the phrase is defined and specified implicitly and in relation to other authors' work (e.g. scientific uncertainty). A variety of methods, including those focused on science, knowledge, action, and decision-making, as well as other categories like actor groups and the temporal dimension, allow for many conceptualizations and definitions of the word uncertainty. This review of the literature covers all of these areas.

KEYWORDS

Uncertainty; geography education; systematic literature review; qualitative content analysis

Introduction

A growing number of educational and scientific initiatives are centering on the concept of uncertainty, which is related to the words "volatile," "uncertain," "complex," and "ambiguous" (VUCA) (Unger, 2019). This phenomenon has been at the forefront of scientific and public discourse since the 1970s, when ambiguities, nescience, uncertainties, and risk supplanted unambiguities, knowledge, and certainties. It occurs both theoretically and practically in various fields of educational science. Uncertainty is an inherent component of professional pedagogical practice (Böing, 2016) and educational thought and action (Paseka et al., 2018). Knowing what students are thinking while they learn, what learning processes are underway, and how students will respond to teachers' actions are all examples of situations where uncertainty arises in practice, both from an individual and an interactional viewpoint (Floden & Clark, 1988; Melville & Pilot, 2014; Paseka et al., 2018).
According to Janich and Rhein (2018), uncertainty is seen as an essential and fundamental feature of science in the field of geography, and it is addressed both theoretically and in practice within the discipline. Major scientific bodies are providing more thorough explanations of uncertainty in their publications. This includes the International Panel on Climate Change (IPCC) and the International Union for the Conservation of Nature (IUCN). According to Fusco et al. (2017) and the Intergovernmental Panel on Climate Change (IPCC, 2021, 2022), uncertainty is a central theme in geographers' scientific work

and in knowledge generally. According to Collins & Nerlich (2016), Schmid-Petri & Arlt (2016), and Stecula & Merkley (2019), media coverage of scientific uncertainty and consensus is on the rise and varies, which influences the comprehension of media consumers.

Given that geography education serves as a bridge between the two fields, it is vital to comprehend uncertainties as they manifest in geography and education in distinct ways. Different interpretations are common, and the understanding of geography teachers is closely tied to their research and teaching, so it's important to understand how uncertainty affects them and the definitions and conceptualizations of ideas they use. Nevertheless, concerns about the significance of uncertainty in the subject are brought up by the uneven use of uncertainty-related terminology in geography curricula. This paper's overarching goal is to define and explain uncertainty as it pertains to geography education. Based on this point of view, the following inquiry is warranted: Looking at it through the lens of geography education, how exactly is uncertainty conceptualized and defined? Therefore, we looked at the many meanings and applications of the phrase. Because of the growing amount of publications in the subject of geography education and associated areas, we choose to do a systematic literature review (e.g. Lane & Bourke, 2019; Puttick & Talks, 2022) to achieve this goal. Due to the increasing importance of ESD and GCED in (geography) school curricula or as cross-curricular themes, we expanded the scope of our review to include related concepts, such as global citizenship education (GCED) and education for sustainable development (ESD) (GermanGeographySociety, 2014). This is because geography education is devoted to the guiding principles of these two fields.

Materials and methods

Following the standards of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we performed a systematic literature review to get a complete and detailed overview of relevant literature (Moher et al., 2009). A well-defined research question, a structured and documented search protocol (Figure 1), and clearly defined selection criteria to determine which studies to include in the review are the building blocks of a systematic literature review, which aims to achieve the quality criteria of replicability, objectivity, and transparency (Boland et al., 2017; Gough & Thomas, 2016; Petticrew & Roberts, 2008).

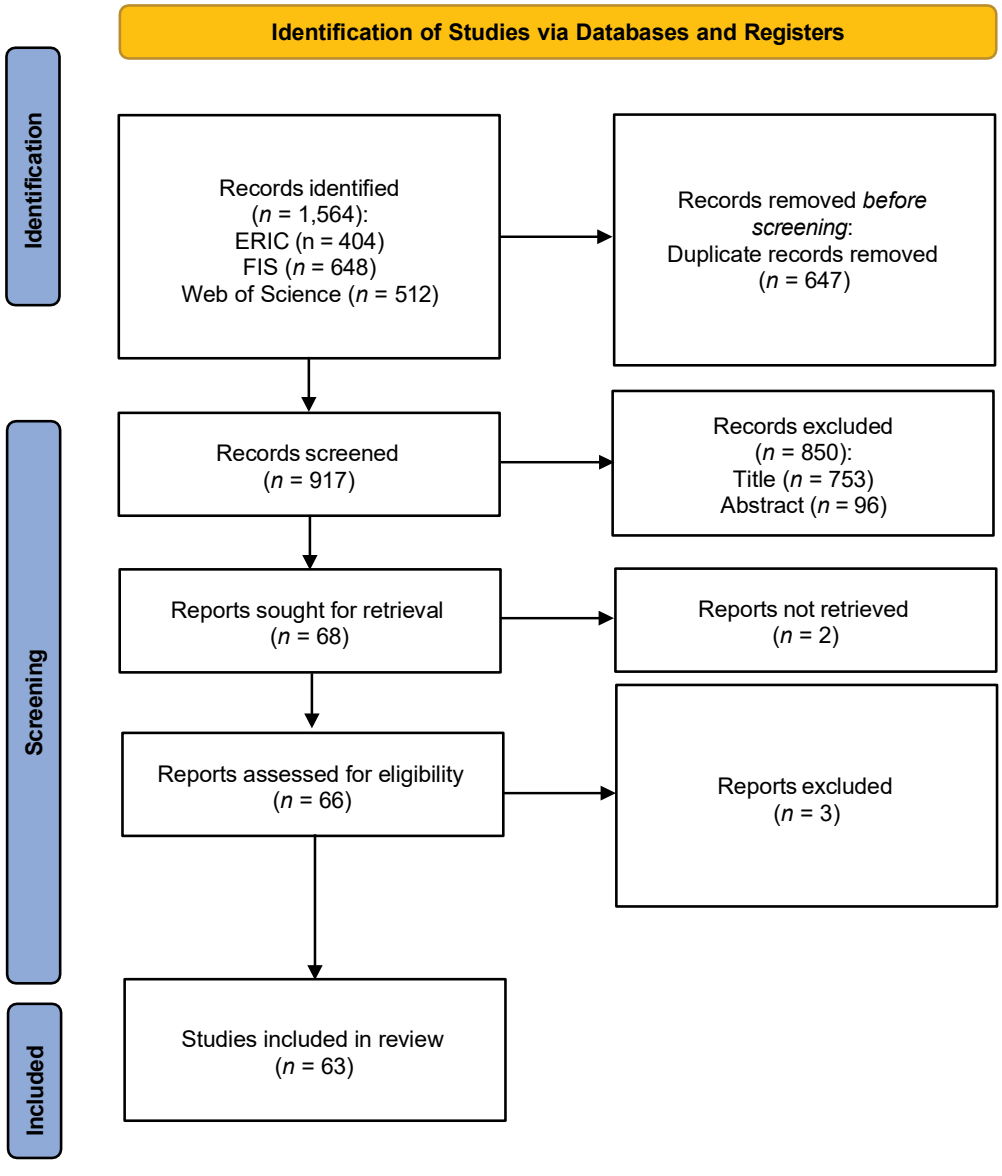

Figure 1. Overview of the systematic search process based on the PRISMA statement guidelines (Moher et al., 2009).

Data collection

The literature search took place in November 2021. As the search was for the definitions and concepts of *uncertainty* in the field of geography education, including in the related fields of ESD and GCED, the following search terms were selected in an iterative process, used, and linked with the operator 'and' in each case:

Uncertainty	and	geography education *OR* geography lesson *OR* climate change education *OR* sustainable development education *OR* global citizenship education

The term *uncertainty* was focused on due to its common use in different contexts. The terms *contingency* (Gray et al., 2010), *complexity*, *ambiguity* (Tauritz, 2012), and *risk* (Dahlbeck, 2014) were considered associated terms because they are related to the concept of uncertainty in terms of content and semantics and frequently occur in one or more denominations in publications. To contextualise these search terms, we also conducted a contextual analysis, but its focus was *uncertainty*.

The databases—Education Resources Information Center (ERIC), Fachinformations-System Bildung (FIS-Education), and Web of Science—were searched without the use of filtering functions, such as a timeframe, to achieve a holistic overview of definitions and concepts. The search was based on titles, abstracts, and keywords. The review protocol is available and can be requested from the authors.

From the results of this initial literature search (n = 1,564), duplicates (n = 647) were deleted. The remaining 917 records were screened, using their titles and abstracts, according to the following inclusion criteria:

- Independent of their place of publication,
- Independent of their year of publication,
- available in English,
- empirical as well as theoretical or conceptual,
- thematically focus on learning or teaching,
- domain-specific to geography, ESD, or GCED,
- related to school or higher education, and
- published in peer-reviewed and non-peer-reviewed journals or as project reports.

Based on these criteria, 63 publications were considered suitable for further analysis (Figure 1), so their full-text versions were downloaded.

Data analysis

A qualitative (structural) content analysis was performed on the 63 publications in accordance with Mayring's (2014) methodology. In order to identify the phrases used in relation to uncertainty, each article was reviewed. We used frequency analysis to tally up all of the recognized words. In the subsequent content analysis, the units of analysis were the contexts in which each phrase appeared. Appendices 1 and 2 include the iterative development of deductive and inductive categories used in the study, respectively. Paper type (e.g., theoretical vs. empirical), uncertainty definition (e.g., explicit vs. discipline-related), actor group (e.g., students), temporal dimension (e.g., future), strategies for dealing with uncertainty (e.g., avoidance), and related terms (e.g., complexity) were the primary categories utilized. Table 2 (refer to chapter findings) displays all of the major and subcategories. We made sure the papers were chosen based on dependability and validity by being explicit about the constructs and classifications. Furthermore, the chosen articles were intercoded individually by a member of the working group. Title and abstract selection had an intercoder reliability of 96.72 percent.

The materials were originally analyzed according to the categories after they were systematized coded. To achieve this goal, they were analyzed in terms of both the major and subcategories, relevant text excerpts were used to illustrate each, and relationships between them were defined in terms of the main and subcategories. It was also determined how often each subcategory occurred by using a crosstab (Mayring, 2014). Due to the paper's concentration on analyzing the words' meanings and underlying ideas in order to provide a synopsis of the terms' comprehension and use in relation to the notion of uncertainty in geography education, no additional categorization criteria were utilized. As a consequence, neither the study findings nor the quality of the papers that were considered for inclusion were evaluated.

Results

The term *uncertainty* is used in all the 63 selected publications. In addition, 16 specifications were found where the term *uncertainty* does not stand singularly but is placed in an initial context using other words (see Table 1). This already allowed conclusions to be drawn on the context of the term.

The detailed results of the content analysis of all the publications are presented in Appendix 3. Table 2 shows a summary of the most important results.

Table 1. Overview of the specified terms.

Specification of the term *uncertainty*	Publications (author & year)	Number of publications
Scientific uncertainty	Adams (2001), Busch and Osborne (2014), Henderson etal. (1993), Labosier and Fay (2019), Mortensen (1996), Pallant and Lee (2015), Román and Busch (2016), Summers and Childs (2007), Mortensen (1996), Román and Busch (2016), Ruggeri (2011), Summers and Childs (2007)	12
Structural uncertainty	Colucci-Gray et al. (2013), Labosier and Fay (2019), Ruggeri (2011), Schauss and Sprenger (2021)	4
Ontological uncertainty	Davidson et al. (2021); Pawson (2015), Ruggeri (2011)	3
Epistemological uncertainty	Pawson (2015), Ruggeri (2011)	2
Knowledge uncertainty	Tauritz (2012), Tauritz (2019)	2
Personal uncertainty	Pallant and Lee (2015), Pawson (2015)	2
Student uncertainty	Schauss and Sprenger (2021), Tonts (2011)	2
Value uncertainty	Ruggeri (2011), Schauss and Sprenger (2021)	2
Climate change uncertainty	Schauss and Sprenger (2021)	1
Confident uncertainty	Lambert (2002)	1
Disciplinary uncertainty	Schauss and Sprenger (2021)	1
Environmental uncertainty	Crossley (2019)	1
Global uncertainty	Crossley (2019)	1
Positive uncertainty	Tauritz (2012)	1
Subjective uncertainty	Ruggeri (2011)	1
Teacher uncertainty	Melville and Pilot (2014)	1

Table 2. Results of the frequency analysis.

Main category	Subcategory	Number of publications (*n* = 63)
Type of publication	Theoretical/conceptual	30
	Empirical	33
Type of definition of *uncertainty*	Explicit definition	3
	Reference to other sources	3
	Implicit definition	42
	No definition	15
Discipline-related references to uncertainty	Geographic subject	47
	Education	27
Actor group	Scientists	9
	Students	37
	Teachers	21
	Society	6
	Non-specified	14
Temporal dimension	Past	2
	Present	11
	Future	26
	Non-specified	33
Ways of dealing with uncertainty	Recognition	7
	Coping	29
	Use	8
	Avoidance	3
	Non-specified	26
Associated terms/contextualisations	Complexity	39
	Ambiguity	10
	Risk	11
	Contingency	4
	Controversy	10

Type of publication

The empirical portion accounts for 33 of the 63 papers, whereas the theoretical or conceptual portion accounts for over half (30 out of 63), as shown in Table 2. A thorough examination (refer to Appendix 3) reveals no correlation between the kind of publishing and the type of definition. Similarly, there is a near-parity of coverage across publications pertaining to geography (20 empirical and 16 theoretical or conceptual), education (8 empirical and 8 theoretical or conceptual), and both topics (5 empirical and 6 theoretical or conceptual).

Type of definition of uncertainty

In 10%(6) of the articles, the word uncertainty is defined unambiguously, either by citing other sources or by providing an explicit definition (3). The geographic topic is defined in four publications, whereas education is defined in two; yet, a fundamental ignorance is consistently mentioned in all of these publications. Appendix 1 is one example of a publication that makes use of implicit definitions; this accounts for 42% of the total publications. A lack of a precise definition or citation is seen in fourteen percent (15) of the publications. The word "uncertainty" is instead used without elaboration or context.

Referring to uncertainty in the context of a discipline Uncertainty is directly linked to location in 36% of the papers (57% for Colucci-Gray and Feng, 2014 and 25% for other publications). both domains in 18% (11) of the papers (McKeown, 2013; Melville & Pilot, 2014), education (Higde et al., 2017; Jones et al.,

2008). You may see this in action in these three places: The phrase "disciplinary uncertainty" was coined by Schauss and Sprenger (2021) in reference to geography. As will be shown in the following paragraphs, there is a distinction between the references to uncertainty in relation to science and knowledge in this context. Lacking a clear definition, Tauritz (2019) used the phrase knowledge uncertainty. "What one person experiences as uncertain knowledge, for instance, because he doesn't know the source, could be experienced as certain knowledge by someone else who does recognize the source and judges it as trustworthy," he said, drawing a connection between uncertainty and knowledge and noting that the perception of this uncertainty is very subjective (Tauritz, 2019, p. 302). According to Condeza-Marmentini and Flores-Gonzalez (2019), uncertainty is mentioned as an intrinsic characteristic of Earth, its climate, and environmental systems in 44% (28) of the articles. These themes are also connected to environmental concerns. While Crossley (2019) used the word "environmental uncertainty" to describe the latter, Schauss and Sprenger (2021) used the word "climate change uncertainty" to describe the former in relation to climate science. Occasionally, the reference is broadened to encompass sustainable development in its entirety (Colucci-Gray et al., 2013; Condeza-Marmentini & Flores-González, 2019; Feng, 2012; Hasslöf, 2015; Lundholm & Plummer, 2010; Román & Busch, 2016; Tauritz, 2019). In this regard, Summers and Childs (2007, p. 311) referred to "real world problems," stating that "[pro-blems are] often so complex and the evidential basis so uncertain that science cannot provide any definite conclusions." Both Davidson et al. (2021, p. 324) and Crossley (2019) used the phrase "changing and uncertain world" to describe this, while Davidson used the word more broadly. Along with knowledge, uncertainty is seen as a fundamental component of geography. Table 1 shows that the phrase scientific uncertainty was used to indicate uncertainty in several publications. It is worth noting that there is already a newer IPCC report; however, the articles that were analyzed utilized the older one. The IPCC report (2007) is being used as a definition in this context more and more (Busch & Osborne, 2014; Ruggeri, 2011; Schauss & Sprenger, 2021). The following is the definition of uncertainty given in the IPCC report: A measure of how little is known about a value (like the climate system's future) because to factors like a lack of data or differing opinions on what is known or even whether it can be known. It might originate from a variety of places, including quantitative data mistakes, poorly defined ideas or language, or speculative predictions about human behavior. Therefore, quantitative measurements (such as a range of values computed by different models) or qualitative assertions (such as expressing the judgement of a panel of experts) may both be used to communicate uncertainty. View also probability. According to Ruggeri (2011), p. 22f., and the IPCC (2007),

According to the IPCC report (2007, cited in Ruggeri, 2011), there are three types of uncertainty in this context: (1) value uncertainty, which is associated with uncertainty in empirical data; (2) structural uncertainty, which is associated with uncertainty in models; and (3) unpredictability, which arises from modeling complex systems, including the stochasticity of future human behavior.

Additionally, Pallant and Lee (2015) defined scientific doubt and made note of its origins. They brought attention to the fact that science has both conceptual and methodological limits. Ruggeri distinguished four forms of scientific doubt, citing previous writers, in 2011 (p. 29): First, there is the epistemological uncertainty that comes from using empirical methods like experimentation and natural observation; second, there is the epistemological uncertainty that comes from using theoretical methods like numerical or conceptual modeling. (3) Uncertainty at the ontological level, which results from the inherent stochasticity of complex systems; (4) Uncertainty at the subjective level, which derives from biases at the individual, institutional, and societal levels.
In discussions of educational uncertainty, the emphasis is usually on the processes of teaching and learning, on the individuals involved, or, less often, on the dynamics between these groups. However, as may be seen in Perkins et al. (2018, p. 1043), uncertainty is seldom examined in a broad educational context that does not pertain to the field of geography or to uncertainties in scientific or knowledge-based information. "presenting scientific knowledge in all its manifestations as predicated on an inherent degree of complexity, uncertainty, and nuance." As an exception, Melville and Pilot (2014) published on schooling alone, ignoring geographical context and scientific ambiguity:

Pedagogical practice is fraught with uncertainty for many reasons, including but not limited to: the absence of a universally accepted body of knowledge; divergent viewpoints on educational objectives and methodologies; the presence of competing and sometimes contradictory values in the field; and the intricacies inherent in interacting with and collaborating with people. Referenced in Melville and Pilot (2014), p. 353, is Helsing's 2007 work.

Perkins et al. (2018) and Schauss and Sprenger (2021) both characterize climate change education as intrinsically fraught with uncertainty. (Condeza-Marmentini & Flores-González, 2019, p. 1) states that ESD and environmental education have both embraced the ideas of complexity and uncertainty from the field of environmental science. Several works (e.g., Feng, 2012; Perkins et al., 2018; Petschel-Held et al., 2001; Sterling et al., 2010; Tauritz, 2019) have proposed specific strategies for fostering competence in handling ambiguity. Also, theories of transformational learning are utilized as guiding principles in dealing with ambiguity (Condeza-Marmentini & Flores- González, 2019; Perkins et al., 2018; Sterling, 2010), which can be said as a result of the thematization of transformational learning in the knowledge society. Here, educators have a responsibility to discuss uncertainty with their students and equip them to make decisions in the face of ambiguity. As a result, educators need new forms of formative assessment and feedback that include risk-taking (Davidson et al., 2021).
It must be noted that publications pertaining to geography, education, or geography education include distinct areas of uncertainty when compiling references from various disciplines. Methods for handling various allusions to uncertainty in the context of geographical education are thematized. Geography is the subject of the following section.

education and fully examines the many disciplinary allusions to uncertainty within this framework.

Strategies for coping with ambiguity

Recognizing uncertainty, coping with it, utilizing it, and avoiding it were the four approaches indicated throughout the articles.

[1] Uncertainty was acknowledged in seven papers, accounting for 11% of the total. They cope with ambiguity by accepting it for what it is. Henderson et al. (1993, p. 1) proposed a number of objectives, including the ability to recognize uncertainty: "(1) introduce students to scientific inquiry [and] (2) clarify the function of uncertainty in scientific inquiry."
[2] in In over half of the articles (46 out of 29), the authors discuss the difficulty of dealing with unknowns (Schauss & Sprenger, 2021). Recommendations for dealing with uncertainty and the need of accepting or promoting it are the main points. One example is the suggestion made by Wals (2010, referenced in McGregor, 2013, p. 3576) that we should focus on accepting uncertainty as a given and not trying to overcome it. Another strategy for coping with ambiguity that Fortuin and Bush (2010) outlined was maintaining an open and adaptable mindset. Here, teaching requires knowing what it's like to be unsure, having strategies for dealing with it, and encouraging students to develop "uncertainty competences" (Tauritz, 2012, p. 299) and the ability to make decisions when faced with unknown outcomes (Colucci-Gray, 2014). In addition, Lambert (2002) said that one objective for educators in this field is to foster students' confident uncertainty. One strategy for coping with uncertainty is to use it as a learning opportunity, which is discussed in nine articles, or fourteen percent of the total. Alderman et al. (2021, p. 190) argues that when shared and thoroughly evaluated, uncertainty may be a valuable resource for enhancing practices and results. So, it's important to put it to good use, which entails more than simply waiting for things to settle down.
In contrast to employing uncertainty, which is present in 5% (3) of the papers, avoiding uncertainty might be seen as the polar opposite. "Uncertainty avoidance [...] measures how the people feel threatened by the unpredictability of the future and therefore try to ensure certainty through rules and regulations," said Kirschner and Peltan (2019, p. 405). That's the definition of uncertainty avoidance. This has led to a drive to reduce unpredictability.

Performer ensemble

Most of the published works on the topic of geography education uncertainty focus on the role of instructors and pupils. Nearly 60% (37) of the publications center on educators, while 33% (21) center on students. A large number of articles focus on how educators and their students cope with or ought to cope with ambiguity. Melville and Pilot (2014) and

Totts (2011) are two articles that use the phrases teacher uncertainty and student uncertainty, respectively, to describe this phenomenon. That these actor groups are so prominent in the media is evident from this.
Uncertainty surrounding scientific activity is addressed in nine papers, accounting for fourteen percent of the total. According to many sources, including Ruggeri (2011), the word "scientific uncertainty" has diverse meanings to scientists and the general public. The journals' articles

argue that the phrase is understood differently by scientists who use it to talk about the likelihood of particular outcomes and by the general public who use it to mean "not knowing" (Busch & Osborne, 2014).
Society is mentioned as an entity in six out of ten articles, particularly those that deal with societal and social life-related future developments (Busch & Osborne, 2014; Julien et al., 2018). In light of this growing sense of unpredictability, the concept of a "learning society" may take root, posits Feng (2012).

Temporal dimension

On this front, 3% (2) of the articles discuss the past, 17% (11) discuss the present, and 41% (26) discuss the future as sources of uncertainty. Since the past may only be roughly recreated, for instance in the case of climate change using models, uncertainty pertains to imperfect knowledge, interpretations, and conclusions with respect to the past (Ruggeri, 2011). Today, uncertainty is not knowing anything for sure or having to cope with a scenario where you don't know what to do. Dahlbeck said, "the future is shrouded in uncertainty" (2014, p. 158), when asked about what lies ahead. Future (sustainable) development was a topic he brought up, as it was in many other articles. The publications address the need to improve students' and instructors' future competences, since sustainability challenges tend to be future-oriented. Making decisions in the face of ambiguity about sustainable development (Davidson et al., 2021) and climatic projections (Busch & Osborne, 2014) are examples of such competences.

Related concepts/settings
Many of the articles also make reference to other concepts or words while discussing uncertainty. The word complexity is used in reference to uncertainty in 62% (39) of the articles, particularly when the topic is geography. Belluigi and Cundill (2017) and Condeza-Marmentini and Flores-González (2019) both draw attention to the environmental system's intrinsic complexity and its ramifications for education. Concerning other phrases that appear often, sometimes with uncertainty, we find: controversy in 16% of the articles (10 total), risk in 17% of the publications (11), ambiguity in 16% of the publications (10 total), and contingency in 6% of the publications (4). Although these words are not thoroughly examined in this study, they are emphasized as important linked terms. This is because the comprehension and use of these terms are not the main focus of the research, likely because they appear less often in the

publications.

Discussion

The purpose of this article is to provide a synopsis of the many ways in which geography curricula have conceptualized and defined uncertainty. Our literature search revealed that most of the articles we looked at either do not describe uncertainty at all, define it only implicitly, or express it partially via specifications. One possible explanation is the widespread usage of the phrase "uncertainty" in common language, which might lead to a consistent

It is expected that people understand it, and even in scientific discourse, an explicit description is seen as outmoded. The lack of clarity on the underlying understanding and kind of doubt around the term's usage in the publications led to critical views of this. Our in-depth research, however, revealed that one's perspective and the surrounding circumstances determine how ambiguity is understood. According to Busch and Osborne (2014), students may not have the same perspective on uncertainty as scientists. We found that the word "uncertainty" was used in a variety of ways and by various academics in the chosen fields. Similar findings have been found in other branches of educational science where the concept of uncertainty is either not well defined or when several interpretations of the word are debated (Bähr et al., 2019; Böing, 2016; Paseka et al., 2018).

Figure 2 shows that while discussing uncertainty in geography education, two extremes emerged from the variety of meanings found in the published works. With a heavy emphasis on geography as a field of study in geography education, one side of the coin discusses uncertainty in terms of scientific and knowledge-based uncertainties. Topic complexes pertaining to the future in ESD and GCED are addressed, with a focus on research heuristics and epistemological conditions as they pertain to (geography) science. On the one hand, uncertainty is thought of as an essential component of knowledge; on the other, it is addressed as uncertainty in action and choice. Interactions between instructors and their students are seldom investigated, despite the fact that the focus is on how people (i.e., students and teachers) handle ambiguity and how to do so competently and professionally. Publications concentrate on coping strategies and related abilities as a means of handling uncertainty (Tauritz, 2019). The examined articles on geography education do not focus primarily on decision-making. This comes as a surprise since uncertainty is intrinsic to decision-making and is often associated with decision-related concerns.

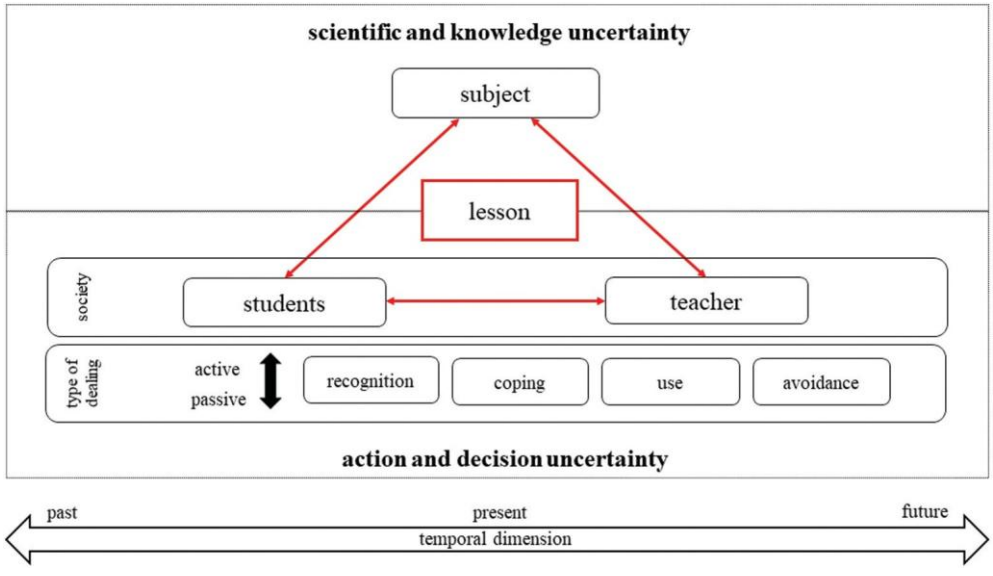

Figure 2. Systematization of reference points for the definition of uncertainty.

theory in a formal—typological sense. From a temporal perspective, dealing with uncertainty is often linked to the future, and consequences of actions are discussed.

Research gaps

What follows is an inventory of further research gaps that we uncovered after conducting our comprehensive literature assessment. As a first point, studies on scientific and knowledge-based doubt still lack key necessary components. For issues pertaining to sustainable development in particular, it became clear that there is an inherent and subject-specific element of uncertainty in the geographical area. How and to what degree this ambiguity is and ought to be conveyed to educators and learners, say, in educational texts, is still up in the air.

Also, there is a lack of study on the topic of action and decision-making. We still don't know (1) how educators and students see uncertainty, (2) which of the current understandings of uncertainty they choose to accept, and (3) which understanding should be actively supported. Various approaches to handling uncertainty were found in the articles that were considered. However, two things are still not clear: (1) how to encourage strategies for effectively handling uncertainty, such training educators and students to make decisions when faced with ambiguity, and (2) what elements are the most important in shaping these strategies. Additionally, this begs the issue of (3) how geography teachers may make the most of uncertainty as a teaching tool. Thirdly, despite the potential causative and conditional connections, it is unusual to see discussions of scientific and knowledge uncertainty and action and decision uncertainty in the same publication, even at the individual level (e.g., among students and professors). Potentially intriguing for future studies in geography education is the idea of a twofold bias, which might provide light on how both students and instructors handle subject-specific uncertainty, such in the case of climate models.

Limitations

A high level of representativeness in the findings is a consequence of this systematic literature review's strength—its formal, methodical approach. To make this more representative, more literature databases like Google Scholar might be included. The same logic applies to adding additional search phrases that are either directly related to or used interchangeably with the current set of terms. Some examples of such words include uncertainty, risk, contingency, non-knowledge, and ambiguity.
The exhaustive procedures used to conduct this research make the likelihood of publication bias minimal (Moher et al., 2009). Nevertheless, there is a little publishing bias due to the usage of only English-language journals. Reproducibility is no longer considered an important metric for reliability and validity in qualitative content analysis; instead, what matters are procedural documentation, argumentative interpretive assurance, subject matter proximity, rule guidance, communicative validation, and triangulation (Mayring, 2014). Further categorization may have been achieved by dually separating the articles that were empirical from those that were theoretical or conceptual. But it doesn't seem to be straightforward to put into action, as theoretical articles usually include normative inserts and are therefore indistinguishable from conceptual articles.

Conclusion

In this systematic review of definitions and concepts of *uncertainty* in the field of geography education, consistent usage of the term was not found in the analysed publications. Different approaches to and contexts of uncertainty were distinguished, which are at least partly interrelated. The summarised differentiation between *scientific and knowledge uncertainty*, as well as between *action and decision uncertainty*, makes clear that different theoretical frames for the discussion of uncertainty in the context of geography education are used. *Scientific and knowledge uncertainty* is embedded in a disciplinary discourse with geography as the subject in the foreground, whereas *action and decision uncertainty* is embedded in a discourse about general questions of interaction in educational settings and the situation of individuals in such settings (teachers and students). Consequently, both of the comprehensions of uncertainty mentioned at the start of this paper, from the perspective of geography (e.g. IPCC, 2022) and education (e.g. Böing, 2016), were found. This result is not surprising since geography education combines the two fields in an interdisciplinary way.

Summing up, it can be said that uncertainty—among other characteristics—is constitutive and omnipresent in the context of geography education. Geography scientists and teachers, as well as students, are confronted with scientific, knowledge, action, and decision uncertainties due to subject-specific challenges and have to learn to deal with them. This requires different competencies (Feng, 2012; Perkins et al., 2018; Sterling, 2010; Tauritz, 2019). If dealing with such different uncertainties is the goal of geography education, there is a need to promote (1) a clear understanding of different forms of uncertainty, (2) an open and critical discussion about adequate handling of uncertainty, and (3) a reflection on different ways of dealing with uncertainty. This gives rise to several research gaps.

Due to the multiple points of reference of uncertainty, the related multi-perspective richness of its facets, the diffuse understanding of the term, and the many research gaps related to it, this review was a promising starting point for further research. Especially in view of increasing changes and opportunities in the VUCA world (Unger, 2019), uncertainty-related topics represent an exciting field of research in the field of (future) geography education.

References

Adams, S. from 2001. An examination of the perspectives of high school pupils and climate change experts on the uncertainty surrounding this topic. Volume 6, Issue 1, pages 58–76, Canadian Journal of Environmental Education.

In 2021, the authors named Alderman, Narro Perez, Eaves, Klein, and Muñoz published a paper. Teaching as regional storytelling: on the topic of operationalizing an anti-racism pedagogy. Volume 45, Issue 2, pages 186–200, Journal of Geography in Higher Education. 1661367 https://doi.org/10.1080/03098265.2019.

In 2019, Bähr, Gebhard, Krieger, Lübke, Pfeiffer, Regenbrecht, Sabisch, and Sting published a paper along with Gebhard, Krieger, Pfeiffer, Böhm, and Sting. Upset as an opportunity. Wiesbaden: Springer Fachmedien. The information may be found at this URL: https://doi.org/10.1007/978-3-658-20293-4.

Publication: 2017 by Belluigi and Cundill. Reimagining environmental science education via the creation of conducive learning environments for the growth of critical thinking abilities. Environmental Education Research, volume 23, issue 7, pages 950-971. The link to the article is https://doi.org/10.1080/13504622e2015.1072802.
In 2019, Benninghaus, Mühling, Kremer, and Sprenger published a study. Mysteries as a data mining tool for sustainability education—the complexity of teaching responsible purchasing habits. Articles 722–738 in the journal Sustainability, volume 11, issue 3. The address of the article is https://doi.org/10.3390/su11030722.
It was Böing (2016). Ungewissheit: Die Auswirkungen einer grenzenlosen pädagogik auf inclusive schulische Konzepte und Methoden. Be-Hinderung der Teilhabe: soziale, politische und institutionelle Herausforderungen inklusiver Bildungsräume (pp. 95-114), edited by U. Böing and A. Köpfer. Publication Julius Klinkhardt.
Three authors (Bolland, Cherry, and Dickson, 2017). An Introduction to Systematic Reviews for Students. Written by SAGE.
With Bergman, E. (2014) and Borg, C. (author). Differences in teachers' conceptual understanding of sustainable development based on subject and experience. Publishing in the journal Environmental Education Research, volume 20, issue 4, pages 526–551. Retrieved from https://doi.org/10.1080/13504622.2013.833584
Publication: 2014 by Busch and Osborne. Methods that work when discussing climate change with students. Journal of School Science, 96(354), 25–32.
A publication by Collins and Nerlich (2016). What does it mean to be "certain"? A look at how the English-language news outlets covered the fifth assessment report from the Intergovernmental Panel on Climate Change and its use of calibrated language. Scientific Communication, Volume 25, Issue 6, Pages 654-673. See the link at https://doi. org/10.1177/0963662515579626.
L. Colucci-Gray (2014) article. Beyond the proof: Some thoughts on the evolving character of scientific literacy education and an analysis of climate change as a socio-scientific problem. Educational Research in the Cultural Context of Science, 9, 3, 633-647. At the following URL: https://doi.org/10.1007/s11422-013-9556-x With contributions from Perazzone, Colucci-Gray, Dodman, and Camino (2013). From the natural sciences to trans-disciplinarity: Education in science for sustainability, epistemological considerations, and pedagogical approaches. Volume 8, Issue 1, pages 127–183, published in the Cultural Studies of Science Education journal. Here is the link to the article: https://doi.org/10. 1007/s11422-012-9405-3r.
Flores-González and Condeza-Marmentini (2019). Environmental activism, social transformation, and teachers' activities of subversive pedagogy in context. Article number: 6145 in the Sustainability journal, volume 11, issue 21. Here is the link to the article: https://doi.org/10.3390/su11216145.
The authors of the 2020 article are Cordero, Centeno, Todd, and Pausata. The impact of climate change education on carbon emissions over an individual's lifespan. e0206266, published in PloS One, 15(2), https://doi.org/