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Development and piloting of a questionnaire to assess pupils' attitudes towards climate change

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Structured Abstract

Background: Climate change is often regarded not only as the central challenge humanity faces in the 21st century but also as an important topic for geography education in school. In addition, geography is a key subject for education for sustainable development. Constructs that include not only knowledge-related but also motivational and affective factors, such as the attitude construct, are considered to be important prerequisites both for learning and for climate-related behavior. In recent years, several studies have addressed the issue of young people's attitudes towards climate change. However, to date, no comprehensibly validated measurement instrument exists to assess pupils' attitudes towards climate change in a differentiated manner with reference to the three dimensions of attitudes (cognitive, affective, behavioral/conative), as well as from a geographic perspective.
Purpose: Therefore, this study describes the development and piloting of a measurement instrument to assess young people's attitudes towards climate change that is oriented towards the three established dimensions of the attitude construct against a geographical (didactic) background. Furthermore, the instrument should be economically manageable for application in further research and practice—not only in geography didactics.
Design and Methods: After developing an item pool in a structured manner and conducting a two-phase qualitative pretest, we examined the factorial structure of the developed instrument by means of exploratory factor analysis (maximum likelihood analysis with Promax rotation ($\varkappa$ = 4)) of the subsequent main test, also with the aim of identifying particularly suitable items from an initially larger item pool.
Sample/Setting: The exploratory factor analysis was conducted with a sample of N = 163 students at three grammar schools ("Gymnasium") in Bavaria. Of these, 51.5% (n = 84) identified as female and 45.4% (n = 74) as male (3.1% (n = 5) did not specify their gender). Seventy-four percent (n = 120) of the students attended grade 9 and 25.8% (n = 42) grade 10 (ages 14–17).
Results: Our analyses resulted in a final questionnaire consisting of 22 items in three scales reflecting the three dimensions of the attitude construct—cognitive, affective, and conative attitudes towards climate change—with good reliability values (.825 ≤ α ≤ .904). Medium correlations between the factors (.405 ≤ r ≤ .554) indicated that the scales are one dimensional. Pupils rated their knowledge of climate change (cognitive dimension; M = 5.40, SD = 0.66; 1 = strongly disagree ("trifft gar nicht zu") to 6 = strongly agree ("trifft voll zu")) and their climate change concerns (affective dimension; M = 4.08, SD = 1.16) as higher than their willingness to act with regard to adaptation and mitigation of climate change (conative dimension; M = 3.70, SD = 1.11).
Conclusions: The designed questionnaire makes it possible to reliably and validly assess the attitudes of pupils towards climate change in a differentiated way in relation to the cognitive, affective, and conative dimensions of the attitude construct while simultaneously including a wide range of topics. Possible application of the developed instrument in research and practice—for example, by teachers in the (geography) classroom to obtain an overview of students' learning preconditions or to use the results as a starting point for discussion during a lesson on the topic—are discussed.
Keywords: *climate change, attitudes, questionnaire, scale development, geography teaching*

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1 Introduction

"It is unequivocal that human activities have heated our climate. Recent changes are rapid, intensifying, and unprecedented over centuries to thousands of years" (IPCC, 2021, p. 3). Although it has been pushed into the background by other recent crises, climate change is often regarded as the central challenge humanity faces in the 21st century (e.g., Endlicher & Gerstengarbe, 2007; IPCC, 2023). In various recent discourses, the systemic connections between current crises and climate change have been highlighted (e.g., Beyer et al., 2021). Not only here it becomes obvious that current climate change is a complex process on different scale levels, which is not only under particular influence of humans, but also influenced by the permanent interaction of different geofactors (Borsdorf, 2019). With regard to climate education processes in the school context, the subject of geography plays a key role, as it is often understood as a connecting subject between the social and the natural sciences with a systemic character (basic concept: human–environment system) (DGfG, 2020). From the perspective of teachers, sustainability issues, and thus also climate change, should become increasingly important in the context of school education and geography lessons in particular (Fögele et al., 2022). Despite the deficits that are still evident in this regard, the concept of education for sustainable development is becoming increasingly established in Germany, with geography being considered its core subject (DGfG, 2020). The so-called sustainability triangle/square is even discussed as a basic concept for geography teaching (Fögele, 2016), but, of course, there are various challenges in this field, as well (Bagoly-Simó, 2014, 2018).
With regard to learning processes, not only cognitive prerequisites, such as the level of knowledge of the learners, must be considered but also other or wider constructs that include motivational and affective preconditions, such as interests or attitudes (Heckhausen & Heckhausen, 2010). Given the challenging topic of climate change, the latter are particularly important since they are considered key factors for climate-related behavior (Frey et al., 1993; Gifford, 2011). The objective of the UNESCO Global Action Programme on Education for Sustainable Development is for learners to acquire the knowledge, skills, values, and attitudes that are necessary to contribute to sustainable development (Kultusministerkonferenz, 2017, p. 2). Furthermore, attitudes and interests of pupils are regarded as crucial learning preconditions that must be addressed in the (geography) classroom (Hemmer, 2010). However, they are also considered important learning goals in learning processes (Krapp, 1998) that must be specifically reflected upon and promoted by teachers (Upmeier zu Belzen, 2007). While there is already evidence that pupils are particularly interested in the topic of climate change in geography lessons (Höhnle et al., 2023), knowledge about the attitudes of pupils towards current climate change is scarce, and there is no adequate, completely convincing questionnaire for assessing them. Findings on pupils' attitudes towards climate change, as well as corresponding measurement instruments, however, are of great importance for the planning and design of geography lessons and for research-based evaluations (e.g., pre–post designs on the impact/effectiveness of learning arrangements regarding attitudes related to climate change) to make pupils' attitudes to climate change measurable. Furthermore, they could be used to further investigate connections with climate-related behavior, as well as with other influencing factors. Given this background, the aim of this project is to develop and pilot a practical, (time-)efficient, and applicable test instrument in the form of a questionnaire for the differentiated assessment of attitudes towards climate change for geography didactic research and practice.

2 Research Background

2.1 Attitudes

The attitude construct is one of the most important constructs in social psychology. Nevertheless, it still has no clear distinction from other constructs, such as beliefs and values (Pajares, 1992; Reusser & Pauli, 2014). In this study, attitude refers to a psychological tendency expressed by valuing a particular object to some degree of like or dislike (Eagly & Chaiken, 1998, p. 269). Attitudes regarding school performance can be seen as a motivational construct that is positively related to school performance in the form of a positive attitude towards learning (Helmke & Schrader, 2010).
The great importance of the attitude construct in the context of learning processes is essentially due to the fact that attitudes are often regarded as a central factor for controlling and influencing individual behavior, although other factors also play a role (Frey et al., 1993). Therefore, behavior cannot be predicted directly from attitudes. According to the theory of planned behavior (TPB), for example, in addition to attitudes, the subjective norm and perceived behavioral control shape an individual's behavioral intentions, which, in turn, determine actual behavior to a certain degree (Ajzen, 1991; Ajzen & Cote, 2008).
In the context of research on attitudes, there are different approaches to modeling the attitude construct. For the presented project, the widespread and well-established three-dimensional structure (Rosenberg & Hovland, 1960), in which distinctions are made between a cognitive, an affective, and a behavioral/conative component, was used. Here, it is assumed that all responses to a specific attitude object are documented in the attitude construct. This construct is a system of dimensions that are thus related to each other. Attitudes are tendencies to respond to certain classes of stimuli with certain classes of responses, and the three main classes of responses are designated as cognitive, affective, and behavioral/conative (Rosenberg & Hovland, 1960). The cognitive dimension reflects thought processes while perceiving an attitude object, that is, knowledge or information about the object. The affective dimension represents the emotional evaluation of an attitude object and can be associated with problem awareness, personal concern, or

responsibility (Braun, 1983). The behavioral/conative dimension comprises behavioral reactions towards the attitude object and, in addition to behavioral intentions and tendencies, also includes current actions towards the attitude object (Rosenberg & Hovland, 1960; Schiefele, 1990).
From an empirical perspective, however, this approach is not without problems: although it has proven itself heuristically, the various dimensions are often associated with high intercorrelations in the context of factor analyses (Breckler, 1984). Nevertheless, the established tripartite model of attitude structure was used in the presented project to ensure that the development process of the instrument was based on a theoretically and empirically established and widely used model, thus additionally allowing comparability with other studies of attitudes (e.g., Uphues, 2007). In addition, the use of this model enables the further examination of the three areas (e.g., the conative dimension/willingness to act) separately and the consideration of connections among the areas and with actual behavior and other influencing constructs.

2.2 Attitudes towards climate change – State of research

Due to their described influence on actual behavior, the attitude construct and its structure are regarded as important, not only in the context of environmental topics in general (e.g., Milfont & Duckitt, 2004, 2010) but also in the context of climate change education and the development of climate literacy (Azevedo & Marques, 2017; Corner et al., 2015). In this sense, according to Azevedo and Marques (2017, p. 442), a climate-literate person needs to, among other things, "reveal a set of attitudes that lead to one's contribution to the conception and/or implementation of adaptation and mitigation strategies." Below, we summarize the state of research on attitudes towards climate change based on current desiderata that led us to develop a new instrument for assessing these attitudes.
Although climate change can be examined from different perspectives and in different research fields, a geographical approach to the problem is important, as it focuses on aspects of space in the human–environment system and thus connects the social and natural sciences. This means, as explained earlier, that climate change can be considered a complex, geographically relevant topic (DGfG, 2020): Underlying processes take place at different scales, are affected by the interplay between human influence and the environment, and are thus under the constant influence of different geofactors (Borsdorf, 2019). As a result, the complexity of attitudes towards climate change needs to be addressed—for example, with regard to a variety of causes, consequences at different scales, and multiple possible mitigation and adaptation measures. Nevertheless, attitudes towards climate change have not yet been examined from a differentiated geographical perspective.
For example, the European Social Survey (Fitzgerald et al., 2018) assesses attitudes towards social and political issues in 23 European countries at regular intervals. In the survey of 2016/2017, in which 44,387 people aged 15 and older participated, climate change and related questions about energy supply in Europe were the main topic, but attitudes towards climate change were surveyed with only a few items and thus not from a differentiated geographical perspective. For example, within the item "How worried are you about climate change?" no distinction is made between concerns about different consequences of climate change. The study showed that the majority of the European population acknowledges human-caused climate change but is not really concerned about it in general. The self-efficacy beliefs of the individual participants regarding their own possible actions against climate change were also very low. Thus, it is not surprising that the general motivation to change behavior was not strong, either. However, national differences emerged: People from Central and Eastern Europe were less committed to taking action against climate change than people from other European countries (Fitzgerald et al., 2018). These differences indicate that attitudes towards climate change must be examined in a region- or country-specific manner, as well. However, for German-speaking countries, no corresponding measurement instrument is available yet.
Another international study that has been conducted regularly since 2009 is the Eurobarometer, in which perceptions of climate change are assessed in a separate survey. The results of the study have shown that a large portion of the population recognizes human-caused climate change and considers it a central challenge in today's world. However, this study also has found that the personal actions already taken against climate change are minor compared to the general evaluation of climate change as a big problem. The main reasons provided for this are a lack of knowledge and information. In addition, there is a widespread view that companies and governments need to take action first and that individuals can make only a comparatively small contribution (TNS Opinion & Social, 2009). However, these results are based on only 13 questions, and action-related aspects are assessed by only two items ("Which of the following actions aimed at fighting climate change have you personally taken?" and "There are many reasons why people take actions aimed at fighting climate change. Please tell me which of the following apply to you.").
The topic of climate change and corresponding attitudes were also addressed to some extent in the Zukunft?! Jugend study from 2019. Here, young people were interviewed as part of a representative online survey (N = 1,007) accompanied by qualitative methods (online community and focus groups). The following subject areas regarding climate change were considered: environment and climate policy (two items on stakeholders, two items on topics/demands, one item on measures), Fridays for Future (three items on commitment/willingness, two items on motives/barriers), and possibilities of influence/commitment (three items). The study showed that environmental and climate protection were the most important issues for young people in Germany and that the younger generation is, in most cases, very sustainability oriented. However, a gap between action-related aspects and other aspects is also evident here. In addition, the study confirmed one finding that had already been determined in the Eurobarometer study at the EU level: The participants consider political decision-makers to have the greatest responsibility for climate-related actions and

have high expectations of them. It also became clear that young people have insufficient knowledge of climate protection. Thirty-five percent of young people see educational institutions such as schools as one of the most important sources of information for relevant knowledge, but, at the same time, most current information gathering occurs on social media (Gossen et al., 2021). Although these results already provide some insights into pupils' perspectives on climate change, the areas under consideration are not sufficiently differentiated. For example, the willingness to act was related exclusively to the willingness to participate in Fridays for Future; other areas relating to sustainable action in everyday life (e.g., choice of different means of transportation in everyday life) were not covered.

Likewise, in an evaluation study of a high school education program, Flora et al. (2014) measured students' intention to act with regard to climate change using three unspecific items ("the behavioural intention 'to reduce one's own carbon footprint, to talk to friends about reducing their footprint, and to talk to parents about the same'"; Flora et al., 2014, p. 425). Again, no specific actions were differentiated on the basis of these three rather vaguely worded items, although it can be assumed that the willingness to act differs greatly depending on the type of action (e.g., change of diet or paying CO_2 taxes).

In the United States, the Climate Change in the American Mind project has representatively surveyed climate change beliefs; risk perceptions; support for policies; behavior; and the underlying psychological, cultural, and political factors that influence these twice a year since 2008. Using the data from 2008, Americans' views on climate change were divided into segments, each representing a spectrum of views, which became known as "Global Warming's Six Americas" (1. The Alarmed, 2. The Concerned, 3. The Cautious, 4. The Disengaged, 5. The Doubtful, and 6. The Dismissive; Leiserowitz et al., 2021). A similar study, which was partly based on the three-dimensional attitude construct, was conducted in Germany, albeit as a secondary analysis (Metag et al., 2017). Five types of differing percentages were found here: "Global Warming's Five Germanys": 1. The Alarmed, 24%; 2. Concerned Activists, 18%; 3. The Cautious, 28%; 4. The Disengaged, 20%; and 5. The Doubtful, 10%). Consequently, there are already approaches to capture the three dimensions of attitudes. Nevertheless, this is not reflected stringently in any of the available instruments.

In a review and analysis of international studies, Brechin & Bhandari (2011) concluded that respondents in some countries are more concerned about general environmental problems than about climate change, which they believe could be because problems such as air and water pollution are more immediately noticeable, although respondents also stated that climate change impacts are felt. Another notable finding of the study was that, while respondents in some countries expressed relatively little concern about climate change, they still want their governments to do more to address it. As an improvement compared to previous studies, respondents now perceive climate change as affecting both people and ecosystems. The authors mention in a particularly critical way that, in some countries that are key to climate agreements, many respondents consider the existence of climate change to be scientifically not yet clarified and that, in this context, e.g. the effects of the activities of climate change skeptics should be scientifically examined.

In the school context, there are results from Finland, for example, about the attitudes of students in grade 9 ($N = 549$) regarding the consequences of climate change (eight items), their views on climate change adaptation (five items), their willingness to act (10 items), and predictors of their willingness to act (16 items). Results showed that the students experience climate change as a risk, but, although they consider climate change adaptation as important, the willingness to act leaves room for improvement. Interest in environmental issues, the perceived relevance of mitigation, and views on the development and content of climate change education were important positive predictors of students' willingness to act (Hermans & Korhonen, 2017).

Similar results are also available for Germany and Austria. Kuthe et al. (2019) surveyed 760 young people aged 13 to 16 in both countries on the topics of interest/responsibility/locus of control (five items), personal concern (three items), knowledge (four items), multiplicative actions (four items), and climate-friendly behavior (eight items) before participating in a climate change project. Based on cluster analysis, four groups were identified that differed in terms of cognitive, affective, and conative aspects of climate change awareness: the Charitables ($n = 305$, 40%), the Paralyzed ($n = 103$, 14%), the Concerned Activists ($n = 158$, 21%), and the Disengaged ($n = 194$, 25%).

These studies exemplify the existing desiderata in the field of attitude research on climate change; there are numerous results indeed. However, none of the studies examined attitudes from a (1) geographical and (2) differentiated perspective relevant to the complex phenomenon of climate change, although a human–environment system approach can yield valuable insights regarding the implementation of, for example, education for sustainable development. In addition, (3) no instrument in the German language is yet available, and (4) none of the studies mentioned above are fully transparent and stringently oriented towards the widely used and well-established three components of the multidimensional attitude construct. Due to the state of research described above, a new instrument for assessing pupils' attitudes towards climate change from a differentiated, geographical perspective and based on the three attitude dimensions is developed and piloted in the presented study.

3 Methods

Although open-ended questions potentially provide an in-depth understanding of topics, we decided to develop a questionnaire with closed-ended questions. This met the criteria of a practicable and time-efficient instrument that delivers results with manageable effort and is also consistent with the usual methodical procedure for assessing attitudes employed by other studies (Uphues, 2007). The work process (Fig. 1) was divided into (1) the structured development and selection of items, (2) a two-phased qualitative pretesting, followed by (3) the main test, which had the goals of identifying particularly suitable items from the initially larger pool of items and assessing the factorial structure of the developed instrument via exploratory factor analysis and an item parameter check.

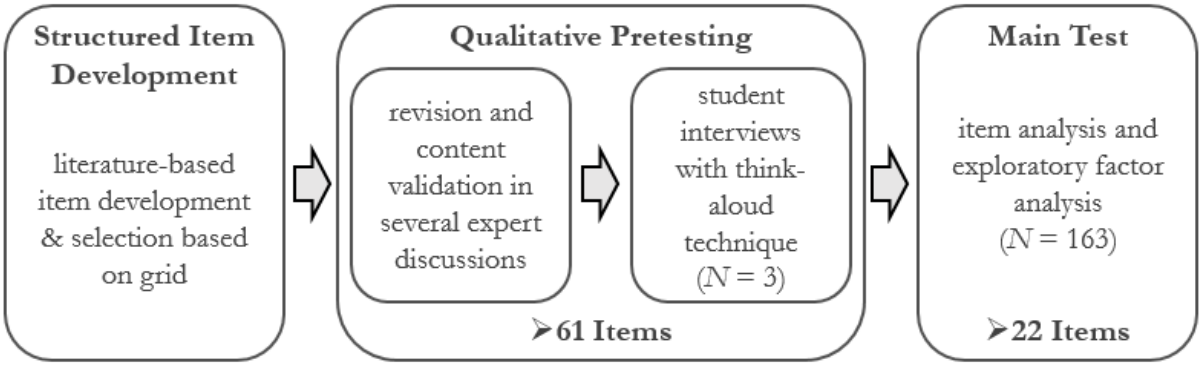

Fig. 1. Overview of the methodological approach.

3.1 Structured item development

Our aim was to develop items that represent the classic three dimensions of the attitude construct, both to ensure compatibility with other works and to be able to consider the dimensions as separate areas (e.g., regarding the willingness to act). It was also necessary to cover the topic of climate change broadly from a geographical perspective, as well as differentiated in terms of content. For example, the willingness to act can vary greatly depending on the subject matter of the action (e.g., choice of different means of transportation in everyday life, change of diet, etc.), and concerns about climate change differ among types of consequences (e.g., floods, shortage of the food supply, etc.). Therefore, a grid was developed based on topics, which should ensure that the topical spectrum was covered broadly. The grid was based on the Intergovernmental Panel on Climate Change (IPCC)[1] categories of causes, consequences, and countermeasures (which were further divided into adaptation and mitigation measures). Two more general categories were added: the phenomenon of climate change and the area of vulnerability. The aim was to create items for each dimension of the attitude construct for each IPCC category. However, a clear classification of the items into the IPCC categories was not always possible and, due to the focus of the questionnaire on the attitude dimensions, was not absolutely necessary, either. Thus, the grid served as a starting point for the development of items related to geographic content based on an analysis of geographic or geography didactic literature, as well as sustainability-related publications on attitude research. The grid on which the item development was based is illustrated in Tab. 1. Some of the items (see supplement for details) were adapted from other studies in a modified form (Bundeszentrale für Politische Bildung, 2007; Loy, 2018; Michelsen et al., 2016; Schmitt et al., 2015; Van Deth & Schnaudt, 2018); in some cases, other studies were used only as guidance for how to generally phrase items (Berger et al., 2019; Osberghaus et al., 2020; Sander, 2007; Schmitt et al., 2015; Uphues, 2007; Van Deth & Schnaudt, 2016; Weller et al., 2010). Consequently, the formulation of the items was based on theoretical and empirical sources. In general, the rules for formulating items for measuring attitudes according to Edwards (1957), which also form a framework for all three dimensions of attitudes towards climate change, were considered. The uniform design of the item stems for each dimension (affective: "I am afraid"/"It worries me"; conative: "I am willing"; cognitive: "I know") served to focus the items more strongly on the respective attitude dimension, which had priority over the thematic facets contained in each dimension. The item stems were taken from empirical studies in the field of research on attitudes towards climate change and the environment (Abun et al., 2019; Christensen & Knezek, 2015; Türkan et al., 2019; Uphues, 2007). The use of this multitude of references for item generation and selection should ensure that all relevant aspects of the topic areas under consideration are covered from a differentiated and geographical perspective, thus ensuring the content validity of the instrument being developed.

[1] The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. It prepares comprehensive assessment reports about the state of scientific, technical, and socio-economic knowledge of climate change; its impacts and future risks; and options for reducing the rate at which climate change is occurring.

Different scales (local–regional, national, global) were considered across all areas during item construction since German students tend to perceive climate change as a "distant topic" (Fiene, 2014; Höhnle, 2014; Höhnle et al. 2023; Schuler, 2009). Consequently, the items were formulated not only on a global scale (e.g., item Ekog19, "Ich weiß, dass der Klimawandel sich auf die Menschen weltweit negativ auswirkt" (I know that climate change is having a negative impact on people worldwide)) but also on a regional or local scale (e.g., item Ekon1, "Ich bin bereit, bei der Beseitigung von Klimawandel bedingten Schäden in meiner Region mitzuhelfen" (I am willing to help repair the damage caused by climate change in my region)). A six-point Likert-type scale, headed with the numbers 1 to 6, was used as the response scale to avoid a tendency of responses to fall towards the middle (Döring & Bortz, 2016). Only the ends of the response scale were verbally labelled (1 = strongly disagree ("trifft gar nicht zu") and 6 = strongly agree ("trifft voll zu")).

Tab. 1. Grid used for item generation.

Thematic facet / **Attitude dimensions**	Phenomenon climate change	Causes	Consequences	Countermeasures		Vulnerability
				Mitigation measures	Adaption measures	
Conative						
Affective						
Cognitive						

3.2 Qualitative pretesting

The developed items were presented to various experts (researchers in geography didactics and geography teachers), discussed with them, and then revised to ensure good content validity. During this process, the items were sent to the experts first so they could study them thoroughly and take notes. The experts were also asked to pay particular attention to whether the construct was covered by the content of the items (i.e., ensuring content validity) and to their comprehensibility for pupils. Subsequently, all the items were openly discussed. These open discussions were repeated several times with different versions of the items.

Based on the expert discussions, the first draft of the questionnaire on the attitudes of pupils towards climate change was tested by three students using the concurrent think-aloud method (Häder, 2019, p. 419). Two students attended tenth grade at two different Bavarian grammar schools ("Gymnasium"), and one student attended eighth grade at a Bavarian lower-level secondary school ("Mittelschule"). Based on the open discussions with the three students, which included simultaneous verbalization while participants were interacting with the test, the wordings of the items were revised. The usability problems discovered were thus considered. Incomprehensible items that required detailed knowledge (e.g., "I am willing to participate in the maintenance of flood protection, which is becoming increasingly important due to climate change") were removed from the questionnaire. In addition, items with a negative answer caused difficulties for the respondents, so these were reformulated. Furthermore, individual difficult technical terms were replaced or supplemented with specific examples or more familiar words (e.g., "extreme weather events" supplemented by "heavy precipitation" and "extreme heat"; "petition" replaced by "signature campaign"). The six-point Likert-type scale was maintained.

This two-phased qualitative pretesting phase resulted in a questionnaire consisting of 61 randomly ordered items on attitudes towards climate change.

3.3 Main test – Sample and procedures

For the main test, the questionnaire was used between May and September 2021 with $N = 163$ students of six classes (grades 9 and 10, ages 14–17) at three grammar schools in the federal state of Bavaria, Germany. Of these, 51.5% ($n = 84$) were female, 45.4% ($n = 74$) were male, and 3.1% ($n = 5$) preferred not to answer. Three-quarters ($n = 120$) of the students attended grade 9 and 25.8% ($n = 42$) grade 10; one person did not provide an answer.

The duration of the survey (processing time of the questionnaire: approximately 20 minutes) was identical for all measurement times, and the survey was administered by the previously instructed teachers. Identical survey instructions for the pupils were included in the questionnaire. These measures were intended to achieve a high level of objectivity in their implementation.

To analyze the available data, descriptive item and scale parameters were calculated using IBM SPSS Statistics software. An exploratory factor analysis was executed instead of a confirmatory approach, as it was possible to assign the items to several dimensions (i.e., to the thematic facet as well as the attitude dimension; Tab. 1), so the latent structure was unclear. In general, Brown (2015) recommends an initial exploratory test for instruments implemented for the first time. In addition, in some cases, the three dimensions of the attitude construct cannot be empirically proven, and there are often strong intercorrelations among the dimensions (e.g., Stahlberg & Frey, 1999). The study also aimed to develop an instrument that can be used in a time-efficient manner, so the initially large and extensive item set needed to be reduced to a selection of the statistically most suitable items. Altogether, these considerations led to the decision to take an exploratory approach. For further validation, based on Brown's (2015) recommendations, we plan to confirm the latent structure discovered in the exploratory factor analysis in a follow-up study with a new, independent sample using a confirmatory approach.

A systematic review of the data in advance revealed data gaps in 25 items (missing values of 0.80% in total). However, this occurred randomly based on Little's MCAR test ($\chi^2 = 595.778$; $df = 643$; $p = .909$). Therefore, it can be assumed that data were missing at random. Based on this assumption, missing values were imputed using the expectation maximization algorithm, which is well-suited for factor and reliability analyses and tolerates possible violations of the normal distribution (Graham, 2009; Lüdtke et al., 2007). Fundamental examination of the item parameters (mean values, standard deviations, and item difficulties) revealed item difficulty values between $P = .40$ and $P = .90$. Six of the seven items in the cognitive dimension were greater than the values recommended by Döring & Bortz (2016), between $P = .20$ and $P = .80$; all items in the other two domains were within the recommended range of values. These six items were retained, however, because they adequately cover the breadth of contents; only one item was excluded from further analysis due to particularly noticeable item difficulty and the associated insufficient variance. For the remaining 60 items, the suitability of the correlation matrix for a factor analysis was tested. The Kaiser–Maier–Olkin criterion (KMO = 0.890), the Bartlett test ($\chi^2 = 6489.686$; $df = 1770$; $p < .001$), and the anti-image matrix indicated a clear suitability of the correlation matrix (Backhaus et al., 2018; Bühner, 2011).

To extract the factors, maximum likelihood analysis was selected both to identify latent factors behind the variable structure and to ensure an alignment of the final questionnaire to the planned confirmatory factor analyses as part of further surveys (Brown, 2015). The decision criteria for the number of factors to be extracted were those recommended by Fabrigar et al. (1999). Both—scree testing and parallel analysis—suggested the extraction of three factors. Due to the expectation of medium to high intercorrelations among the factors, the oblique Promax rotation ($\varkappa = 4$) was chosen to rotate the factor solution (Brown, 2015; Bühner, 2011; Tabachnick & Fidell, 2014). Given the goal of selecting particularly suitable items for the survey instrument, a comparatively strict cut-off value of $\lambda > .55$ was chosen for the factor loadings based on the recommendations by Tabachnick & Fidell (2014).

To check the quality of the solution of the factor analysis, a χ^2 test was performed, and the root mean square error of approximation (RMSEA) was calculated to check the overall goodness of fit of the model. Additionally, reliability was calculated using Cronbach's alpha at the level of the factors. At the level of the individual items, the item scale correlation was also considered.

4 Results

4.1 Factor extraction

The χ^2 test for goodness of fit initially did not show a perfect fit with the data ($\chi^2 = 245.678$; $df = 169$; $p < .001$; Schendera, 2010). However, with RMSEA = 0.053 (95% CI 0.031–0.070), the model reached a sufficient approximate fit (Browne & Cudeck, 1993; Moschopoulos, 1983).

All three extracted factors from the exploratory factor analysis of the 60 items represented meaningfully interpretable factors that consisted of at least three variables (Tabachnick & Fidell, 2014). These factors corresponded to the three dimensions of the tripartite model (Zanna & Rempel, 1988). Due to low primary loading ($\lambda \leq 0.55$) and secondary loading, 37 items were removed from the original solution. Secondary loading applied to two other items. These were retained because their simple structure was confirmed using the Fürntratt criterion, as the factor assigned to the items accounted for greater than 50% of the respective item commonality (Fürntratt, 1969). The high number of excluded items is mainly due to employing a strict statistical criterion for the selection. However, the high primary loadings of the remaining items potentially strengthen the convergent validity of the solution's factorial structure (Brown, 2015). With the remaining 23 items, another exploratory factor analysis was executed with the same sample according to the recommendations of Brown (2015); this analysis also led to the extraction of three factors. In this second factor analysis, another item was removed due to double loading (Eaff18, "Es beunruhigt mich, dass Deutschland zu den Hauptverursachern des Klimawandels zählt" (It worries me that Germany is one of the main causers of climate change)) in order to preserve the simple structure of the solution. Thus, the final version of the questionnaire con-

sisted of 22 items within the three latent factors (Tab. 2). Despite the high number of excluded items, the questionnaire reflects all important content areas, so content validity can be guaranteed. This solution was initially able to explain 58% of the total variance.

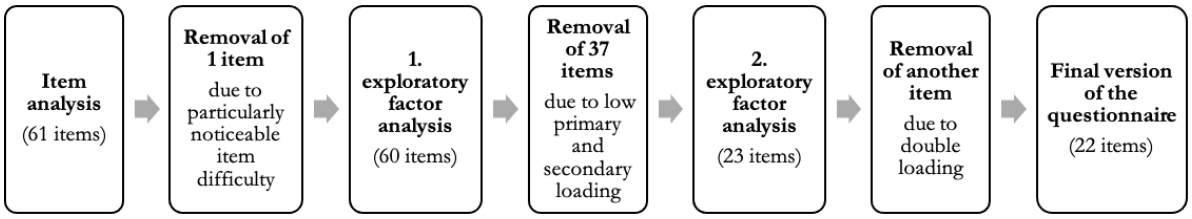

Fig. 2. Process of factor extraction.

4.2 Description of the scales

The first scale describes the conative level of attitudes towards climate change, that is, behavioral items (10 items: Ekon1, Ekon3, Ekon6, Ekon7, Ekon8, Ekon12, Ekon15, Ekon17, Ekon19, and Ekon20). The second scale describes the cognitive level and consists of seven items (Ekog2, Ekog3, Ekog4, Ekog7, Ekog17, Ekog19, and Ekog21). The third scale describes the affective dimension of attitudes (five items: Eaff1, Eaff3, Eaff9, Eaff14, and Eaff19), addressing feelings and emotions regarding climate change. The feelings of fear and worry are essential to this scale. The scales contain items on the local level (e.g., Ekon1, Tab. 2), as well as on the global level (e.g., Ekog19, Tab. 2).

Tab. 2. Results from the exploratory factor analysis (factor loadings from rotated repeated principal axis factor analysis), reliability (Cronbach's alpha), and mean (*M*) and standard deviation (*SD*) values of the items and scales; characteristic values for the extracted factors are presented at the end of the table).

Scale	Item wording	1	2	3	*M*	*SD*
Conative	(Ekon6) Ich bin bereit, mich in einer Klimaschutzgruppe zu engagieren. *(I am willing to get involved in a climate protection group.)*	**.815**			**2.96**	**1.57**
	(Ekon12) Ich bin bereit, mich in Form von Demonstrationen für den Klimaschutz einzusetzen. *(I am willing to campaign for climate protection in the form of demonstrations.)*	**.811**			**3.58**	**1.73**
	(Ekon3) Ich bin bereit, mein Freizeitverhalten hinsichtlich des Klimawandels zu verändern. *(I am willing to change my leisure time behavior due to climate change.)*	**.723**			**3.52**	**1.47**
	(Ekon8) Ich bin bereit, mein Verkehrsmittel, mit dem ich in den Urlaub reise, so zu wählen, dass möglichst wenig CO_2 ausgestoßen wird. *(I am willing to choose the means of transportation I use to travel on vacation in such a way that the lowest possible amount of CO_2 is emitted.)*	**.680**			**3.98**	**1.58**
	(Ekon17) Ich bin bereit, bewusst mit dem Gesetz in Konflikt zu kommen, um mich für Klimaschutz einzusetzen. *(I am willing to consciously get in trouble with the law by doing something for climate protection.)*	**.668**			**3.06**	**1.47**
	(Ekon19) Ich bin bereit, mich in Form von Unterschriftenaktionen für den Klimaschutz einzusetzen. *(I am ready to campaign for climate protection through signature campaigns.)*	**.665**			**4.49**	**1.46**
	(Ekon15) Ich bin bereit, höhere CO_2-Steuern zu zahlen. um den Klimawandel zu mindern. *(I am willing to pay higher CO_2 taxes to mitigate climate change.)*	**.656**			**3.55**	**1.61**
	(Ekon7) Ich bin bereit, meine Verkehrsmittelwahl im Alltag zugunsten des Klimawandels zu verändern. *(I am willing to change my choice of transportation in everyday life in favor of climate change.)*	**.632**			**4.13**	**1.50**
	(Ekon20) Ich bin bereit, eine freiwillige Gebühr als Ausgleich für Flugreisen zu zahlen. *(I am willing to pay a voluntary fee to compensate for air travel.)*	**.620**			**3.29**	**1.49**

	(Ekon1) Ich bin bereit, bei der Beseitigung von Klimawandel bedingten Schäden in meiner Region mitzuhelfen. *(I am willing to help repair the damage connected to climate change in my region.)*	**.538**			**4.39**	**1.22**
Cognitive	(Ekog17) Ich weiß, dass die sich erhöhende CO_2-Konzentration in der Atmosphäre ein Grund für die globale Erwärmung ist. *(I know that the increasing concentration of CO_2 in the atmosphere is one reason for global warming.)*		**.778**		**5.45**	**1.03**
	(Ekog19) Ich weiß, dass der Klimawandel sich auf die Menschen weltweit negativ auswirkt. *(I know that climate change is having a negative impact on people around the world.)*		**.680**		**5.34**	**0.98**
	(Ekog7) Ich weiß, dass der Klimawandel gravierende Folgen auf die Menschen und die Natur haben wird. *(I know that climate change will have serious consequences for people and nature.)*		**.678**		**5.49**	**0.87**
	(Ekog21) Ich weiß, dass durch den Klimawandel Extremwetterereignisse wie zum Beispiel Starkniederschläge oder extreme Hitze häufiger werden. *(I know that extreme weather events, such as heavy precipitation or extreme heat, are becoming more frequent as a result of climate change.)*		**.635**		**5.43**	**0.98**
	(Ekog2) Ich weiß, dass ein globaler Klimawandel eintreten wird. *(I know that global climate change will occur.)*		**.622**		**5.50**	**0.85**
	(Ekog4) Ich weiß, dass menschliche Aktivitäten die Hauptursache für den gegenwärtigen Klimawandel sind. *(I know that human activities are the main cause of current climate change.)*		**.594**		**5.51**	**0.85**
	(Ekog3) Ich weiß, wie der Klimawandel entsteht. *(I know how climate change occurs.)*		**.514**		**4.75**	**1.27**
Affective	(Eaff9) Ich habe Angst, dass durch die Folgen des Klimawandels meine Lebensgrundlage zerstört wird. *(I'm afraid that my livelihood will be destroyed by the consequences of climate change.)*			**.867**	**3.58**	**1.48**
	(Eaff19) Der Klimawandel macht mir Angst. (*Climate change makes me afraid.)*			**.745**	**3.94**	**1.52**
	(Eaff1) Ich habe Angst, dass sich der Klimawandel nicht mehr aufhalten lässt. *(I'm afraid that climate change can no longer be stopped.)*			**.696**	**4.28**	**1.47**
	(Eaff3) Ich habe Angst, dass die Folgen des Klimawandels in den nächsten zehn Jahren auch in meiner Heimatregion spürbar sein werden. *(I am afraid that the consequences of climate change will also be felt in my home region within the next 10 years.)*			**.688**	**4.49**	**1.35**
	(Eaff14) Ich habe Angst davor, dass der Klimawandel mich stark in meiner Lebensweise beeinträchtigen wird. *(I am afraid that climate change will severely affect the way I live.)*			**.655**	**3.98**	**1.49**
	Rotated eigenvalue[a]	8.225	2.553	1.952		
	Variance explained (%)	37.386	11.606	8.874		
	Cronbach's alpha	.904	.825	.877		
	M (*SD*) of scale	3.70 (1.11)	5.40 (0.66)	4.08 (1.16)		

The English translations of items (italics) are for communicative understanding only; the original German wording was provided to students. The questionnaire employed a six-point Likert scale (1 = strongly disagree ("trifft gar nicht zu") to 6 = strongly agree ("trifft voll zu")). $N = 163$; factor loadings < .30 are not displayed.
[a]Before rotation (Bühner, 2011); the calculation was carried out excluding the item Eaff18 (not listed in this table).

4.3 Descriptive statistics

The internal consistencies of the scales, which were determined using Cronbach's alpha, were in the medium to high range at .825 to .904 and can all be regarded as acceptable (Bühner, 2011, p. 81; Fisseni, 1997, pp. 40ff).
The scale for the cognitive dimension had the highest level of agreement by far, followed by the scale for the affective dimension, while agreement of the conative dimension had the lowest mean value (see Tab. 2). At the level of individual items, 21 items were above the middle of the scale (M = 3.06–5.51; SD = 0.85–1.73); only one item from the conative scale was below (M = 2.96, SD = 1.57). Values of the item scale correlations between r_{it} = .54 and r_{it} = .77, which can be classified as high (Cohen, 1988; Weise, 1975), were found for all items, with the exception of the lowest value by far, r_{it} = .42 for the item Ekog 21 ("Ich weiß, dass durch den Klimawandel Extremwetterereignisse wie zum Beispiel Starkniederschläge oder extreme Hitze häufiger werden" (I know that extreme weather events, such as heavy precipitation or extreme heat, are becoming more frequent as a result of climate change)), which is still in the middle range (Weise, 1975). These values can be interpreted as a further indication of a reliable assessment of attitudes towards climate change.
The correlations between the factors were below the limits of $r < .80$ and $r < .85$ (Brown, 2015, p. 116; Bühner, 2011, p. 432), which indicates that the factors are one dimensional. The highest correlation was found for the conative and affective attitudes (r = .554). The affective and cognitive attitudes (r = .405) and the cognitive and conative attitudes (r = .461) were also positively correlated with one another.

5 Discussion and Conclusions

The aims of the work presented were to design a questionnaire to gauge the attitudes of pupils towards climate change and to explore its underlying factorial structure. For the first time, the designed questionnaire makes it possible to adequately assess the attitudes of students towards climate change in a differentiated way in relation to the cognitive, affective, and conative dimensions while simultaneously including a wide range of topics.

5.1 Structure of the test instrument

A comprehensive set of items was created based on literature analysis with the classic dimensions of the attitude construct (cognitive, affective, and conative) as guidelines. These three factors were also identified in the exploratory factor analysis. Upon closer inspection of the items of the affective dimension, it is remarkable that in particular items that include the emotion of fear ("I am afraid") were statistically suitable. One reason for this could be the high importance of this emotion in relation to climate change (Pihkala, 2020). It is striking that there was a strong positive correlation between the affective and conative dimensions in particular. Pupils who showed high values in the affective dimension and therefore felt greater worry or fear about climate change also showed high values for behavior-related aspects and consequently showed a greater willingness to act. This result has been found by other studies (e.g., Heberlein, 2012; Taber & Taylor, 2009) and could indicate that the affective/emotional dimension is also very important for dealing with climate change in general.
Although the primary goal of the work presented in this paper was to design a questionnaire to assess the attitudes of students towards climate change, the results provide first indications of their manifestations.
The mean values on the cognitive scale were particularly high, while the mean values on the other two scales were noticeably lower, especially those on the conative scale. These results indicate that the students surveyed rated their knowledge of climate change as very high. This contrasts with the results of qualitative research studies, which have shown, for example, that students sometimes have insufficiently complex ideas about the greenhouse effect and the causes and consequences of climate change (e.g., Reinfried et al., 2008; Schuler, 2011). Although these results must first be replicated using larger samples, they could indicate pupils' misjudgment of their knowledge of climate change. The pupils surveyed rated their willingness to act regarding climate change as comparatively low, which aligns with the knowledge–behavior gap (Hunecke, 2022) found in other studies (Boyes & Stanisstreet, 2012; Moser & Dilling, 2011).

5.2 Limits of the presented approach

The high levels of agreement with the items on the cognitive scale should be examined critically, not only regarding a potential ceiling effect. The fact that the survey was administered in the school context, in which the dichotomy "I know" vs. "I don't know" is traditionally associated with performance measurement, must be critically examined, as well. However, this issue was addressed by including explicit notes for the pupils that performance was irrelevant, both in writing on the questionnaire and again orally during the completion period. The anonymity of the survey was also clearly stated. During further development of the questionnaire, the extent to which the wording of the items may influence the results should also be considered and the items adapted accordingly, e.g. with regard to the wording of the item stem. Under certain circumstances, there could also be a manifestation of the Dunning–Kruger effect (Kruger & Dunning, 1999): The students rate their knowledge as far too high precisely because of a lack of knowledge.

Due to the selection of only 22 of the original 61 items for statistical reasons, the questionnaire experienced a loss of information. However, it still allows a detailed description of the attitudes of pupils towards climate change since all the different content levels included in the IPCC classification, as well as the local and global levels, are considered (see supplement for details).
Nevertheless, the assessment of the attitudes is limited by the fundamental decision to use a closed response format: This type of survey allows assessment of only parts of pupils' attitudes towards climate change. Despite this limitation, the use of a closed questionnaire is necessary for the intended purpose, which is to assess pupils' attitudes towards climate change using surveys with large samples. In this context, using a closed response format enables efficient data collection and analysis.
Additionally, the small sample size for conducting factor analyses should be noted (MacCallum et al., 1999). Considering factor loadings as indicators for reliable measurement of factors, Guadagnoli & Velicer (1988) found reliable and stable solutions if a factor had more than four loadings greater than .60, regardless of sample size. This condition was fulfilled in our analysis, so the sample size can still be described as sufficient. A further indication of the adequacy of the sample was provided by the satisfactory KMO measure of sampling adequacy.
It is also important to note that attitudes, views, or intentions cannot be measured in an absolute sense (Reid, 2006). The developed questionnaire will allow only comparisons or an analysis of interrelations.

5.3 Outlook

The cognitive, affective, and conative dimensions from the tripartite model, which were already the foundation for the design of the questionnaire during the theoretical preparatory work, were also revealed by the factor analysis. This resulted in a statistics-based selection of items for the questionnaire, which can be used to assess the attitudes towards climate change of a large sample of students in a differentiated manner. The development and exploration of the dimensionality of the instrument to measure attitudes towards climate change was a first step in our research project. In accordance with Brown's (2015) recommendation for construct validity, confirmatory tests will be performed on the discovered underlying three-dimensional structure using a larger independent sample of students. The urgency of addressing the topic of climate change more at school is particularly evident in view of the insufficient level of knowledge among young Germans (Reinfried et al., 2008; Schuler, 2011). Educational institutions such as schools currently still make a comparatively small contribution as a source of information for young people (Gossen et al., 2021), which is not favorable in this context. To develop adequate teaching arrangements, teaching should be linked as coherently as possible to the learning preconditions of the students. In doing so, rather motivationally oriented learning preconditions, such as attitudes and interests, are also relevant along with rather cognitive learning preconditions. This is also evident when considering the close connection between cognitive and motivational learning outcomes (Hemmer & Hemmer, 2010). The questionnaire presented in this paper can be used to assess the learning preconditions of attitudes towards climate change, as well as to determine the effectiveness of learning arrangements on climate change in the framework of intervention studies. Furthermore, in the long term, a (concise) version of the instrument will be developed for geography teachers to easily gain an overview of their pupils' learning preconditions with regard to climate change to use the results either as a starting point for discussions on climate change during lessons or as an evaluation of their work with their students on the topic.
In addition, independent variables, which are crucial for attitudes towards a complex topic such as climate change, should also be considered in a survey with a larger sample (Hornsey et al., 2018). The knowledge of pupils' attitudes and the influence of independent variables, such as type of school or gender, could be used in the future to develop strategies for changing attitudes. This could help schools meet the standard of promoting more sustainable and more socially responsible behavior in the long term.
Moreover, it is necessary to further clarify the relationships between students' attitudes and various other behavior-relevant constructs, such as interests or self-efficacy expectations, regarding climate change.

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