

## Article

# Exploring German High School Students' Conceptual Learning Pathways of Space and Place

Natalie Bienert

Department of Geography Education, University of Münster, 48149 Münster, Germany;  
natalie.bienert@uni-muenster.de

**Abstract:** Space and place, fundamental concepts in geography, uniquely contribute to the development of students' geographical thinking. Despite this, these concepts are underrepresented in German geography classrooms, partly due to a distinct lack of empirical evidence concerning the learning processes associated with learning complex geographical concepts. This study employed videography to explore how  $n = 64$  grade twelve students from various school types in Germany develop a more sophisticated understanding of space and place during a 90 min. teaching experiment. To delve into the micro-level of students' learning processes, qualitative content analysis was employed to analyse the data. The subsequent detailed reconstruction of an individual learning pathway unveiled several pivotal moments. Notably, the concepts demonstrated significant potential for restructuring students' existing knowledge into a more conceptual and systematic framework. Moreover, barriers to learning were identified as well. For example, conceptual interferences between the concepts of space/place and other geographical key concepts such as sustainability were observed, partially impeding the formation of a clear conceptual framework in students' minds. The results provide insights for teaching implications, such as emphasising a single key concept to avoid conceptual interferences, and suggest further research avenues, including longitudinal studies to empirically derive learning progressions related to space and place.

**Keywords:** learning pathways; conceptual understanding; key concepts; space and place; geography education; content analysis; case study



**Citation:** Bienert, N. Exploring German High School Students' Conceptual Learning Pathways of Space and Place. *Educ. Sci.* **2024**, *14*, 69. <https://doi.org/10.3390/educsci14010069>

Academic Editor: Thomas Barclay Larsen

Received: 27 October 2023

Revised: 22 December 2023

Accepted: 29 December 2023

Published: 8 January 2024



**Copyright:** © 2024 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

“Concepts [...] constitute our understanding of the world” [1] (p. 6); likewise, key concepts are essential to understanding geography [2,3]. These big ideas represent the core of the discipline and are shaping forces of the subject [4,5]. Although key concepts may have varied designations due to differences in historical evolution, subject-cultural developments, and contemporary currents [3,6], there seems to be a general consensus regarding the concepts of space and place: not only are they generally regarded as “central concepts of modern life” [7] (p. 50), but also considered to be among the most fundamental key concepts of geography herself [6]. Offering unique potential for developing powerful geographical thinking, there is a constant demand for their widespread implementation in geography classrooms [2]. However, despite the concepts' historic evolution and contemporary relevance, their implementation is lacking so far: the frequency of use of space and place in German geography classrooms is low [8], even though it is a curriculum requirement [9]. This highlights a gap between the concepts' exceptional potential for developing powerful geographical thinking and its underrepresented practical application. Furthermore, this gap extends to research in geography education: there is a notable scarcity of findings on the acquisition of key concepts in general and space and place in particular. While Fögele [3] demonstrated that teachers' conceptual orientations can be categorised into four distinct types, Larsen & Harrington [10] provided a theory-based approach to developing a large-scale learning progression for place. However, a significant

gap persists in empirical evidence regarding the learning processes associated with complex geographical concepts [11]. The latter, however, is necessary to provide an empirically grounded and theory-based strategy to properly introduce the extended understanding of space/place to students.

Addressing this desideratum, the article outlined the learning pathway [12,13] of a single case. This detailed examination sheds light on the intricate dynamics of conceptual development, illustrating both milestones and obstacles to conceptual learning. Building on these insights, the article derived implications for teaching space and place as a key geographical concept, along with suggesting pathways for further research.

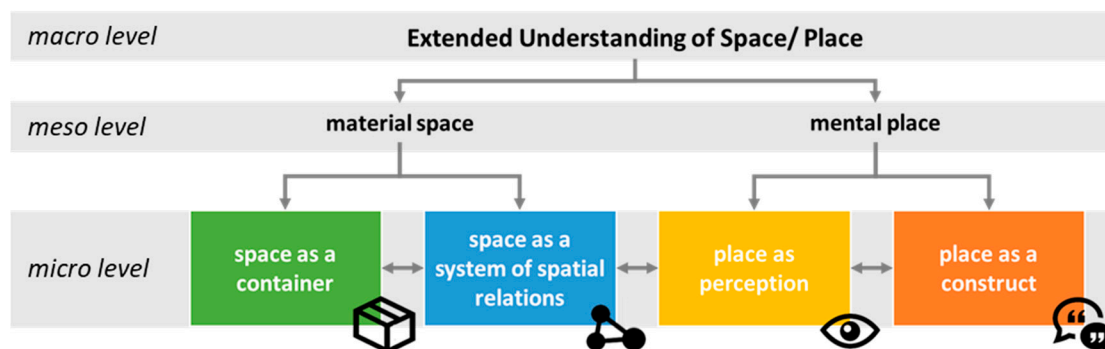
## 2. Theoretical and Empirical Background

“Concepts are the glue that hold our mental world together” [14] (p. 1). As a major cognitive function, concepts allow people to structure and interpret ideas, things, and experiences in classes, leading to generating explanative knowledge [15]. Depending on the discipline, the term “concept” is employed broadly, hence requiring specification in the context of geography education. Commonly, concepts are categorised based on levels of abstraction and specificity. At the lowest degree of abstraction, so-called first-order concepts refer to subject-specific content such as terminology (i.e., “gentrification”) and models (i.e., Krajewski’s pillar model of gentrification) [16]. Because of their high degree of specificity, they are thematically bound to a given subdiscipline of geography (i.e., urban geography) and cannot be detached and reapplied to other contexts. In contrast, second-order concepts encompass a higher degree of abstraction and commonly refer to key concepts of a subject (i.e., human–environment–system). In the words of Taylor, “second order concepts are those used to shape knowledge into a discipline [...] across the whole range of subject content” [6] (p. 54). Accordingly, these key concepts are transferable across the whole thematic range of a discipline. To differentiate between these kinds of concepts, the metaphor of vocabulary (representing first-order concepts) and grammar (representing second-order concepts) is frequently used [17]. Both components are essential for acquiring a sophisticated and proficient understanding of geography.

### 2.1. Extended Understanding of Space/Place

Despite varying compilations of geographical key concepts in different countries’ curricula, one key concept serves as a common denominator. As stated by Taylor, “place, space [...] underlie everything we teach and learn about in geography” [6] (p. 52). In anglophone geography education, the concept of space and place is prevalent. Emphasising its relevance, Tuan [18] went so far as to view space and place as the defining core of the discipline. Space, in its essence, involves an objective, quantitative analysis, focusing on aspects such as location, interaction, flows, patterns, and networks. On the other hand, place encompasses ascribed social, historical, individual, and/or cultural significances (ibid.). It is unique, represented, dynamic, and imagined [19].

In German-speaking geography education, there is a nuanced conceptualisation of space and place. The so-called extended understanding of space/place is established in the academic discourse and educational curricula alike [9]. Building upon the theoretical principles of cognitive psychology discussed earlier, this hierarchical concept can be delineated across three conceptual levels (see Figure 1). At the overarching, macro-conceptual level, this concept encapsulates the extended understanding of space/place. However, on a basic conceptual level, the concept can be differentiated into two distinct basal concepts, space and place, which follow different underlying paradigms. Distinguishing the paradigms, the concept of physical–material space aligns with a positivist paradigm, whereas the concept of mental place is grounded in a constructivist paradigm [20].



**Figure 1.** Hierarchical order of the extended understanding of space/place. The color-coding of the sub-concepts is also applied later in Figures 2 and 3.

At a conceptual micro-level, there are four sub-concepts in total, each presenting a distinct and characteristic perspective on space/place:

- Following the landscape-geographical understanding of ‘space as a container’, space is characterised as an enclosed entity, encompassing both human and physical-geographical phenomena [21–23]. This perspective understands space as real, absolute, territorial, and object-oriented. As a result, this concept directs attention to the assessment of material objects within their designated spatial arrangement. It aligns with the guiding question: “Which natural and anthropogenic features are characteristic in a given space?” [3] (p. 77);
- According to the second, spatial-geographical sub-concept, space is conceptualised as a ‘system of relationships’ between material objects [21,24]. It focuses on empirically assessing distributions and interconnections of geographical features in their spatial patterns. Thus, space is understood as relational, dynamic, and systematic. This perspective is addressed through the guiding question: “What relationships exist between spaces or between elements within a space?” [3] (p. 77);
- Applying the third perspective aligned to perception geography, ‘place as perception’, places are seen through the lens “of individual sensory perception” [21] (p. 8). The emphasis is, accordingly, on people’s “perception and interpretation of place and its significance for human actions” [25] (p. 184). Places are perceived as sense-based, subjective, and multi-perspectival. This understanding culminates in the guiding question: “How are places perceived and valued by different individuals and groups?” [3] (p. 78);
- The fourth sub-concept, ‘place as a construct’, is related to new cultural geography and conceptualises places as social, technical, and socially constructed products to which meaning is ascribed through communication and action [21,26]. This conceptualisation views places as communicated, socially produced constructs that are dependent on perspective. The guiding question for this concept explores: “Who (individual), communicates what (content), when (temporal scope), where (scale level), how (style), with what intention (objective), and with what consequences about place?” [3] (p. 78).

While some differing positions regarding the relationships of the sub-concepts exist, there is a prevailing consensus in the current geography education discourse regarding their equal recognition [3,9]. These perspectives are considered complementary, allowing to identify blind spots in each other’s understanding [26]. Accordingly, their maximum potential is realised when combining them to address geographical inquiries [27].

## 2.2. State of Research

In sharp contrast to the often-ascribed relevance of space and place as the supposed core of geography [28], the state of empirical research is much less pronounced. This section will outline studies that focus on said concept. On this basis, central research desiderata are derived.

Despite a clear demand for it in curricula [9], a study conducted by Bette and Schubert [8] revealed that the extended understanding of space/place is only rarely used in geography lessons in Germany. Similarly, Larsen and Harrington [10] also observed that space/place is often not taught at all or only inadequately in the United States (cf. p. 112), partly due to a lack of conceptual knowledge on the teachers' part [29]. Indeed, as studies on pre-service teachers show, this holds true in part: research conducted with pre-service elementary geography teachers' convictions show a clear preference for the physical–material concepts of space instead of the mental concepts of place, with space as a container as the most preferred concept [30]. In accordance, Lindau and Renner [31] showed that inquiry questions posed by pre-service secondary geography teachers emphasise physical–material space, too, and rate mental place as less relevant. Evidently, there is a strong imbalance in teachers' perception of the concepts' individual relevance, with the material concepts consistently being preferred.

This also shows on a student level. While students generally hold positive attitudes towards the extended understanding of space/place, they too prefer the material concepts over the mental ones [8,32]. Specifically, students favor space as a container, while they rate place as perception the lowest (ibid.). Moreover, Bette and Schubert identify interest in geography, interest in spatial concepts, and independent engagement with geographical topics outside of school as relevant variables influencing students' attitudes, while gender differences were insignificant. A subsequent follow-up study further showed that using meta-reflection in lessons leads to a significant increase in students' attitudes towards mental concepts of place, while attitudes towards space as a container decrease [33]. Overall, there generally seems to be a strong preference for material concepts of space among (pre-service) teachers and students alike. Additionally, although students generally hold positive attitudes towards spatial concepts, these are only rarely used in geography lessons so far. Accordingly, an apparent disparity emerges when comparing the subject-specific, didactic, political, and practical significance of the extended understanding of space/place on one hand, and the so-far unmet requirements in school and research practices alike on the other.

In conclusion, the research conducted primarily aligns with affective constructs such as attitudes, orientations, and perceptions. Up to this point, no studies have focused on the more cognitive aspects involved in learning the four concepts of space/place. Further, all existing studies are status surveys and, as such, do not illuminate any processes involved. Mohan also described this gap, pointing out a distinct lack of empirical evidence on learning processes involved in learning complex geographical concepts [11]. It is crucial to urgently focus on dynamic conceptual learning processes to generate empirically grounded descriptive and explanatory knowledge that can be translated into practice [34] (p. 344). A comprehensive understanding of learning processes is vital for optimising instructional support (ibid.). In particular, identifying milestones and obstacles to learning is critical and should be the focal point of research efforts [35].

### 3. Research Questions and Objectives

Addressing the previously described gap of research regarding conceptual learning processes, this explorative study aims to investigate how students acquire an increasingly sophisticated understanding of the geographical key concept of the extended understanding of space and place. Thus, the guiding research question arises: "How can high school students' understanding of key concepts be cultivated, using the extended understanding of space/place as an example?"

Because of the complex nature of conceptual learning, it is necessary to investigate this process in fine detail [35]. This can be realised through a detailed reconstruction of learning pathways, which is only to be achieved on a case level. This leads to the subsequent research question: "Which learning pathways of concept acquisition can be reconstructed?"

During reconstructing learning pathways, specific emphasis is placed on identifying obstacles and milestones of learning due to their relevance for concept learning. While obstacles refer to points in the learning process that temporarily or permanently impede or

prevent the acquisition of concepts, milestones encompass moments of accelerated learning, deepened understanding, or facilitated comprehension. Accordingly, the next research question is as follows: “Which milestones and obstacles of learning can be identified?”

To address these research questions, this study pursues three consecutive objectives. Firstly, a structured learning opportunity focusing on space/place needs to be developed. A specifically designed teaching experiment [36] provides a context to, secondly, gain empirical insights into the learning processes that are involved in developing a conceptual understanding of geography, focusing on milestones as well as obstacles to learning, and reconstructing individual learning pathways [12]. Thirdly, these empirical results allow to subsequently derive teaching implications for teaching space/place as well as identify further research desiderata.

#### 4. Materials and Methods

##### 4.1. Sample

Given the explorative nature of this qualitative study, criterion sampling was employed [37]. In order to ensure the quality of the sample, it is imperative to maximise variance between cases while ensuring comparability. Two criteria were particularly important: grade level and unfamiliarity of the concept. Regarding grade level, the target group comprises upper-grade high school students near the end of their geographical education to allow for a first empirical examination of the development of their comprehension of spatial concepts, starting with this “upper anchor”. There are two primary reasons for this selection. Firstly, it involves a relatively intricate concept, and a certain level of age-dependent cognitive development is necessary to grasp it, as suggested by Vygotsky [38]. Secondly, there is a limited amount of empirical data regarding how to enhance the accessibility of this concept for lower grade levels. Therefore, it is sensible to align the operationalisation of the concept as closely as possible with the scientific concept without making substantial reductions or simplifications (i.e., the number of spatial concepts or terminology). Secondly, as the central focus of the study was the development of understanding for the extended understanding of space/place as a geographical key concept, it is crucial that the participants have no prior familiarity with the subject of investigation. This was ensured by talking to the students’ teachers. Following these criteria, in total, 64 high school students from both grammar schools and comprehensive schools in North Rhine-Westphalia ( $n = 18$ ) and Hesse ( $n = 46$ ) participated in this study. Among them, 36 students were enrolled in basic courses, and 28 were taking advanced courses. In a second sampling process, students were carefully chosen in collaboration with their respective course instructors to ensure similarity in terms of their performance levels and cooperativeness. This process resulted in a total of 32 pairs of students, with one pair being excluded due to technical issues. As a result, a total of 31 cases were considered for the analysis. Subsequently, a selection of six cases was made for a detailed examination of the learning processes with an emphasis on maximising variance.

##### 4.2. Instrument

Because of the dual research interest, this study employed a hybrid data collection approach known as a teaching experiment, which places a strong emphasis on the interaction between learners and their learning environment [36]. Teaching experiments offer a conceptual framework for the qualitative exploration of teaching and learning environments. In this case, the focus was on the tension between the (practical) intention to convey the four concepts of space/place and the (empirical) investigation of conceptual learning processes [39,40]. Accordingly, a structured learning environment involving a gradual approach to the extended understanding of space/place was developed. Based on a proposal on how to initiate key conceptual understanding from biology education [41], the learning environment was adapted according to the needs of this study and underwent six piloting cycles over the course of a year. To further ensure a good fit and its quality, these were accompanied by cognitive pretesting and expert ratings [42]. The final treatment includes

six consecutive stages of concept acquisition, each with an increasing level of complexity: I. phenomenological discovery, II. retrospective comparison, III. concept specification, IV. transfer to further examples, V. in-depth application, and VI. generalisation [41].

In stage I, the students encounter the covert concept for the first time, using the example of emigration from Berlin-Marzahn. For this, twelve cards were presented, each focusing on one reason with a specific sub-concept which, however, was not immediately made explicit to the students (e.g., “Marzahn residents miss the urban flair” → perceived place). Students were then prompted to create categories and headlines of their own choosing to encourage the inductive exploration of the concept. Following this stage, the retrospective comparison (stage II) was introduced using a second case study (“Tourism Development in Bali”). The introduction of another example was intended to promote the detachment of the concept from a specific place or topic. Applying the same principles from stage I, the students were presented with twelve cards which they had to categorise once more. Subsequently, the concept underwent refinement in stage III, wherein the concept itself was elaborated. This stage was characterised by the students’ refinement of spatial concepts through a contrastive examination between the students’ categorisations in both stage I and II. Additionally, they were then provided with a short definition of each concept. This served as the basis for the independent application of the concept in stage IV, at first to another preselected case study (“Deforestation of the tropical rainforest”). Moreover, students were then prompted to transfer the four concepts to another geographical topic of their own choosing, intending to further encourage the concepts’ detachment. Stage V then focused on interconnecting the individual sub-concepts and their in-depth application to further encourage the students’ active usage of spatial concepts. Tasks encompass exploring the interconnections of the four concepts as well as developing a specific geographical question based on the previous, self-chosen example. Finally, stage VI involved the generalisation of the four spatial concepts through self-generated guiding questions for each sub-concept.

In total, the treatment lasted for 90 min, covering 23 tasks and a dozen accompanying materials. To ensure a high degree of standardisation, tasks and materials were provided throughout the entire treatment by field interviewers, six in total, which comprised extensively trained researchers and research assistants. As typical with teaching experiments, they have a dual role as both educators and researchers. Specifically, their role was to guide the students through the treatment using standardised tasks and questions, but refraining from offering additional support or feedback to avoid interfering with the research interest.

#### 4.3. Videobased Data Collection

To adequately capture conceptual learning processes, it is necessary to employ a data collection method that registers the complexity involved [43]. Videography fulfils this requirement, acting as a tool that “provide[s] researches with powerful ‘microscopes’ that greatly increase the interactional detail” [44] (p. 6). Videotaping learning processes allows for the documentation of real-time dynamics and provides the ability to stop, slow down, and/or repeat scenes. This enables detailed analyses beyond what regular observation can achieve. Given that the learning process involves both (verbal) interactions between participants and (haptic) interactions with the materials provided, the camera position utilises an angular frame, focusing on both the learners and the tabletop [45].

As with other types of data, video data require post-recording processing. To fully leverage the potential of video technologies, data processing encompasses both the auditory and the visual level. The former is accomplished by creating transcripts of participants’ dialogue [46], while the latter involves recreating various learning products. This approach optimally captures the complexity of conceptual learning on both levels [43]. These learning products include participants’ sortings, written headlines, and written interaction with the provided materials (for example, see Figures 2–5 below). An optimised reconstruction of learning processes is then achieved through targeted triangulation of the different types of data [47].

#### 4.4. Qualitative Content Analysis

Applying qualitative content analysis [46], a structured, systematic and criteria-based method to analyse qualitative data, an inductive category system was developed based on the video data, transcripts, and learning products. To aptly reflect the essential combination of process and context, it employed two strands of main categories, “content” and “procedure”. These were further differentiated into various middle and minor categories with decreasing levels of abstraction (see Table 1).

**Table 1.** Illustrative excerpt from the category system.

| Major Category | Middle Category | Minor Category        |
|----------------|-----------------|-----------------------|
| content        | conceptual      | scale level           |
|                |                 | sustainability        |
|                |                 | ...                   |
|                | thematic        | geographical model    |
|                |                 | technical terms       |
|                |                 | ...                   |
| procedure      | exploring       | ...                   |
|                |                 | using metaphors       |
|                |                 | generating hypotheses |
|                | ...             | ...                   |
|                |                 | ...                   |
|                |                 | ...                   |

For instance, the major category “content” was subdivided into five middle categories, including “conceptual”, which refers to any kind of geographical key concept. These were further differentiated into various minor categories, for example, “scale level”, which denotes a reference to the geographic key concept of scale. Similarly, the second major category “procedure” was organised into ten middle categories, such as “exploring”, which involves going beyond the information given in the material. In return, these were subdivided into more than 100 minor categories, including “using metaphors”, which involves playing with words (e.g., “this is like the left brain, right brain”). Applying the designated categories, the entire dataset was independently coded by the primary researcher and a specifically trained assistant. Employing the method of communicative validation [48], which encompasses the discursive reflection on the data analysis with another researcher, divergent codings were discussed to reach consensus and ensure validity.

#### 4.5. Learning Pathway Analysis

The reconstruction and subsequent analysis of learning pathways offer great potential to properly illustrate the process of conceptual learning, directly addressing the guiding research question. Learning pathways are related to conceptual pathways, defined as “learning routes along which students pass in developing understanding in any domain of science” [13] (p. 221). As “any pathway will be peculiar to a particular learner in any given domain” (ibid.), the objective is to understand each case from within. By revealing case-immanent structures of the concept acquisition process, it is possible to offer a plausible, theory-based, and comprehensive reconstruction of individual cases’ pathways [12]. It is important to point out that learning pathways not only focus on stable ideas but specifically include changing cognitive structures and can, thus, be understood as a “stroboscopic description of learning processes” [49] (p. 1076). In this context, Petri frames learning pathways as a “description of the sequence of individual conceptual development steps” [12] (p. 95). Accordingly, in this study, learning pathway analyses are thus characterised by case-basedness, a descriptive–analytical mode, and a combination of

the process with learning products. The content-analytical codings form the basis for the reconstruction of learning pathways by implementing them in an explicative manner.

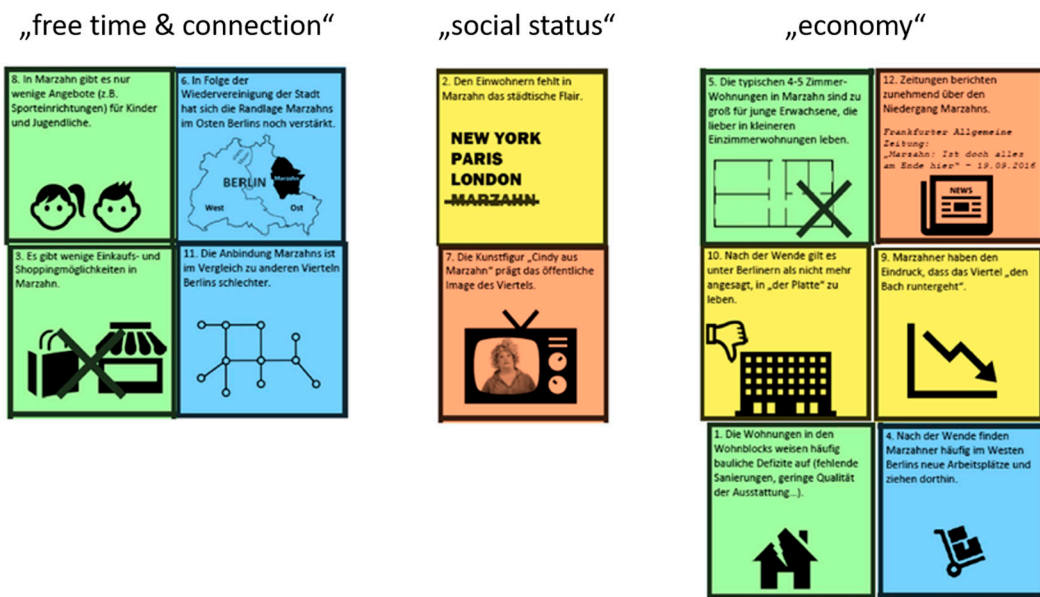
For the ensuing reconstruction of learning pathways, six cases showing a high variance across all phases (e.g., categorisation and transfer strategies...) were selected. Given the extensive scope of each pathway, this article focused on a single selected pathway. The chosen case exhibited a notably high frequency of oscillation between learning obstacles and milestones, along with a distinct solidification of some learning obstacles.

## 5. Results

This section outlines the learning pathway of the case labeled “tree” (due to how the students branch out their conceptual learning strategies), featuring two participants from a German high school—pseudonymously identified as Liam and Sarah. Both students were enrolled in a basic geography class and showed high performance levels. Concentrating on a single case allows a detailed and fine-grained analysis of the learning process. Special attention will be given to the identification of learning obstacles and milestones. This includes examining when and how these elements manifest themselves and their interrelationships, with the goal of outlining the complexities of learning an abstract geographical key concept.

### 5.1. Stage I: Phenomenological Discovery

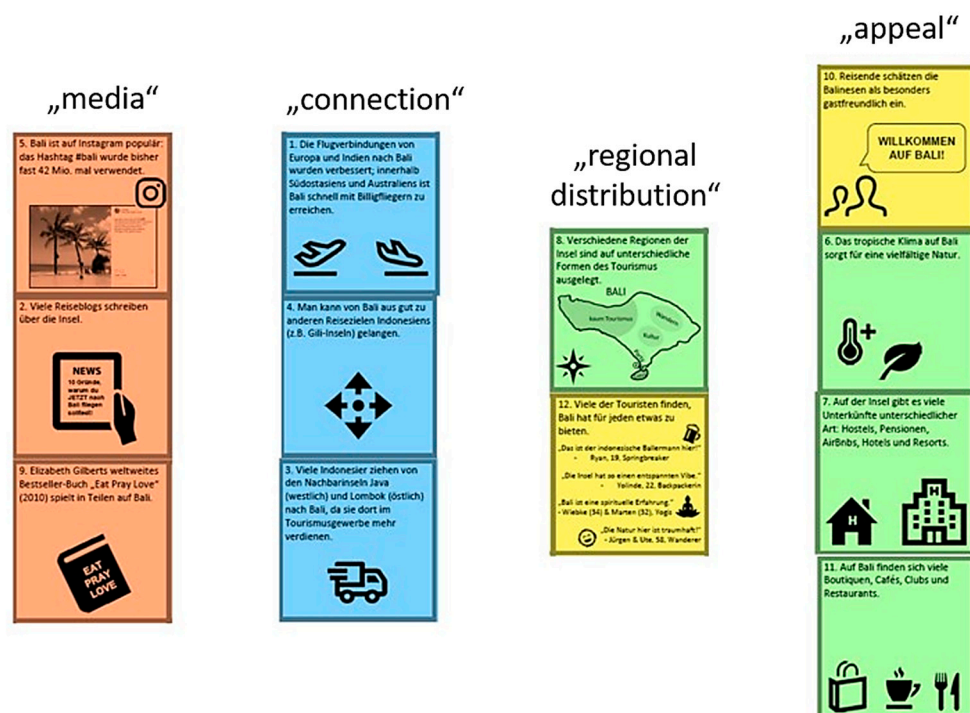
As illustrated in Figure 2, in the initial stage, the case “tree” formed three conceptually mixed categories. However, a first attempt to partially distinguish between material space and mental place—i.e., differentiating the concepts on a basic level—became evident. For instance, the category ‘free time and connection’ exclusively comprised cards related to material space (i.e., space as a container and space as a system), whereas the category ‘social status’ solely featured cards associated with mental place (i.e., place as perception and place as a construct). The last category, economy, however, blended various sub-concepts from both material space and mental place. Considering the students’ rationale for forming the categories, it became evident that the conceptual ambiguity stems from their incorporation of components from another geographical key concept—sustainability: Liam: “so now that I’ve seen a few [cards], I think you could distribute [them] easily between the different types(.) economy(.) social (Sarah: Social) and so on”. Accordingly, the examination of the cards is not neutral but is guided by the previously expressed preconceptions in the sense of a confirmation bias. As a result, using the sub-dimensions of economic sustainability and social sustainability for structuring their categories obstructs the inductive exploration of the underlying concepts of space and place. Therefore, in this stage, the incorporation of other geographical key concepts became a learning obstacle due to conceptual interferences driven by confirmation bias.



**Figure 2.** Reconstructed categories and headlines for stage I “phenomenological discovery”, using the example of emigration in Berlin-Marzahn (case “tree”).

### 5.2. Stage II: Retrospective Comparison

During stage II, there was a noticeable shift in organising strategies observed with case “tree”: Having previously utilised a deductive strategy by applying an already known geographic key concept to structure the cards, the participants now switched to an inductive strategy, resulting in the formation of four categories (see Figure 3).



**Figure 3.** Reconstructed categories and headlines for stage II “retrospective comparison”, using the example of tourism development in Bali (case “tree”).

This proved to be a successful strategy, as the conceptual clarity on a micro level significantly improved compared to the previous stage. This showed in the conceptu-

ally homogeneous categories “media”, exclusively comprising cards referring to place as a construct, and “connection”, consisting solely of cards related to space as a system. Furthermore, the students begin to identify initial conceptual features by establishing media-boundness in the context of place as a construct and connectivity for space as a system. Clearly, categories developed inductively demonstrate greater compatibility with spatial concepts, marking this strategy a milestone in conceptual learning. Nevertheless, the categories “regional distribution” and “appeal” remained conceptually mixed, even though the headlines indicated a degree of proximity to the underlying concepts but yet not fully realised.

### 5.3. Stage III: Concept Specification

During this stage, the students delved into various aspects of the concepts, exploring ascribed differences such as digital vs. analogue and subjective vs. objective. Additionally, occasional references were made back to the initial examples, along with cross-references. This not only indicates a further building of interconnections between new and old bodies of knowledge but also illustrates the students’ combining the abstract (i.e., general concept characteristics) with the concrete (i.e., using specific examples).

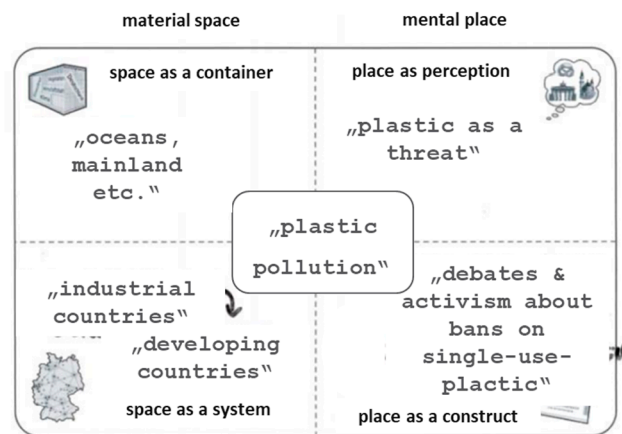
In this context, further concept specifications can be observed. Until now, the students implicitly distinguished the extended understanding of space/place on a conceptual meso-level, i.e., between cards referring to material space and mental place. Through further approximations, this distinction became explicit and was elaborated upon by Liam: “I’d say that this [mental place] is subjective and this [material space] is objective”. Consequently, the participants began to explore the concepts’ different underlying paradigms (i.e., positivism and constructivism). This represents another significant milestone in the conceptual learning process.

Throughout this process, the individual sub-concepts also underwent varying levels of elaboration. The participants made efforts to further differentiate between the two material concepts of space. For instance, referring to space as a container, Liam elaborated by referring back to the first example: “You can’t really say, like, this is Berlin and now we just cut it off from all other places. It’s not an autonomy”. Thereby, they established the attribute of connectivity as exclusive to space as a system and started to grasp the enclosed nature of space as a container. Distinguishing the material space proves to be another milestone in their conceptual learning process. Regarding mental place, the concept of “place as a construct” receives a notably high level of attention and is particularly detailed in its attributional specification, especially in the context of its digital and variable nature.

Additionally, it is noteworthy that participants frequently used the term “things” as a reference for spatial concepts in general (for example, when discussing space as a system, they mention “there are always two things to it”), suggesting that their understanding of spatial concepts at this stage is primarily thematic in nature, indicating a starting point of a learning obstacle.

### 5.4. Stage IV: Transfer

During stage IV, the case “tree” promptly opted to explore “a topic from [our] presentations” (see Figure 4), establishing a cross-reference between the new concept and prior knowledge. This results in the creation of knowledge networks, a pivotal aspect of the learning process. It becomes also clear that the students drew on examples where they possess a high level of expertise, ensuring the availability of declarative and easily accessible factual knowledge.

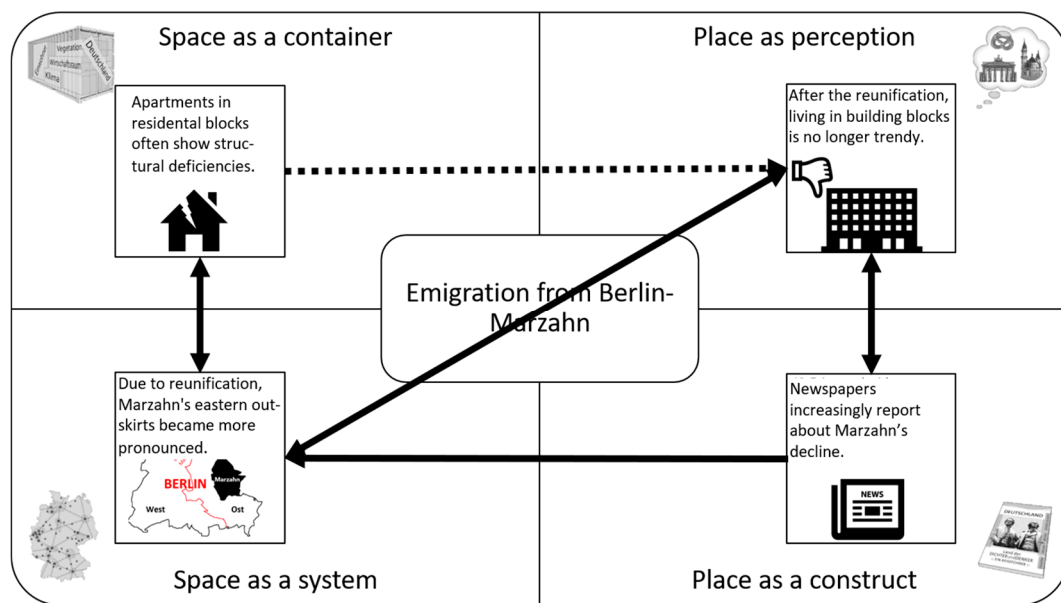


**Figure 4.** Reconstructed learning product for stage IV “transfer”, using the chosen example of plastic pollution (case “tree”).

However, the chosen example “plastic pollution” lacks a specific spatial reference (e.g., “plastic pollution in Germany”) and instead focuses on a broader topic. Using a purely content-based example indicates a thematic understanding of the concepts, rather than a spatial one. The absence of a spatial dimension, therefore, constitutes another obstacle as it impedes a deep understanding of the spatial concepts as a whole. Nonetheless, in the subsequent exploration of individual sub-concepts, the students exhibited a decent grasp of each concept’s major characteristics. Regarding space as a container, the students articulated an understanding of its characteristic territoriality, yet a concrete spatial focus was still lacking, as seen in Sarah’s statement: “[These] are areas where plastic pollutions generally occurs [...] primarily in oceans, but also on mainland”. Similarly, for space as a system, they emphasised its relational characteristic, with Liam stating: “[Between industrial and developing countries] there is a developing relationship, in that they exchange waste, like, time and time again”. Regarding the place as a construct, the students referenced its characteristic of communication “which can be both offline and online” and made connections to everyday life, as highlighted by Liam: “At Fridays for Future demonstrations there are also a lot of protests against plastic”. Lastly, regarding place as perception, the students highlight its subjectivity, claiming it can be either positive or negative. This represents a rather less complex conceptualisation. In summary, participants distinguished the chosen example based on individual spatial concepts by leveraging their expertise, yet without establishing a direct spatial connection. This resulted in the application of relevant attributes related to spatial concepts, albeit within a thematic instead of a spatial framework, hindering a sophisticated spatial conceptual understanding at this point. This solidification of the obstacle „lack of spatial focus“ illustrates the persistence of some barriers to learning.

### 5.5. Stage V: In-Depth Application

When asked to form connections between the four sub-concepts in stage V (see Figure 5), again referring to the example of emigration from Berlin-Marzahn, both moments relevant for conceptual learning as well as those hindering the process occurred.



**Figure 5.** Reconstructed learning product for stage V “in-depth application” (case “tree”).

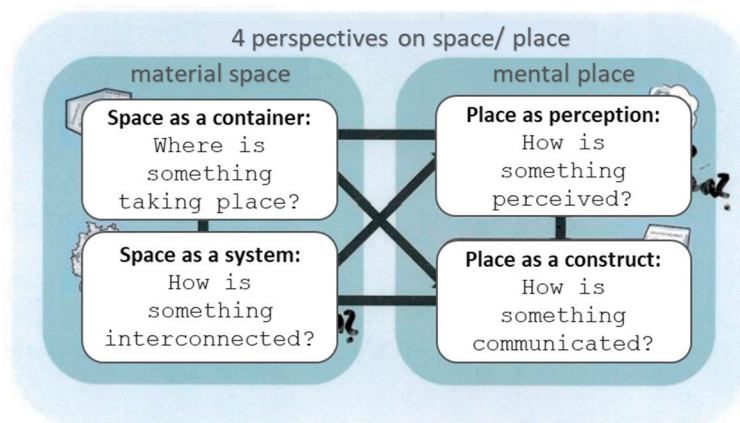
Firstly, the participants increasingly exhibited a growing mastery of the technical terminology linked to spatial concepts, actively incorporating these terms into their vocabulary. This marks a milestone in learning as it showcases an enhanced incorporation of the concepts into the mental knowledge network. However, the students’ line of argumentation while connecting the cards also revealed a consolidation of geodeterministic tendencies, as exemplified by Liam’s statement: “So there were definitely different mentalities in East and West Germany, which was perhaps also reflected in journalism and the media”. Clearly, stereotypical ideas surfaced as the participants conceptualised mentality as dependent on space. This poses an obstacle to learning, signifying a subject-related oversimplification that is undesirable.

To further stimulate the active application of the concepts, the students were then tasked with developing a geographical question related to their previously chosen example “plastic pollution”, ensuring that it addresses at least two spatial concepts. To do this, the participants again drew on their prior knowledge and drafted a question focusing on space as a system and place as perception, as shown by Sarah: “How can you provide countermeasures [against plastic pollution] that do not disadvantage any side [industrial and developing countries, people and children affected. . .]?”. Concerning space as a system, they delve into establishing a more equitable relation between countries, as Liam expressed: “You have to make sure that it is not only, for example, good for industrialised countries but bad for developing countries. Or the other way round, that you don’t just make a compromise (Sarah: Mhm.) but a real solution”. Evidently, they strongly referred to the actual relations between the countries in question in a literal sense, less so on a more abstract, conceptual level. With respect to place as perception, the students stressed different relevant stakeholders and differentiate between perceptions, as illustrated by Sarah: “So you have people who actually associate plastic negatively, because they live on or next to a landfill and are constantly confronted with it, [ . . . ] also in the other direction, that plastic is not glorified any further”. While the participants established primary spatial experience as a characteristic here, they fell short of offering a direct reference to a specific space/place. Consequently, the concepts remained exclusively content-oriented. This learning obstacle is both persistent and especially challenging because the participants themselves remain unaware of it. Nonetheless, formulating a guiding question proves valuable in the learning process, as using the spatial concepts enables a reorganisation of knowledge, ultimately leading to the students’ developing geographical inquiry. They employed the concepts

as tools to identify a specific geographical issue and formulate a question geared towards finding solutions, all while considering the role of spatial constructs in their analysis.

### 5.6. Stage VI: Generalisation

As becomes obvious in the resulting questions (see Figure 6), at the end of the treatment (stage VI), the students showed a decent grasp of the concepts' individual characteristics.



**Figure 6.** Reconstructed learning product for stage VI “generalisation” (case “tree”).

While space as a container is conceptualised through localization (“Where is something taking place?”), space as a system is framed through its connectivity (“How is something interconnected?”). Regarding place as perception, the students stressed it as being based on (sensory) perception (“How is something perceived?”). Lastly, the students perceived place as a construct rooted in communication (“How is something communicated?”), including digital- and analogue-types of communication. In contrast, the reference frame for the concepts remains obscure, showing in the repeated use of the word “something”. Given the exclusive focus on object-related topics, none of the questions exhibited a distinct spatial dimension, suggesting that the participants perceived spatial concepts primarily as analytical tools for addressing a topic. This absence of clear spatial references presents a learning challenge. Despite its attributive appropriateness, this impediment hinders a comprehensive understanding of the extended spatial understanding implied by the concept.

## 6. Discussion

The guiding research question focused on the learning pathway of students in developing a conceptual understanding of the four concepts of space/place, with a specific emphasis on obstacles to and milestones of learning. The detailed examination of the learning pathway of the case “tree” vividly illustrates the complexities inherent in conceptual learning, marked by both conceptual dead ends and regressions, as well as leaps and bounds (see Table 2). Using a deductive strategy at the beginning (stage I), the participants draw upon another geographic key concept (sustainability) without conscious awareness. Subsequently, a shift to an inductive strategy in stage II resulted in higher conceptual soundness. A possible explanation for this change of strategy towards a more exploratory approach might be a deeper engagement with the material and an ensuing tracing of initial conceptual characteristics. However, pre-existing stereotypical, geo-deterministic tendencies were retroactively associated with spatial concepts and thus formed an unwanted learning outcome. Notably, the exploratory development of their own geographical inquiries was characterised by its relevance to the learning process. However, the final conceptual guiding questions were devoid of any spatial context. This exclusively thematic perspective had already been hinted at through the use of an example lacking spatial context (‘plastic waste’) and hindered the development of a conceptual understanding.

**Table 2.** Overview of conceptual learning milestones and obstacles for each stage of the treatment (case “tree”).

| Stage                         | Milestones                                                                              | Obstacles                     |
|-------------------------------|-----------------------------------------------------------------------------------------|-------------------------------|
| I: phenomenological discovery | • partial implicit distinction on a conceptual mesolevel                                | • conceptual interferences    |
| II: retrospective comparison  | • establishing partial conceptual clarity                                               |                               |
| III: concept specification    | • making cross-references<br>• combining the abstract and the concrete                  |                               |
| IV: transfer                  | • establishing knowledge networks                                                       | • lack of spatial dimension   |
| V: in-depth application       | • restructuring existing geographical knowledge<br>• using concepts as analytical tools | • geodeterministic tendencies |
| VI: generalisation            | • grasping the concepts’ individual characteristics                                     | • lack of spatial dimension   |

Moreover, as became obvious, the participants’ understanding of the individual sub-concepts varied greatly, with a particularly more pronounced understanding of space as a system and place as a construct and a, comparatively, conceptually more obscure understanding of space as a container and place as perception. This result partly deviates from existing research which suggests students’ preference for the material concepts of space, especially regarding space as a container [8]. A possible explanation lies in the methodology employed: Bette and Schubert covertly investigated students’ attitudes toward the concepts, which were unbeknownst to them. To address this challenge, the authors attempted to tackle it by carefully operationalising the survey items. In contrast, in the current study, all participants were presented with the concepts explicitly and overtly. Thus, it is possible that students may have had different attitudes toward spatial concepts in this study, as they were already acquainted with and had applied them in practice. These diverging findings offer a fruitful starting point for further research. For instance, it would be intriguing to employ the currently available quantitative test instrument [8] following the initiation of spatial conceptual understanding, as demonstrated in this study, to investigate the hypothesis posed above.

Another research question explicitly focused on milestones and obstacles to learning (see Table 2). As became obvious, sometimes, key moments and barriers changed rapidly (i.e., temporary interference with another key concept), while other times, some obstacles petrified and became somewhat resistant to change (i.e., lack of spatial dimension). Regarding this, parallels emerge to conceptual change research that report similar tendencies concerning a variety of geographical topics [47]. However, conceptual change research in geography education typically focuses on more concrete, material concepts (i.e., “deserts”, cf. [50]), while this research is of abstract conceptual nature. In the future, it might be worth exploring combining approaches from conceptual change research and key conceptual research to further explore the underlying mechanisms of abstract conceptual development and methodologically and theoretically broadening the fields.

Some select obstacles and milestones of conceptual learning are discussed in more detail due to their relevance to the process. One example of a more temporary obstacle is the interference with another key concept, sustainability, in stage I. The inclusion of additional key concepts was found to impede the understanding of spatial concepts in terms of overlap effects. Possibly, these key concepts are more readily accessible to the students compared to the intricate process of grasping spatial concepts, which comes with a significant cognitive load due to their novelty (see [51]). This finding, however, is not uncommon in conceptual learning: as Taylor [1] remarked, “although learning in each sequence is driven by a particular [key] concept, it will naturally bump into other [key] concepts” [6] (p. 53). To minimise such interferences that hinder conceptual acquisition,

there is a need for a clear conceptual focus on a single key concept when it is being introduced. Therefore, this finding supports theory-based recommendations, suggesting that in a teaching unit, only one key concept should be its basis [2,6].

One of the major, permanent learning obstacles was the lack of the spatial dimension in their understanding of the concepts. In addition, this also proved to be the most consistent obstacle, firstly occurring in stage III, further solidifying in stage IV, and becoming fossilised in stage VI. Evidently, the extended understanding of space/place was not utilised as a spatial concept but, to put it bluntly, as a thematic concept. Thus, the concept remains narrowly focused and, in a sense, literally utopian. This limited use of the concept raises concerns as it lacks a spatial dimension, resulting in a depletion of its geographical core and a shortfall in technicality.

Aside from obstacles to learning, important milestones have been identified as well. In the beginning, the students were already able to distinguish implicitly between the material and mental concepts, a differentiation which they followed consistently and precisely over the course of the entire treatment. This result is consistent with findings from cognitive psychology which show a steady preference for concepts on a basic level (material space and mental place) of hierarchy as opposed to a superordinate (extended understanding of space/place as a whole) or a subordinate (individual four sub-concepts of space/place) one [14]. An explanation for this is the reduced cognitive load due to a reduced amount of cognitive comparative processes on a purely quantitative level [52]. Additionally, taking a qualitative level into account, the subject-specific content of the concepts on this level also plays a crucial role here: the enhanced differentiation in the students' understanding of the mental and material concepts mirrors the greater separation of these concepts on an academic level [20,22]. This arises from the paradigmatic assumptions underlying physical-material spatial concepts, which are starkly dissimilar from those guiding concepts of mental place (see Section 2.1). Accordingly, reducing the number of concepts on this level proves to be a lever for reducing complexity in the learning process [53].

Additionally, the students' active usage of the four concepts in stage V proves a fruitful milestone of learning because it fosters restructuring of existing knowledge. The availability of factual knowledge ("vocabulary"), actualised by this case through prior expert presentations, is a key factor for a successful and sophisticated application of the four concepts of space/place ("grammar", [19]). This result aligns with empirical findings in geography and chemistry education, which suggest that students' declarative factual knowledge has an impact on concept-related competencies [54,55]. This function of structuring knowledge becomes obvious here as the students use the concepts to reorganise existing knowledge, pose new questions and gain new insights. This evident synergy between concepts and content thus emphasises the emancipatory role often attributed to key concepts (see [56]): "That is why we should focus on geography's grammar as well as on its endless vocabulary. That is the power of thinking geographically" [57] (p. 203).

## 7. Conclusions

Teaching the extended understanding of space/place enables learners to develop a nuanced, profound and inherently geographical understanding of an increasingly complex world by flexibly changing perspectives. This article focused on outlining the learning pathway of students while developing an increasingly sophisticated understanding of the key concept extended understanding of space/place in the course of a 90 min pre-structured treatment. While reconstructing the processes involved in concept acquisition, special attention was paid towards barriers and milestones of learning, which were shown to differ greatly regarding timeframe, impact, and persistency.

Furthermore, limitations as well as strengths are herein addressed. Regarding the former, the study's results have limited generalisability due to the highly structured treatment, potentially influencing learner behavior, and the small non-representative sample. To mitigate this common qualitative design limitation, a sampling strategy involving theoretical saturation and diverse case selection was employed. Further, regarding transferability of

results, it has to be kept in mind that the study design itself, in particular the treatment, does not constitute an instructional unit. While it identified numerous conceptual learning processes, it did not lead to an improvement of the practical use of the concept regarding quality and quantity of usage in classroom practice. To achieve this, there is a need for a focused transfer of these findings in the form of instructional examples and teacher training.

Despite these limitations, this study offers valuable insights into cognitive learning processes. It substantially contributes to understanding conceptual learning processes at a cognitive level, which are highly relevant for practical teaching. The study's strength lies in its practical approach and detailed, process-focused analysis, offering profound explanatory insights into students' key concept comprehension. Accordingly, this work can contribute to designing effective learning environments for key concepts, allowing students to better understand spatial concepts and leverage their potential in geography education.

Following this, several implications for teaching spatial concepts in the classroom can be derived on the basis of this study. Given the students' largely thematic understanding of the concept, a consistent combination of a thematic and a spatial focus while teaching and learning with the concept in the geography classroom is non-negotiable. Additionally, there should be a clear focus on a single key concept per teaching unit to avoid unwanted conceptual interferences. Moreover, the active usage of the concepts proved to be a fruitful moment in the learning process given and should be encouraged through appropriate tasks, exercises and materials.

Additionally, further research is needed on various levels. Combining quantitative and qualitative approaches would make it possible to, for example, investigate possibly changing students' attitudes towards the concepts in the course of acquiring them. In the future, it would seem particularly beneficial to take a longer-term look at students' acquisition of the extended understanding of space/place in the context of a spiral curricular, cumulative approach in the classroom. This would provide a fruitful base to subsequently model the development of conceptual understanding in the form of learning progressions, rooted in empirical data, or competency development models. Lastly, connecting key conceptual research with conceptual change research could offer a fruitful starting point for methodological advances and making use of potential synergies.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Conflicts of Interest:** The author declares no conflicts of interest.

## References

1. Montello, D.R.; Grossner, K.; Janelle, D.G. (Eds.) *Space in Mind: Concepts for Spatial Learning and Education*; MIT Press: Cambridge, MA, USA, 2014.
2. Uhlenwinkel, A. Geographical Concepts als Strukturierungshilfe für den Geographieunterricht. Ein international erfolgreicher Weg zur Erlangung fachlicher Identität und gesellschaftlicher Relevanz. *Geogr. Ihre Didakt.* **2013**, *41*, 18–43.
3. Fögele, J. Entwicklung basiskonzeptionellen Verständnisses in geographischen Lehrerfortbildungen I Rekonstruktive Typenbildung I Relationale Prozessanalyse I Responsive Evaluation [Dissertationsschrift JLU Gießen]. In *Geographiedidaktische Forschungen*; Band 61; Hochschulverband für Geographiedidaktik, Ed.; MV-Verlag: Münster, Germany, 2016.
4. Demuth, R.; Ralle, B.; Parchmann, I. Basiskonzepte—Eine Herausforderung an den Chemieunterricht. *Chemkon* **2005**, *12*, 55–60. [[CrossRef](#)]
5. Uphues, R. Basiskonzepte. In *Wörterbuch der Geographiedidaktik*; Böhn, D., Obermaier, G., Eds.; Westermann: Braunschweig, Germany, 2013; pp. 22–23.
6. Taylor, L. Key concepts and medium term planning. *Teach. Geogr.* **2008**, *33*, 50–54.
7. Massey, D. The Geographical Mind. In *Secondary Geography Handbook*; Balderstone, D., Ed.; Geographical Association: Sheffield, UK, 2006; pp. 46–51.

8. Bette, J.; Schubert, J.C. Einstellungen von Schülerinnen und Schülern zu Raumkonzepten der Geographie. Ergebnisse einer empirischen Studie zur Erfassung der Lernerperspektive. *Z. Geogr.—J. Geogr. Educ.* **2015**, *43*, 29–58.
9. Deutsche Gesellschaft für Geographie (Ed.) *Bildungsstandards im Fach Geographie für den Mittleren Schulabschluss*, 10th ed.; Deutsche Gesellschaft für Geographie: Bonn, Germany, 2020.
10. Larsen, T.; Harrington, J.A. Developing a Learning Progression for Place. *J. Geogr.* **2018**, *117*, 100–118. [CrossRef]
11. Mohan, L. Student learning of place: Learning progression can help fill the gaps. *J. Geogr.* **2018**, *117*, 125–127. [CrossRef]
12. Petri, J. Fallstudien zur Analyse von Lernpfaden. In *Methoden in der Naturwissenschafts-Didaktischen Forschung*; Krüger, D., Parchmann, I., Schecker, H., Eds.; Springer Spektrum: Berlin & Heidelberg, Germany, 2014; pp. 95–105.
13. Scott, P.H. Pathways in learning science: A case study of the development of one student's ideas relating to the structure of matter. In *Research in Physics Learning: Theoretical Issues and Empirical Studies*; Duit, R., Goldberg, F., Niederer, H., Eds.; IPN: Kiel, Germany, 1992; pp. 203–224.
14. Murphy, G.L. On the conceptual-perceptual divide in early concepts. *Dev. Sci.* **2004**, *7*, 513–515. [CrossRef]
15. Vergnaud, G. The Theory of Conceptual Fields. *Hum. Dev.* **2009**, *52*, 83–94. [CrossRef]
16. Lee, P.J. Putting principles into practice: Understanding history. In *How Students Learn: History, Mathematics, and Science in the Classroom*, National Research Council, Ed.; The National Academies Press: Washington, DC, USA, 2005; pp. 31–77.
17. Lambert, D. The Power of Geography. 2004. Available online: <https://www.geography.org.uk/download/npogpower.doc> (accessed on 22 December 2021).
18. Tuan, Y. Space and place: Humanistic perspective. In *Philosophy in Geography*, 20th ed.; Gale, S., Ollson, G., Eds.; D. Reidel Publishing Company: Dordrecht, The Netherlands, 1979; pp. 387–427.
19. Lambert, D. Introduction—Part 1: What is living Geography? In *Living Geography: Exciting Futures for Teachers and Students*; Mitchell, D., Ed.; Chris Kington: London, UK, 2009; pp. 1–7. Available online: [https://www.geography.org.uk/write/MediaUploads/Support%20and%20guidance/GA\\_ADVLivingGeogCh1.pdf](https://www.geography.org.uk/write/MediaUploads/Support%20and%20guidance/GA_ADVLivingGeogCh1.pdf) (accessed on 21 December 2021).
20. Dickel, M. TatOrte—Zur Implementation neuer Raumkonzepte im Geographieunterricht. In *TatOrte. Neue Raumkonzepte Geographiedidaktisch Inszeniert*; Dickel, M., Kanwischer, D., Eds.; Lit Verlag: Berlin & Münster, Germany, 2006; pp. 7–20.
21. Wardenga, U. Räume in der Geographie, Zu Raumbegriffen im Geographieunterricht. *Wiss. Nachrichten* **2002**, *120*, 47–52.
22. Wardenga, U. Raum- und Kulturbegriffe in der Geographie. In *TatOrte. Neue Raumkonzepte Geographiedidaktisch Inszeniert*; Dickel, M., Kanwischer, D., Eds.; Lit Verlag: Berlin & Münster, Germany, 2006; pp. 21–47.
23. Weichhart, P. Raumkonstruktionen, “Turns” und Paradigmen. In *Tourismusräume*; Wöhler, K., Pott, A., Denzer, V., Eds.; transcript Verlag: Bielefeld, Germany, 2014; pp. 21–40.
24. Köck, H. Der chronologische Raum—Die Mitte der Geographie. In *Die Kunst Sich Einzumischen: Vom Vielfältigen und Kreativen Wirken des Geographen Tilman Rhode-Jüchtern; Von Freunden und Wegegefährten zum 60. Geburtstag zu-Geeignet*; Horst, U., Rhode-Jüchtern, T., Eds.; Mensch & Buch Verlag: Berlin, Germany, 2005; pp. 45–56.
25. Blotevogel, H.H. *Handwörterbuch der Stadt- und Raumentwicklung*; Akademie für Raumforschung und Landesplanung: Hannover, Germany, 2018.
26. Gryl, I. *Raumtheorien, Raumkonzepte und ein Kompetenzbereich Räumliche Orientierung: Geographiedidaktische Theoriebezüge und deren Adaption*; Erziehungswissenschaft: Münster Germany, 2020. [CrossRef]
27. Fögele, J.; Mehren, M. Raumkonzepte der Geographie: Förderung eines erweiterten Raumverständnisses. *Prax. Geogr.* **2017**, *47*, 4–8.
28. Borsdorf, A. *Geographisch Denken und Wissenschaftlich Arbeiten*; Springer Spektrum: Berlin & Heidelberg, Germany, 2007.
29. Rawling, E. Reflections on place. *Teach. Geogr.* **2018**, *43*, 55–58.
30. Haltenberger, M. Überzeugungen von Grundschullehramtsstudierenden zu Basiskonzepten der geographischen Perspektive des Sachunterrichts. *GDSU-J.* **2021**, *12*, 87–106.
31. Lindau, A.; Renner, T. Zur Bedeutung des Fragenstellens bei geographischen Exkursionen. Eine empirische Studie mit Lehramtsstudierenden am Beispiel einer Exkursion in die nördliche Toskana. *Z. Geogr./J. Geogr. Educ.* **2019**, *47*, 24–44.
32. Bette, J.; Schubert, J.C. Einstellungen von Schülerinnen und Schülern zu geographischen Raumkonzepten. Ausgewählte Ergebnisse einer empirischen Studie. *Geogr. Aktuell Sch.* **2014**, *36*, 15–20.
33. Thieroff, B. Metareflexive Phasen zu den geographischen Raumkonzepten und deren Einfluss auf die Schüler\*inneneinstellungen zu diesen. Theoretische Grundlagen und empirische Untersuchung. In *Mitteilungen der Fränkischen Geographischen Gesellschaft*; Fränkische geographische Gesellschaft, Ed.; Selbstverlag der Fränkischen Geographischen Gesellschaft: Erlangen, Germany, 2020; pp. 75–88.
34. Prediger, S.; Parchmann, I.; Hammann, M.; Frederking, V. Unterrichtsqualität braucht Fachlichkeit—Zur Bedeutung fachdidaktischer Grundlagen- und Anwendungsforschung als Bindeglied zwischen Forschung und Praxis. In *Bildungsforschung 2020. Zwischen Wissenschaftlicher Exzellenz und Gesellschaftlicher Verantwortung*; BMBF, Ed.; Bundesministerium für Bildung und Forschung: Berlin, Germany, 2016; pp. 405–435. Available online: [http://www.mathematik.tu-dortmund.de/~prediger/veroeff/16-BMBF-Forum-Fachdidaktik-Prediger\\_etal.pdf](http://www.mathematik.tu-dortmund.de/~prediger/veroeff/16-BMBF-Forum-Fachdidaktik-Prediger_etal.pdf) (accessed on 22 December 2021).
35. Aufschnaiter, C.V. Process based investigations of conceptual development: An explorative study. *Int. J. Sci. Math. Educ.* **2006**, *4*, 689–725. [CrossRef]
36. Steffe, L.P.; Thompson, P.W. Teaching Experiment Methodology: Underlying Principles and Essential Elements. In *Research Design and Mathematics and Science Education*; Lesh, R., Kelly, A.E., Eds.; Routledge: New York, NY, USA, 2000; pp. 267–307.

37. Schreier, M. Varianten qualitativer Inhaltsanalyse: Ein Wegweiser im Dickicht der Begrifflichkeiten. *Forum Qual. Sozialforschung* **2014**, *15*, 18.
38. Vygotsky, L.S. Thinking and Speech. In *The Collected Works of L. S. Vygotsky (Volume 1). Problems of General Psychology*; Rieber, R.W., Carton, A.S., Eds.; Plenum Press: New York, NY, USA, 1987.
39. Prediger, S.; Link, M. Fachdidaktische Entwicklungsforschung—Ein lernprozessfokussierendes Forschungsprogramm mit Verschränkung fachdidaktischer Arbeitsbereiche. In *Formate Fachdidaktischer Forschung. Empirische Projekte—historische Analysen—Theoretische Grundlegungen* (S. 29–46). *Fachdidaktische Forschungen, Band 2*; Bayrhuber, H., Harms, U., Mus-Zynski, B., Ralle, B., Rothgangel, M., Schön, L., Vollmer, H.J., Weigand, H., Eds.; Waxmann: Münster, Germany; New York, NY, USA, 2012.
40. Trautmann, T. Zur Vertretbarkeit von Video- und Audiografien an Schulen—Eine Betrachtung zur Erhebung im Unterricht aus forschungsethischer Perspektive. In *Video- und Audiografie von Unterricht in der LehrerInnenbildung*; Sonnleitner, M., Prock, S., Rank, S.A., Kirchhoff, P., Eds.; UTB: Stuttgart, Germany, 2018; pp. 105–122.
41. Lichtner, H. Basiskonzepte—Eine Einführung in das Denken in Konzepten; 2012. Available online: <http://www.biologieunterricht.org/Basiskonzept2012.pdf> (accessed on 27 September 2021).
42. Lenzer, T.; Neuert, C.; Otto, W. *Kognitives Pretesting*; GESIS Leibniz-Institut für Sozialwissenschaften (GESIS Survey Guidelines): Mannheim, Germany, 2015.
43. Herrle, M.; Breitenbach, S. Planung, Durchführung und Nachbereitung videogestützter Beobachtungen im Unterricht. In *Videoanalysen in der Unterrichtsforschung. Methodische Vorgehensweisen und Anwendungsbeispiele*; Rauin, U., Herrle, M., Engartner, T., Eds.; Beltz Juventa: Weinheim und Basel, Germany und Schweiz, 2016; pp. 30–49.
44. Derry, S.J.; Pea, R.D.; Barron, B.; Engle, R.A.; Erickson, F.; Goldman, R.; Hall, R.; Koschmann, T.; Lemke, J.L.; Sherin, M.G.; et al. Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *J. Learn. Sci.* **2010**, *19*, 3–53. [CrossRef]
45. Aufschnaiter, C.V. Laborstudien zur Untersuchung von Lernprozessen. In *Methoden der Naturwissenschaftsdidaktischen Forschung*; Krüger, D., Parchmann, I., Schecker, H., Eds.; Springer: Dordrecht, Netherlands, 2014; pp. 81–94.
46. Kuckartz, U. *Qualitative Inhaltsanalyse, Methoden, Praxis, Computerunterstützung*, 4th ed.; Beltz Juventa: Weinheim, Germany; Basel, Switzerland, 2018.
47. Reinfried, S. Der Einfluss kognitiver und motivationaler Faktoren auf die Konstruktion hydrologischen Wissens—Eine Analyse individueller Lernpfade. *Z. Geogr.* **2015**, *43*, 107–138.
48. Gläser-Zikuda, M. Qualitative Auswertungsverfahren. In *Empirische Bildungsforschung*; Reinders, H., Ed.; VS-Verlag für Sozialwissenschaften: Wiesbaden, Germany, 2011; pp. 109–111.
49. Petri, J.; Niedderer, H. A Learning Pathway in High-School Level Quantum Atomic Physics. *Int. J. Sci. Ed.* **1998**, *20*, 1075–1088. [CrossRef]
50. Schubert, J.C. *Schülervorstellungen zu Wüsten und Desertifikation—Eine Empirische Untersuchung zu Einem Zentralen Thema des Geographieunterrichts*; University of Muenster: Münster, Germany, 2012.
51. Förtsch, C.; Werner, S.; Dorfner, T.; von Kotzebue, L.; Neuhaus, B.J. Effects of cognitive activation in biology lessons on students' situational interest and achievement. *Res. Sci. Educ.* **2017**, *47*, 559–578. [CrossRef]
52. Sweller, J. Implications of Cognitive Load theory for multimedia learning. In *The Cambridge Handbook of Multimedia Learning*; Mayer, R.E., Ed.; Cambridge University Press: New York, NY, USA, 2005; pp. 19–30.
53. Fögele, J.; Mehren, R. Basiskonzepte. Schlüssel zur Förderung geographischen Denkens. *Prax. Geogr.* **2021**, *5*, 50–57.
54. Ropohl, M.; Walpuski, M.; Sumfleth, E. Welches Aufgabenformat ist das richtige? Empirischer Vergleich zweier Aufgabenformate zur standardbasierten Kompetenzmessung. *Z. Didakt. Naturwissenschaften* **2015**, *21*, 1–15. [CrossRef]
55. Trygstad, J. *Students' Conceptual Thinking in Geography*; University of Minnesota: Minneapolis, MN, USA, 1997.
56. Lambert, D. Geography in School and a Curriculum of Survival. *Theory Res. Educ.* **2013**, *11*, 85–98. [CrossRef]
57. Jackson, P. Thinking Geographically. *Geography* **2006**, *91*, 199–204. [CrossRef]

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.