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Promoting geographic internet searches and subsequent argumentation using an Open Educational Resource

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ABSTRACT

The internet provides up-to-date, multi-dimensional and spatial information on geographical conflicts worldwide. Internet searches can therefore be used in geography education for students to learn about geographical conflicts and to form their own opinions on them. However, previous research indicates that students lack competences in searching and evaluating digital information on geographical conflicts and also in processing the information found argumentatively. Therefore, we developed a digital learning unit, available as Open Educational Resource, to train upper secondary and university students in targeted strategies for conducting internet searches on geographical conflicts and developing subsequent argumentations. In this study, we investigated whether geographic internet searches and argumentation skills can be promoted using the learning unit. For this purpose, we analysed the work products of 39 students that they produced within the learning unit, consisting of an internet search on a geographical conflict and a subsequent argumentation. In addition, the students evaluated the learning unit using digitally provided questionnaires. A comparison of the students' work results with previous research shows that the learning unit does not seem to affect the amount of information students find on the internet, but students seemed to engage more intensively with the information found. Using the information from the internet, students were able to create multi-perspective argumentations in which they could defend their opinions with justifications, counter-arguments and rebuttals. The results of our study thus show that internet searches on geographical conflicts and the development of subsequent argumentation can be promoted with the digital learning unit.

1. Introduction

German teenagers spend on average almost half an hour per day searching for information online, with their top three search options being Google or other search engines, YouTube and Wikipedia ([40], p. 33,49). With numerous Google queries every day, the digital search for information easily becomes an almost unconscious habit, liable to be a superficial process with little reflection ([24], p. 40).

Turning our students into responsible participants in society also means training them in the critical use of information. Educational institutions need to address, in particular, the opportunities and challenges of information from the internet, as many people struggle with the necessary competencies for dealing with digital information, lacking either technical or cognitive skills ([7], p. 2). The ability *"to recognise information needs, to identify, acquire, evaluate and use information effectively*" is referred to as information literacy ([51], p. 225). It is increasingly related to digital information and the internet. Hence, it interconnects with other areas of competence such as digital literacy, data literacy and media literacy ([25], p. 34).

In Germany, there have long been calls for the information literacy skills of children and young people to be promoted more strongly in schools (i.a. [22,26]). The current results of the International Computer and Information Literacy Study (ICILS), a comparative study of eighth graders, confirm the urgency of this need [17]. Approximately one third of the German students in the study have shown to have only very basic computer and information literacy skills. Less than 2% of the German eighth graders reached the highest level of competence and were thus able to evaluate and organise digital information independently and to produce information products that were high-quality in terms of content and form ([17], p. 13).

In this context, the need for the integration of media education and information literacy into teacher training and into the school subject

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curricula emerges ([51], p. 232). A basic awareness of information literacy can be promoted by interdisciplinary measures such as courses on "search techniques", but should not be limited to that ([25], p. 36,40). The different school subjects can contribute to the development of information competence in their own way. To make this possible, there is a need for action for educationalists in each subject area on how the development of these competences can be integrated within the subject curricula ([16], p. 158).

We created a digital learning unit, available as Open Education Resource (OER)[1], focussing on the subject-specific needs for internet searches and information processing in the form of argumentations in geography courses in universities and upper secondary schools. Previous research on students' skills in researching and processing geographical conflicts on the internet has shown that students have difficulties researching information effectively and with the evaluation of the information found ([18], p. 18). In addition, students were not always able to further process the information found on the internet in a high-quality geographical argumentation ([20], p. 15). The aim of our study is to find out whether students' skills in internet searches on geographical conflicts and the processing of the information found in the form of argumentation can be promoted through the digital learning unit we have created. Thus, it is designed to foster strategies when searching the internet to answer geographical conflicts, to organise the information found, to support the opinion forming process and to train the development of a subsequent geographic argumentation. The research questions that emerged for the evaluation of the digital learning unit were the following:

1 How do students evaluate the digital learning unit in terms of realisation and usability, content and structure, and (perceived) learning effect?
2 To what extent can the digital learning unit improve students' internet searches and subsequent argumentation on complex geographical conflicts?

This paper is structured as follows. We first give a theoretical background on internet searches on geographical conflicts and the processing of the information found in the form of geographical argumentations. Then we describe the digital learning unit, explaining the study design and the evaluation methods. Finally, we present the results and discuss them with regard to our research questions.

2. Theoretical basckground

2.1. Internet searches and the processing of information in geography courses

Existing research on students' general competencies in internet searches and in dealing with digital information suggests that adolescents often show an unreflective behaviour in the selection of websites ([31], p. 15; [49], p. 1457) and are often too uncritical in their use of information from the internet [10,39,46]. However, research mostly refers to skills in dealing with digital information in general, yet each (school) discipline has its own unique challenges to internet research and also to the handling of digital information. For instance, if mathematics requires the ability to find the *one* correct answer, competent internet research in modern foreign languages requires linguistic and intercultural skills in order to be able to use content at all. To address the specifics of internet searches in geography, we will initially outline the content and objectives of the subject.

According to the German Educational Standards in Geography [15], in geography education students learn to understand the interactions between nature and society by dealing with specific regional examples of geographical conflicts, exploring their processes and problems and developing solutions to them. The special potential in dealing with geographical processes and conflicts lies in the fact that these arise from the interactions between natural, physical-geographical conditions and human activities. Geography is the bridging subject between the social sciences and the natural sciences ([15], pp. 5–6). Geographical conflicts include, amongst others, disputes over questions of spatial or urban planning that are affected by divergent economic, ecological and social interests. They are complex problems, because they are ill-defined situations with a number of unknown factors and influences that usually only become apparent during the process of dealing with the problem ([8], p. 154). Further, the elements of the conflict are interrelated and have a spatio-temporal dynamic (Budke and Müller, 2015, 177). In distinction to political or historical conflicts, geographical conflicts are always spatially related and combine both, natural and anthropogenic factors or actors with their interests. Examples of geographical conflicts include disputes over the construction of wind farms in particular locations, the new development or expansion of an airport, the conversion of specific agricultural land to housing or commercial use, etc.

In order to understand geographical conflicts in their entirety, multi-dimensional, spatial and temporally relevant information is needed ([18], 6): Multi-dimensional information provides an overview of the different actors involved in the conflict, their interests and arguments. Spatial information is necessary because arguments that apply to a similar conflict in another place may not necessarily be transferable due to the different natural and man-made conditions of the spaces involved. As geographical conflicts are also subject to temporal change and can have various historical causes, older information can represent the course of the conflict, but current information is needed to evaluate the present state of the conflict. Textbooks can hardly provide up-to-date information on a multitude of geographical conflicts in their numerous perspectives, for lack of space. The internet is the source where all this information can be found on a great number of geographical conflicts worldwide. When searching the internet to understand a geographical conflict, students thus need to identify multi-dimensional information, analyse spatial information and recognise temporally relevant information on the conflict (see Fig. 1).

To explore a geographical conflict in its multiple dimensions, finding the information is the necessary prerequisite, but it is not the end of the process. When solving information problems with the help of the internet, the information retrieved needs to be put together to address the problem. As such, the organisation and presentation of information can be called the "synthesis" of the problem-solving process ([9], p. 1209). Since geographical conflicts are characterised by the clash of different interests and opinions, the logical synthesis of the information retrieved constitutes a discussion or argumentation. In this context, a high-quality argumentation must present, connect and discuss different perspectives of the geographical conflict, such as economic, ecological and social concerns. In order to be able to develop an argumentation on the conflict, students need to organise their information and form their own opinions on the conflict. A convincing argumentation, however, is not only about listing arguments that support one's own opinion: students need to be able to weigh and discuss the pros and cons of the conflict, as the inclusion of counter-arguments raises the quality of the argumentation, showing awareness of both sides of the conflict ([37], p. 142). Also, to argue geographically, the spatial conditions of the conflict location must be taken into account, e.g. infrastructure, population, natural conditions, etc. ([11], p. 276). Until now there have been no tested didactic concepts to support students in searching the internet for geographical questions, to help them organise the information they find and to support them in developing an argumentation on the basis of the information found. In the following section, we outline which strategies have proven useful in geographical internet searches and subsequent argumentation and thus ought to be promoted.

[1] Link to the OER "Internet searches as a basis for argumentation in geography":https://www.ilias.uni-koeln.de/ilias/goto_uk_lm_4510018.html

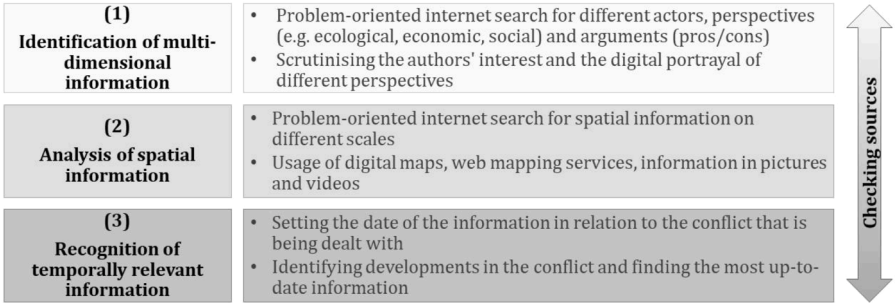

Fig. 1. Internet searches on complex geographical conflicts (cf. [18], 6).

2.2. Useful strategies for geographic internet searches and subsequent argumentations

Searching the internet for multi-dimensional information on geographical conflicts, students need to understand that information published on the internet often does not provide a neutral overview of a topic, but presents arguments that support a particular position. Students thus have to question the interest of a source and to "*give a critical opinion on the role of special interests in the presentation of geographically relevant information*" ([15], p. 23). However, many young people and adults have little awareness that digital sources often come from a particular perspective with a special interest, as they often do not question the author's background and thus do not recognise possible interests ([10], p. 3,14–16). Digital information is often even accepted without adequate evidence or verification of the sources ([51], p. 229). Moreover, a German study of over 4000 adult internet users has shown that, when assessing the credibility of websites, conflicts of interest were rarely recognised ([38], p. 4,67–70). When researching geographical conflicts, students need to learn to question the author's interest and find information from different interest groups in order to grasp the conflict in its multiple dimensions.

A study on geographical internet searches [18] shows that the usage of a higher number of websites and the selection of different types of websites, such as those of newspapers, citizen initiatives, environmental or commercial associations, etc. had a good effect on the multi-dimensionality of the information found. This may be due to the fact that news websites or Wikipedia give an overview of the conflict and may briefly present the positions of different actors, but the websites of private action groups help to understand the positions of the actors involved and provide detailed information about the conflict. However, they can be very one-sided, so the source's interest must be questioned and the websites of actors with contrasting interests should be used for information retrieval as well. Also, taking notes that were structured in terms of pro and con arguments or according to interest group seemed to improve the information search, especially when using digital writing tools ([18], pp. 18–19). The students had thus created a clear organisation, which presumably encouraged them to continue researching if they had not yet found enough information for one or another area. As they were working on the computer anyway, the digital notes here seemed natural and were probably less time-consuming than writing notes by hand.

Related research dealing with geographical argumentation based on internet research [20] showed that searching for information and processing the information found in the form of argumentations are two different competences that both need to be supported. It was the first research to explore the extent to which competences for researching geographical questions on the internet are related to those for geographical argumentation. The results showed that students who performed well in their internet searches on geographical conflicts did not necessarily use the information found to write high-quality geographic argumentations. The majority included only one or no counter-argument in their argumentation and hardly included any spatial information; they often did not even mention the name of the place they were talking about ([20], pp. 10–13). The majority of students based their argumentation on only a few pieces of information, even though they had found many more arguments during their internet search. Yet again, students who structured their information into pro and con arguments benefited from this and, on average, developed better arguments than students who found more information but did not note it down in a structured way ([20], pp. 15–16). Consequently, in order to understand geographical conflicts using the internet, we need to promote, in particular, the search for multidimensional information, the structured recording of information and interests, and the criteria-based writing of geographical argumentations.

2.3. Using a digital learning approach to promote geographic internet searches and argumentations

Effective training in information literacy requires different approaches depending on the context, preconditions and needs of the target group ([6], p. 300). Supporting students in geographic internet searches and the processing of information in the form of argumentations thus requires subject-specific methods, material and teaching concepts. For our purposes, a digital learning approach to foster digital competence provides a natural fit between method and content. In addition, digital learning concepts have taken on a new relevance since the coronavirus pandemic. Since March 2020, German schools and universities have repeatedly been completely or partially closed and teachers had to teach spontaneously under these new conditions. Teachers had to learn and use new digital methods and tools and some teachers are likely to use them in the future ([14], p. 135; [29], p. 3). This current teaching and learning situation could provide a certain push for the development of digital (higher) education in Germany ([53], p. 224). An exploratory study on geography teaching under COVID-19 in Germany (Bagoly-Simó et al., [4]) however showed that of the teachers surveyed, young teachers in particular often struggled with the technology and planning of digital lessons. In this context, the demand for educational media and adaptation to the new conditions of teaching were called for ([4], pp. 230, 235). Digital learning resources are needed as never before.

We created our digital learning unit "Internet searches as a basis for argumentation in geography" as an OER. Thus, it can be used without hindrance by teachers and students and also meets new requirements for (digital) teaching. The term OER refers to all educational resources that are freely available on the internet without any licence fees ([13], p. 5). OER is an emerging teaching and learning culture with open and individually adaptable learning resources ([44], p. 115). In the future, the increasing use of OER may mean that geography teachers will not only use textbooks, atlases and worksheets for lesson planning, but will also be able to access geomedia-based learning materials and lesson plans on the internet ([32], p. 9).

Digital learning formats offer the possibility to use a range of multimedia elements to convey the content, such as (audio) texts, (explanatory) videos, presentations, different task formats, links to

websites, etc. When dealing with media in (geography) lessons, we need to make sure that it is appropriate for our students and does not over- or under-challenge the learner ([42], p. 305). However, when students search the internet for information, teachers cannot estimate what information the students will be confronted with, or whether the websites used will overwhelm students in terms of content, language or technology. Specific strategies in digital information retrieval can support students in searching and managing the information. In digital learning formats, explanatory videos can be used to demonstrate useful strategies. For our purpose, explanatory videos of real internet searches on geographical conflicts enable us to show which aspects the students should pay attention to, and how they can find multi-dimensional, spatial and temporally relevant information (see Fig. 1). Interactive self-tests can be integrated for learners to assess their newly acquired knowledge, to review content and to check understanding. Students can playfully try out the answers until they find the right one. Repeatedly confronting the students with the content until the solution is found is likely to support the learning process ([35], pp. 46–47).

Using a digital learning approach has a further advantage when it comes to teaching internet competences, as – unlike in books or worksheets – these competences can be practised immediately, digitally and online. After the content has been taught, the digital learning format enables the students to carry out an internet search in order to apply and practise the newly learned strategies immediately and repeatedly. The instant independent application of the newly learned content is intended to contribute to the students' consolidation of the content. Further, the possibility of repeated practice is necessary, as new skills need to be practised several times to be acquired ([33], p. 103).

3. Description of the digital learning unit "Internet searches as a basis for argumentation in geography"

The digital learning unit "Internet searches as a basis for argumentation in geography" was created and made available with the learning platform ILIAS (Integrated Learning, Information and Work Cooperation System) at the University of Cologne. It is embedded in the digital subject concept "DiGeo"[2], which aims to build up competence in the responsible use of digital geomedia in geography teacher training and to prepare prospective geography teachers to convey these competencies to their future students ([44], p. 115). Further OER within the framework of the "DiGeo" project for the acquisition and teaching of geographical communication and argumentation skills can be accessed via the following link: https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_3758292.html.

Link to the digital learning unit "Internet searches as a basis for argumentation in geography"

https://www.ilias.uni-koeln.de/ilias/goto_uk_lm_4510018.html

To enhance students' information literacy and internet research skills, there is already a variety of OERs available which are often provided by (university) libraries. To give an example, the Chemnitz University of Technology offers an online course with different thematic modules for students on the topic of information literacy.[3] However, we could not find any OER that addresses the specifics of geographic internet research and argumentation. Thus, the digital learning unit was created entirely by us and is not similar to other digital learning units, both in terms of content and concept. The information requirements for internet research on geographic questions were developed by us [18] and meaningful strategies for geographic internet research and subsequent argumentation were empirically collected by us [18,20]. Our literature search did not yield a hit for an empirical validation of a comparable OER.

The learning unit was designed to foster useful strategies for internet searches on geographical conflicts (see Fig. 1) and the processing of the information found in form of an argumentation. Embedded in a short introduction which is meant to be informative and motivational, and in a final self-reflection on one's own learning gain, the learning unit consists of two main content parts (Fig. 2). Part I, *Learning about strategies*, is designed to introduce useful strategies for internet research and processing of the information in the form of opinion forming and argumentation on geographical conflicts. Part II, *Applying the learnt strategies*, is a work assignment supported with work materials, in which students are requested to apply the strategies learnt from Part I to answer a complex geographical conflict using the internet independently. In the following, the two parts of the learning unit are described in more detail.

In Part I, *Learning about strategies*, strategies for internet research, information processing and argumentation on geographical conflicts are explained in an interactive way. These strategies are presented by means of the example of a geographical conflict in Austria concerning whether the ski areas between the glacier lifts in the Pitztal and the Ötztal should be connected. In this conflict, different economic, ecological and social interests clash and many actors involved present their positions and arguments online. With the help of explanatory videos and presentations, students are shown real-life internet searches on the conflict, using search engines, result lists, homepages and maps to explain strategies for finding multi-dimensional, spatial and temporally relevant information. The videos also show how they can use supporting work materials to organise the information they find on the internet and to form their own opinions about the conflict. A presentation is used to present the learning content for writing a high-quality geographic argumentation. To check and consolidate the understanding of the contents, interactive self-tests are integrated after each content block, for example cloze texts or multiple choice tasks.

In Part II, *Applying the learnt strategies*, students are supposed to independently apply the strategies previously acquired in Part I, by conducting their own internet research on a geographical conflict, organising the information, forming an opinion on the conflict and writing an argumentation. They receive the work task in the form of a Word document containing the geographical conflict to be dealt with and supporting work material. The task is *"Should a bridge be built between the towns of Darchau and Neu Darchau? Justify your opinion by weighing up the pros and cons of a bridge's construction over the River Elbe."* Here, too, there are economic, ecological and social interests that collide, and many actors represent their opinions on the internet. We chose this question because the conflict involves natural, social, and economic interests colliding. These are typical elements of geographical conflicts, so the results are not unique to this specific example, but are broadly transferable to other geographical conflicts. Many involved actors express their opinions about the conflict on websites, such as citizens' initiatives or associations. The analysis of digital maps allows finding various arguments for or against a bridge. In addition, the conflict is spatially located about 500 km away from the current residence of the students, thus minimizing the likelihood of a personal connection or prior knowledge of the conflict (this was confirmed in the surveys; none of the participants had heard of the conflict before). As shown in Fig. 3, the students receive four different supporting work materials for the individual work steps, which had already been introduced to the students in Part I of the digital learning unit, *Learning about strategies*:

1 A table in which the information found can be recorded in a structured way with further relevant information on source, date and actors. The table is supposed to help the students keep track of the information they find and support them in questioning the credibility, interest and date of the sources and information.
2 A pro/con table to organise the information they have found by dividing it into pro and con arguments. This is intended to provide an overview of the arguments found and thus support the opinion-

[2] https://digeo-oer.net/doku.php

[3] https://www.tu-chemnitz.de/ub/kurse-und-e-learning/elearning/studierende/index.html

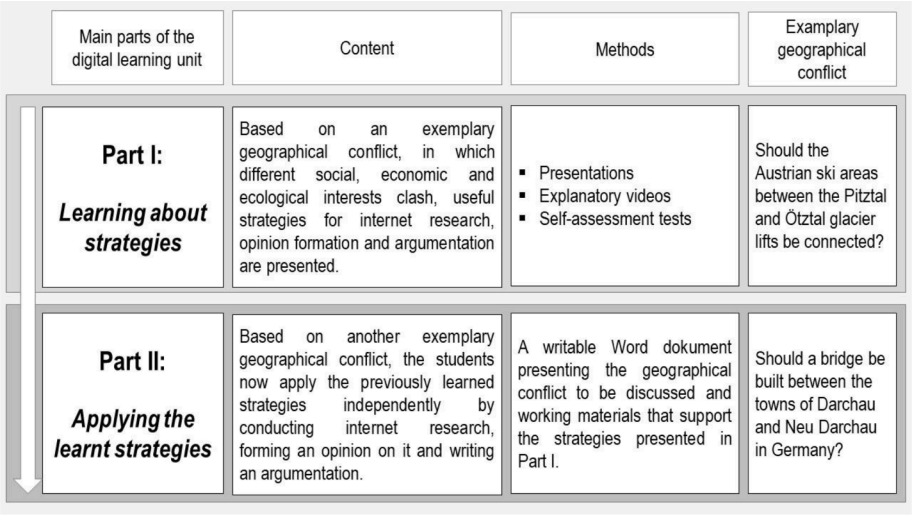

Fig. 2. . Structure and content of the digital learning unit (own illustration).

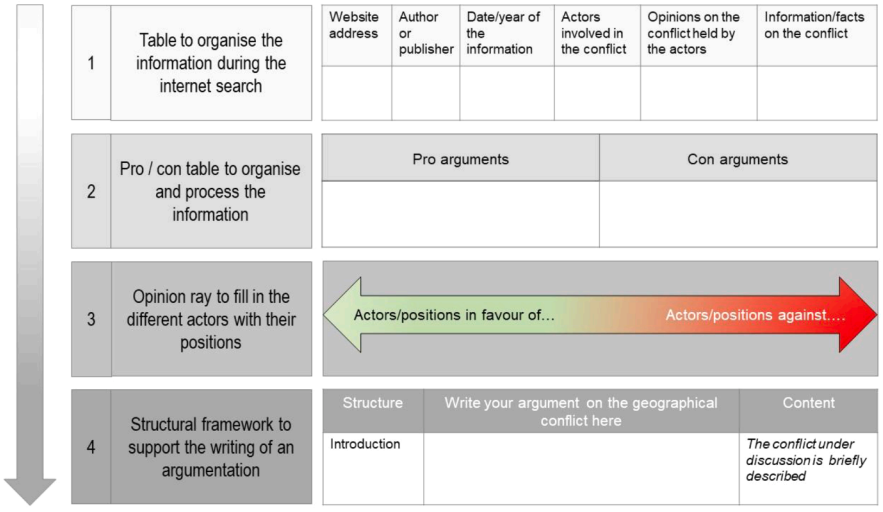

Fig. 3. . Structure and excerpts of the work material (following [19], pp. 305–307).

forming process and the development of the subsequent argumentation.

3 An opinion ray to fill in the different actors with their positions on the conflict. The visualisation of the different interests in the conflict is meant to be an additional step in the organisation of the information and to support the opinion-forming process. The students are asked to position themselves and their opinion in the opinion ray as well.

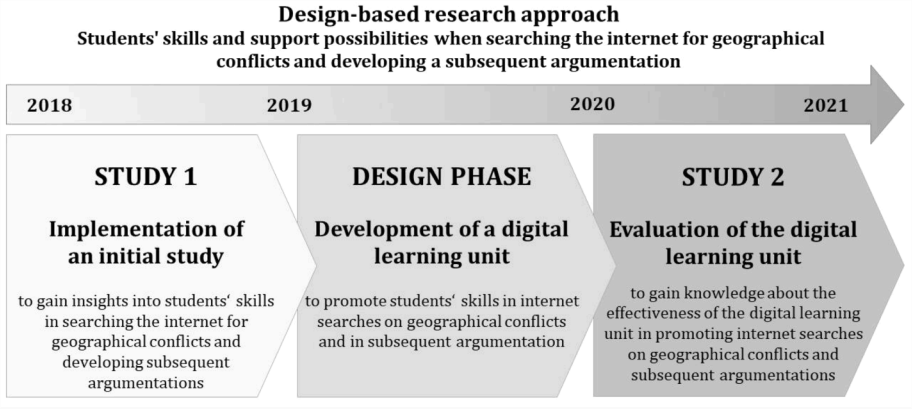

Fig. 4. Design-based research approach to students' skills and support possibilities when searching the internet for geographical conflicts and developing a subsequent argumentation (own illustration).

4 A structural framework (scaffolding) to fill in their argumentation, reminding them of the structure and main contents of geographical argumentation, i.e. arguments to support the own opinion, counter-arguments, rebuttals, sources, etc.

4. Study design

4.1. Embedding of our study in a design-based research approach

The evaluation of the digital learning unit "Internet searches as a basis for argumentation in geography", which is central to this article, was embedded in a larger study design that aims to gain insights into students' skills and support possibilities when answering geographical questions using the internet (see Fig. 4). We had noticed that there is hardly any literature and no supporting material for conducting subject-specific internet searches in geography courses, so we felt that there was a need for action in geography didactics to develop teaching concepts and materials. As we approached the topic from the ground up, we followed the design-based research (DBR) approach, which has the goal of solving problems in educational practice. DBR is not characterised by a particular method, but by research and development taking place in continuous cycles of design, implementation, analysis and re-design ([41], p. 62).

As shown in Fig. 4, to approach this new field of research, we conducted Study 1 in 2018 to gain insights into the students' skills in searching the internet for information on a geographical conflict and presenting their opinions in an argumentation [18,20]. In this first study, we therefore observed 20 secondary school students researching a geographical conflict and writing a subsequent argumentation. The participants were not given any supporting work material, but only the following question about a geographical conflict (which will be taken up again in the digital learning unit): *"Should a bridge be built between the towns of Darchau and Neu Darchau,? Justify your opinion by weighing up the pros and cons of a bridge's construction over the River Elbe."* The students' work on the computer and their simultaneous "thinking aloud" were recorded with the help of screen and audio recording devices. We wanted to find out whether secondary school students are able to find the necessary information to understand a geographical conflict, what difficulties they encounter and what strategies are helpful in the process. We also wanted to explore to what extent students are able to develop a geographical argumentation with the information they have found and to what extent their success in the internet searches influences the quality of their argumentation, i.e. whether a successful internet search also means a successful processing of the information in the form of high quality argumentation. We conducted the study exclusively with secondary school students in their final years of school to find out what competences in geographical internet research and reasoning students have at the end of their secondary school career. This information is also useful for universities to find out what skills their incoming students have in this area.

On the basis of the findings in Study 1, we went through a design phase during which we first developed the supporting work material (see Fig. 3). Following this, we developed the digital learning unit in which the materials are embedded. In Study 2, which is the subject of this article, the students carried out and evaluated the learning unit. We also assessed the students' work results from the learning unit, which were an internet search on a geographical conflict and a subsequent argumentation. We conducted Study 2 with both secondary school students and university students to find out whether the learning unit is suitable for both groups. To allow comparability between the results of Study 1 and Study 2, the students in both studies conducted internet research with subsequent argumentation on exactly the same work assignment (whether a bridge should be built between Darchau and Neu Darchau, Germany). We hoped the comparison of the results would give us an indication of the effectiveness of the learning unit with regard to the intended competence enhancement. The detailed presentation of the study design and evaluation of the learning unit is given in the next chapter.

4.2. Study structure and evaluation

The aim of this study (Study 2) is the evaluation of the two content parts of the digital learning unit "Internet searches as a basis for argumentation in geography" and the assessment of its impact on learning. To achieve this, we collected two different types of data (Fig. 5). First, in addition to personal data on internet use and information behaviour, we collected the students' opinions and evaluations of the learning unit in terms of realisation and usability, content and structure, and (perceived) learning gains. To gather this data we added three questionnaires to Part I and Part II of the learning unit, (a) a pre-task questionnaire, (b) a mid-task questionnaire, and (c) a post-task questionnaire, in which the participants gave their personal information, evaluated the learning unit and assessed their (perceived) learning gains. Second, the participants provided their work results from Part II of the learning unit, *Applying the learnt strategies*, i.e. the results of their internet searches and their subsequently written argumentations. Both of which were analysed by us in a criterion-orientated way. Thus, a comparison could be made between the participants' self-assessment in the questionnaires and their actual success in internet searches and argumentations. We used Microsoft Excel to organise and evaluate the data collected, both from the questionnaires and from the analyses of internet searches and argumentation. In the following, the evaluation of the data collected is presented in more detail, starting with the three questionnaires, followed by the analysis of the internet searches and the evaluation of the argumentations.

The pre-task questionnaire helped to get more information on our participating students, such as socio-demographic details, education, digital equipment, their internet use and information search habits. This information helped us to explain or exclude any influences on possible study results. It gave insights into the students' use of the internet and digital sources in their geography courses and thus gave some indication of the participants' previous knowledge. Further, through comparison with representative surveys, it allowed us to assess whether we were dealing with a representative group or whether they deviated strongly from the norm in terms of internet use.

In the mid-task questionnaire the participants gave their feedback on Part I of the digital learning unit, *Learning about strategies*. They evaluated it regarding realisation and usability, content and structure, and (perceived) learning gain. We saw these quality criteria as relevant for the evaluation of our learning unit from the students' perspective. Although there are entire collections of quality criteria for e-learning offerings, individual criteria must be defined context-specifically, integrating learner orientation as a guiding principle for one's own educational offering ([2], pp. 385, 391). The collected data helped us to make an assessment of Part I of the learning unit, and also enabled us to explain possible results of the following work task in Part II, in which the students were supposed to apply the learnt strategies.

In the post-task questionnaire the participants had the chance to give a feedback on Part II of the learning unit, *Applying the learnt strategies*, as well as the entire learning unit regarding the above mentioned criteria. They also evaluated the usefulness of the supporting material presented to answer a geographical conflict (see Fig. 3) and self-assessed their own learning gains regarding internet research, opinion formation and argumentation on geographical conflicts after conducting the whole learning unit. This helped us to find out which methods and materials were particularly useful from the students' perspective.

We further analysed the students' results from Part II of the digital learning unit, *Applying the learnt strategies,* namely their internet searches and the development of their subsequent argumentations (Fig. 6). Firstly, to evaluate the students' success in their internet searches, we analysed the information that the students wrote down in their table during their information search (see Fig. 3, Number 1). We counted each

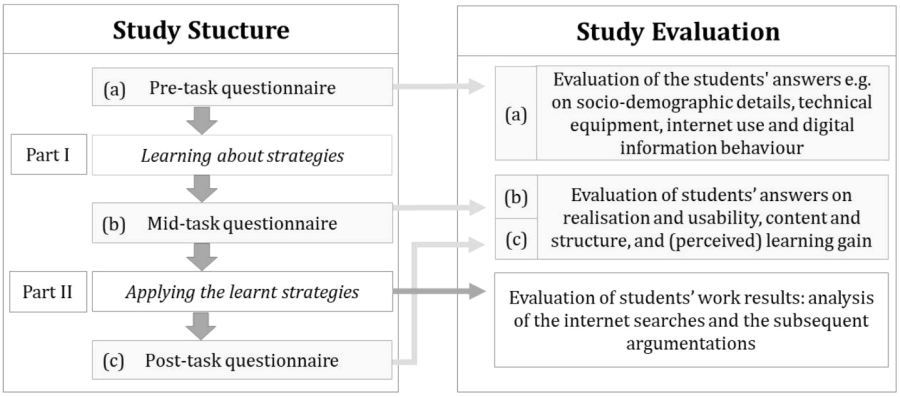

Fig. 5. Structure and evaluation of Study 2 (own illustration).

Internet searches **Evaluation includes the following aspects:**	**Argumentation** **Evaluation of valid, relevant and accurate statements in the argumentation:**	
→ number of relevant and correct pieces of information the students found	→ own opinion clearly stated	2 points
→ number of websites the students found information on	→ number of justifications → number of counter-arguments → number of rebuttals of counter-arguments	1 point each
→ number of different types of websites the students found information on	information specifying the arguments, such as →numbers, figures, dates, sources →(further) perspectives →temporal- and spatial references	0.5 points each

Fig. 6. Evaluation of internet searches and argumentation (own illustration); (cf. [18], 11, 2021, 8).

piece of relevant information that the students found during their internet searches, defining "relevant information" as any correct information that could serve as evidence for an argument about the conflict (see [18], 11). For example, the statement "The operation of the ferry is dependant on the weather and water levels" can be used as evidence in an argument for a bridge construction. If the student then added the information "The ferry cannot operate at low water", this is not counted as further piece of information as it merely specifies and supports the previous statement, but cannot be used as evidence for a new argument. We further counted the absolute number of websites and the number of different types of websites that students used to extract information about the conflict. Secondly, to assess the students' arguments, we analysed the argumentations that the students wrote down in the structural framework (see Fig. 3, Number 4). We scored each justification, each counter-argument, and each rebuttal of a counter-argument with one point, provided that the arguments were accurate, relevant and valid ([12], pp. 117–119). We gave an additional 0.5 points when students used specific information, such as numbers and figures, when the students related an argument to a particular actor, source, place or time (see [21], 8–9). To present an example of our argumentation assessment, Fig. 7 presents an excerpt of a student's argumentation with our scoring.

To be able to assess the students' success in their internet searches and argumentations, we compared the results of Study 2 (conducted in 2020/2021), in which the students used the learning unit, with the results of our initial Study 1 (conducted in 2018), in which the students did not use the learning unit, but only did the work task, as mentioned in Section 4.1. To ensure comparability of the results we used precisely the same work task and the same evaluation methods for the students' internet searches and argumentations in both studies. In order to substantiate the descriptive statistics, we have performed t-tests to assess whether there is a statistically significant difference between the reported averages of both study groups. Using the Kolmogorov-Smirnov test we have tested for the normal distribution of the underlying datasets.

4.3. Study implementation and participants

The implementation of this study (Study 2) took place in the context of geography teaching courses at the University of Cologne, as well as in the context of upper secondary school geography lessons. Although these were compulsory courses for the study participants, their participation in the questionnaires and the provision of their work results from the internet searches and argumentation were voluntary. All course

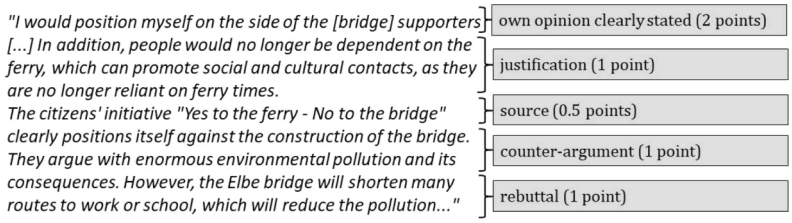

Fig. 7. Excerpt of a students' argumentation with evaluation (own illustration).

participants had the opportunity to carry out the digital learning unit without evaluating it and without giving their consent to the use of their work results for scientific purposes. They did not suffer any disadvantages if they did not participate in the study. We explicitly pointed out the voluntary nature of their participation.

The study was conducted between fall 2020 and spring 2021. Due to the coronavirus pandemic, it thus fell into the predominantly home-schooling phase, both at university and school. All participating students stated that they had the necessary technical facilities and access to the internet at home. When the university students did the study, they were introduced to the materials by the teacher via the Zoom video teleconferencing software programme and were digitally accompanied by the teacher via Zoom while carrying out the study. The secondary school students were able to start the study together with their teacher in the classroom, and then finished it on their home computers.

The study unit was carried out by university students of geography at the University of Cologne (37) and secondary school students (22) from North Rhine-Westphalia. Through our personal experience as teachers of upper secondary school students and prospective geography teachers at university, we considered it very relevant for both groups to expand their competences in the area of internet research and argumentation on geographical conflicts. The participating secondary school students were between 16 and 19 years old, with an average age of 16.9 years. They had all chosen geography as a major course of study, with 5 lessons per week. The participating university students were geography students on a Bachelor's teaching degree programme, except one, who was already in his Master's programme. Many of them were rather in the early stages of their geography studies. They were between 19 and 28 years old, with an average age of 23.2 years. All participants were almost equally divided between male (52%) and female (48%). The average age of all participants was 20.8 years old. All study participants stated that they had not heard anything before about the geographical conflict in the application task in Part II of the digital learning unit– the construction of a bridge between Darchau and Neu Darchau, Germany. Table 1 shows how many participants took part in the individual parts of the project and made their work results available. The number of participants during each part of the study became progressively smaller. This may have been due to the lower learning motivation during home-schooling in the coronavirus pandemic. Furthermore, some participants did not hand in their results or did not consent to the use of their work results. We also believe that some students considered the unit finished after carrying out the task and simply forgot to fill in the final questionnaire.

In terms of internet behaviour, our study participants estimated their daily internet use at 273 min per day. This result was very similar to the representative results of the JIM Study, a far larger survey of 1002 young people in Germany, in which the 16 to 19 year olds estimated their daily internet use at 285 min ([40], p. 34). Concerning their digital information behaviour, too, the results for our study group are in most aspects similar to the results of the JIM Study. Our study participants stated that they use the following sources on a daily basis or several times per week to find information online: search engines such as Google (98%), video platforms such as YouTube (69%), news on Facebook/Twitter or similar (58%), and Wikipedia or similar (51%). In the JIM Study, the 16 to 19 year olds stated that they retrieve information daily or several times a week via search engines such as Google (91%), via YouTube (62%), via Wikipedia or similar (41%), and via Facebook/Twitter (26%) (ibid, 51).

With regard to internet use in geography courses, the majority of secondary school students stated that they regularly search for information on the internet for their geography homework and for work assignments, followed by occasional digital information searches to prepare presentations. The university students reported using internet research for their geography classes most regularly to answer work assignments in class and to prepare presentations, followed by internet research to complete their homework.

Table 1
Study participants in the different sections of the study (own illustration).

Study section	University students who submitted their results and consented to their use	Upper secondary school students who submitted their results and consented to their use
Pre-task questionnaire	37	22
Mid-task questionnaire	34	21
Part II: *Applying the learnt strategies*	**27**	**12**
Post-task questionnaire	25	15

5. Results

5.1. Global evaluation of the digital learning unit

The students evaluated Part I and II of the digital learning unit in the questionnaires, largely in closed questions with verbalised answer options, following the Likert scale, e.g. with answer options ranging from "very great" to "none". After they had completed Part I of the learning unit, *Learning about strategies*, they assessed it in the mid-task questionnaire in terms of realisation and usability, structure and content, and (perceived) learning gain. Having completed Part II, *Applying the learnt strategies*, they evaluated the entire learning unit in the post-task questionnaire with regard to the criteria mentioned above.

Regarding realisation and usability, the general feedback on the digital learning unit was mostly positive, as shown in Fig. 8. The vast majority stated that they liked the layout of the learning unit and that it was technically easy or mostly easy to use. Furthermore, all students but one assessed the media and task formats as varied or mostly varied. In terms of structure, almost all participants answered the question whether they found the structure of the learning unit comprehensible with 'yes' or 'mostly yes'.

Regarding the contents of the digital learning unit, more than 90% of the participants found the presentations and videos in Part I, *Learning about strategies*, interesting or mostly interesting, and the interactive tests and quizzes useful or mostly useful for repeating and practising the contents of the presentations and videos. About three quarters of the participants stated that the strategies presented in Part I, *Learning about strategies*, were helpful or mostly helpful in completing Part II, *Applying the learnt strategies*. 83% also stated that they found the work tasks in Part II useful or mostly useful to practise the strategies presented to them in Part I.

The students rated the working material provided (as presented in Fig. 3) as mostly helpful. As shown in Fig. 9, 90% of the participants gave a positive answer to the question of whether the table (see Fig. 3, Number 1) was helpful in gaining an overview of the information they had found on the internet. The vast majority stated that they would probably use this kind of table in future internet research on complex topics again. The pro/con table (see Fig. 3, Number 2) and the structural framework (see Fig. 3, Number 4) were rated as helpful or mostly helpful in forming their opinion and writing their argumentation by more than 80% of the participants. The usefulness of the opinion ray (see Fig. 3, Number 3) was rated lower, with the majority finding it unhelpful or of little use.

Regarding overall learning effects, 74% of the participants responded to the question of whether they would rate their learning gains from working through the digital learning unit as high with "yes" or "mostly yes". The vast majority stated, in the mid-task questionnaire, that they had learned new strategies for internet research, opinion formation and argumentation about geographical conflicts in Part I, *Learning about strategies*. As shown in Fig. 10, the vast majority of students stated in the

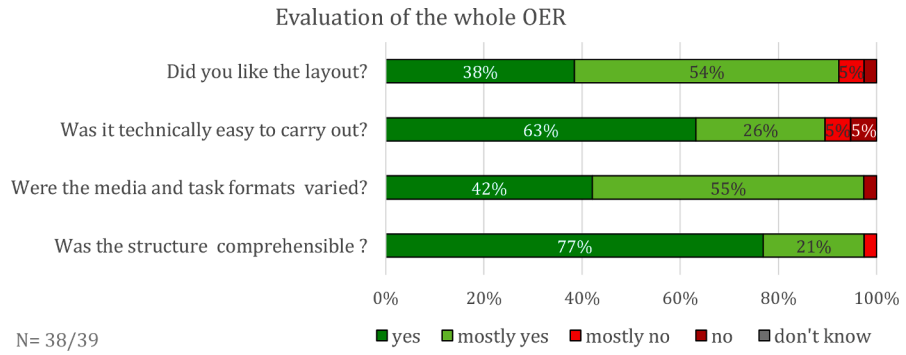

Fig. 8. Participants' responses to evaluation questions about the whole digital learning unit ($N = 38/39$; own illustration).

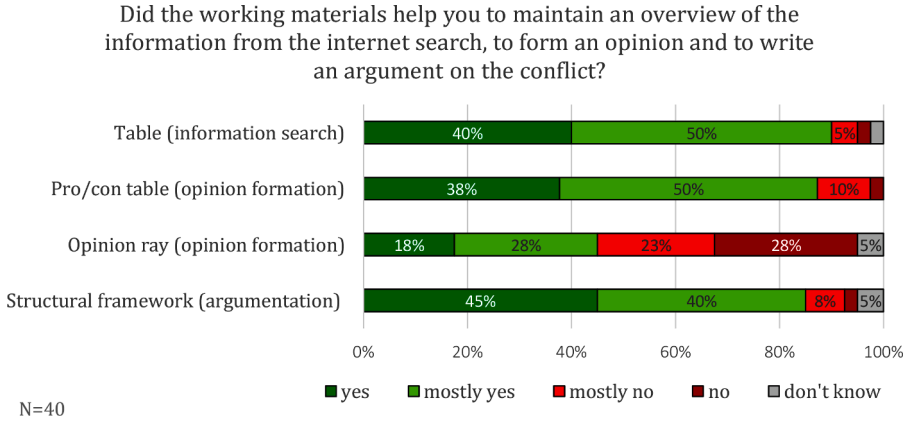

Fig. 9. Participants' answers to the question whether the supporting work material helped during their internet search, their opinion formation and their argumentation ($N = 40$; own illustration).

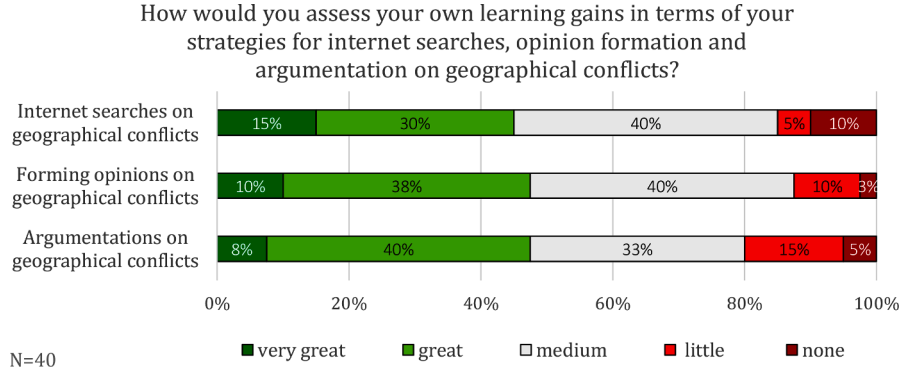

Fig. 10. Participants' evaluation of their own learning gains through the digital learning unit ($N = 40$; own illustration).

post-task questionnaire that they had achieved learning gains by working with the learning unit, with almost half of the participants rating their own learning gains in the three learning areas of internet research, opinion formation and argumentation on geographical conflicts as "great" or "very great". Less than 20% stated that they had achieved "little" or "none". In the following, we will present the students' results in the internet research and argumentation and explore the question of the extent to which the students' self-assessments in the questionnaires correspond to their actual performance.

5.2. Performance in internet searches

In Part II of the digital learning unit, *Applying the learnt strategies*, the students applied the strategies presented beforehand in Part I by independently searching the internet to find information on the geographical conflict in question, by forming their opinion on the conflict and by writing their argumentation. Regarding the internet search, 80% of the participants stated, in the post-task questionnaire, that it was easy or mostly easy for them to find information about the conflict on the internet and 65% stated that they were happy or mostly happy with the results of their internet search. The table that the students used to organise the information they had found on the internet (see Fig. 3, Number 1) was positively evaluated by most participants and was filled in conscientiously by the vast majority of participants, as students noted the name of the source, author or publisher of their information search in 90% of the cases.

In the following, the results of the internet searches conducted by the students in the context of the digital learning unit will be presented. As

shown in Fig. 11, our study participants found, on average 7.7 pieces of information on the conflict by searching the internet, with the secondary school students finding on average 8.5 pieces of information and the university students 7.4. The vast majority of participants found information from economic, ecological and social points of view and they thus gained a good basis for forming an opinion on the conflict based on multi-dimensional information. The students found this information on an average of 3.6 websites, with the secondary school students using on average of 3.3 and the university students 3.7 websites. This average number of websites that the students used to search for information included 2.7 different types of websites for both secondary school students and university students. As shown in Section 2.2, the use of different kinds of websites can be beneficial to understanding a geographical conflict in its entirety.

To evaluate the students' performances in the internet searches, we compared the results of Study 2 (conducted in 2020/2021 with usage of the learning unit) with the results of Study 1 (conducted in 2018 without usage of the learning unit). As shown in Fig. 11, the number of website the students used and the amount of information they found on these websites was very comparable in the two studies, with an average of 7.9 pieces of information in 2018 and an average of 7.7 pieces of information in 2020/2021. The average number of websites they found the information on was identical in both studies, with an average of 3.6 websites in 2018 and in 2020/2021. The fact that these numbers were similar in both study groups shows that this average amount of information and the usage of this number of websites was probably the amount needed for the students to feel they had an overview of the topic and could form an opinion on the conflict. It also showed that the students who carried out the study in 2018 were able to research the topic on the internet and find a sufficient amount of information, even without working through the OER.

Looking at the number of different types of websites students used to find information was somewhat different. These increased by around 23%, from an average of 2.2 different types of websites in 2018 to an average of 2.7 different types of websites in 2020/2021. In both studies, around 90% of participants used news websites to find information about the conflict. In the 2020/2021 study, 87% also used private action group websites, while in the earlier study only 55% used private action group websites. Thus, not only does the number of different types of websites used to gather information show an increasing trend, but also the type of websites used indicates a positive trend towards the gathering of multi-dimensional information. The more frequent use of different types of websites could be due to the contents presented in Part I of the learning unit, *Learning about strategies*, which we used to demonstrate the usefulness of different types of websites for opening up a conflict. The organisation of information and sources in the prefabricated table for organising the information found (see Fig. 3, Number 1) may also have had a beneficial effect on the use of different types of websites, as it provided a quick overview over the websites used.

The results are supported when applying inferential statistics to the datasets. Based on the Kolmogorov-Smirnov test of normality we cannot reject the null hypothesis that the data are normally distributed at a confidence level of 95%. Thus, our assumption is that the data is (broadly) normally distributed. Above findings are supported based on t-tests to assess whether there are statistically significant differences in the averages of Study 1 and Study 2 of the three elements regarding students' performance in internet searches. Specifically, we fail to detect significant differences between "relevant pieces of information found during internet search" and "websites students found information on". Students in both groups performed similarly in these two aspects. In contrast, the difference (increase) in "different types of websites the students found information on" is statistically significant both at the 95% and 99% level (p value of 2.553 with 56 degrees of freedom and a significance level of 1.674 (95%) respectively 2.397 (99%)). Accordingly, in this aspect the participants of Study 2 who worked with the digital learning unit performed significantly better than the participants of Study 1 who worked without the digital learning unit.

5.3. Performance in the argumentation task

In the argumentation developed on the basis of the internet searches, the participating students showed that they were able to form an opinion on the conflict with the information they found and justify it argumentatively. As shown in Fig. 12, they used an average of 3.3 justifications to support their opinion. All students also integrated at least one counter-argument, with an average of 2.6 counter-arguments in the argumentations. A large number of the counter-arguments mentioned were rebutted by the students in their argumentation, with an average of 1.6 rebuttals per argumentation, which thus significantly increases the quality of the reasoning. The students also showed that they understood the multi-dimensionality of the conflict by including an average of 5.2 different perspectives in their argumentation. The students also included, on average, 2.3 spatial references in their argumentations and thus showed that they were able to include the spatial features of the location (e.g. the Elbe valley floodplains as an ecosystem worthy of protection) or its positional relationship to other locations (e.g. no other

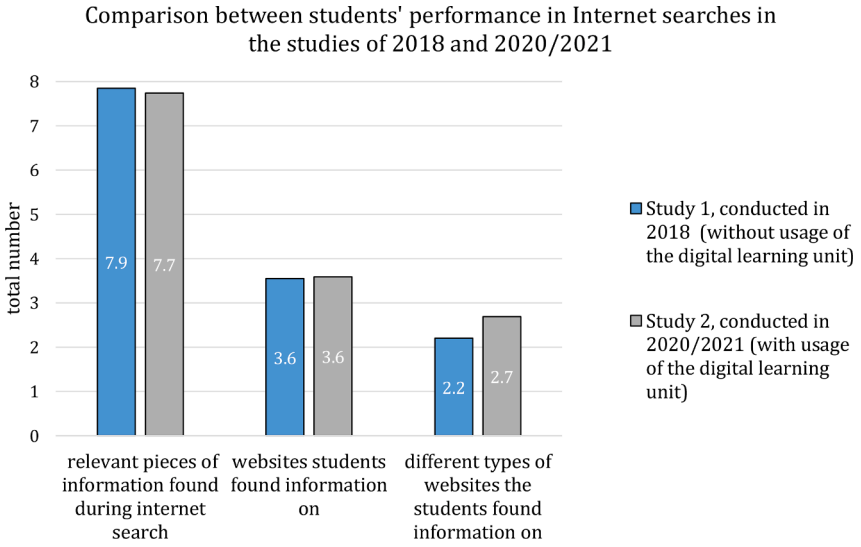

Fig. 11. Comparison between students' performance in internet searches in the studies of 2020/2021 ($N = 38$) and 2018 ($N = 20$), ([18], p. 12).

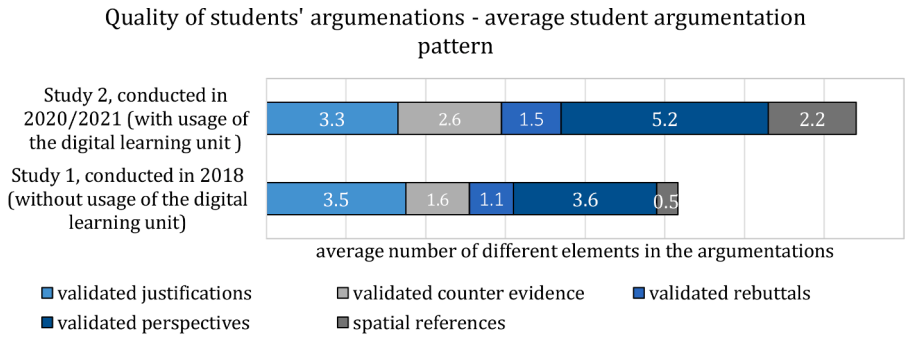

Fig. 12. . Comparison of average students' argumentation patterns in the studies of 2018 ($N = 19$) and 2020/2021 ($N = 39$) (own illustration).

bridge in the immediate vicinity; long detours in the event of ferry failure) in their opinion-forming and argumentation.

Comparing the results of the argumentation task, we noticed that the students performed considerably better in Study 2 of 2020/2021 (with usage of the learning unit) than in Study 1 of 2018 (without usage of the learning unit). In 2018, the participants scored, on average, 10.3 points in the argumentation task ([20], p. 13), whereas in 2020/2021, the participants achieved, on average, 13.6 points, with the secondary school students achieving, on average, 15.8 points and the university students 12.6 points. Thus, both groups were clearly better, on average, than the participants in 2018 and showed a higher quality of argumentation. We can only make assumptions about why the secondary school students scored better than the university students. Perhaps they are more used to writing argumentations in their everyday school life or they are more used to working with structural frameworks for writing texts. We can certainly state that the sample of secondary school students was very small, with only 12 argumentations submitted for evaluation. Among them were three students who scored 20 or more points and thus pulled up the average very strongly.

When comparing the student argumentation patterns in the two studies, it is striking that, on average, students in Study 2 of 2020/2021 used slightly fewer justifications to support their own opinions; however they used more counter-arguments, more rebuttals of counter-arguments, more perspectives and more spatial references (Fig. 12). This evaluation indicates that there was an improvement in terms of the quality of geographical argumentation. Rather than primarily using opinion-supporting arguments to justify their own position, the students were able to introduce and rebut more counter-arguments, introduce more arguments from different perspectives and add spatial references to the argumentation. The quality of the argumentations was also substantially better, as over 60% of the participants in Study 2 of 2020/2021 used sources to indicate the origins of the arguments mentioned. In Study 1 of 2018, only 5% (1 participant) integrated sources into his/her argumentation. Even though secondary school students and university students in the 2020/2021 study scored differently in the arguments, both groups scored better than the secondary school students in 2018. In fact, when comparing only the secondary school students in the two studies, the average score in the argumentations actually increased by over 50% from 2018 to 2020/2021.

To support the descriptive statistics respectively the comparison of average students' argumentation patterns, we perform t-tests[4] to assess whether there is a statistically significant difference between the reported averages of the participants of Study 1 and Study 2. We find that there are significant differences between the averages of "validated counter evidence (total number)", "perspectives (total number)" and "spatial references (total number)" both at the 95% and 99% level (p values of 2.706, 3.248 and 5.869 with 56 degrees of freedom and a significance level of 1.674 (95%) respectively 2.397 (99%)). With regard to these three aspects, participants in Study 2 were able to significantly improve their argumentation quality by working with the digital learning unit, compared to participants in Study 1 who did not work with the learning unit. We fail to detect a significant difference in the means of "validatedjustifications (total number)" and "validated rebuttals (total number)". Thus, there was no (significant) improvement in these aspects among Study 2 participants. Looking at the subgroup of upper secondary students (12) these results are confirmed, i.e. we detect significant differences in the averages both at the 95% and 99% level for "validated counter evidence (total number)", "perspectives (total number)" and "spatial references (total number)" (p values of 3.808, 3.934 and 3.723 with 29 degrees of freedom and a significance level of 1.699 (95%) respectively 2.462 (99%)) but not the remaining two elements ("validated justifications (total number)"; "validated rebuttals (total number)"). All in all, the inferential statistics support our descriptive finding that the participants in Study 2 (with usage of the digital learning unit) show a (statistically significantly) higher quality of argumentation as measured by three key elements.

An example of the integration of sources and spatial references is shown in Fig. 13, which quotes an excerpt of a study participant's argumentation from Study 2. None of the participants in Study 1 incorporated as many spatial references or source references into their arguments as seen in this text excerpt. The text example also nicely demonstrates how well some students were able to integrate different perspectives into their argument. The student incorporated economic, natural, and social/cultural perspectives into this section of the reasoning.

Different measures seem to have supported the students of Study 2 in developing their argumentations. The majority of participants answered the questions about whether the contents of Part I of the digital learning unit, *Learning about strategies*, and the structural framework provided in Part II, *Applying the learnt strategies* (see Fig. 3 Number 4), helped them to write the argumentation with "yes" or "mostly yes". The pro/con table (see Fig. 3, Number 2), which was supposed to support the formation of opinions and the preparation of argumentations, was also evaluated mostly positively. In addition, the increased use of different types of websites, especially the increased use of private action group websites to extract information, may have led to a better understanding of the conflict and thus enabled argumentations of higher quality. In summary, although the students from Study 2 in 2020/2021 did not find more information about the conflict on the internet through the use of the learning unit than the students from Study 1 in 2018, they were able to process the information into higher quality arguments. This suggests that the learning unit particularly promoted the writing of a geographical argumentation based on the information found on the internet.

6. Conclusion and discussion

The aim of our study was to find out whether competencies in

[4] We have tested for the required normal distribution of the underlying datasets using the Kolmogorov-Smirnov test and cannot reject the null hypothesis that the data are normally distributed at a confidence level of 95%.

> *"The historical background speaks for [the construction of a bridge], because especially after* ***the unification of East and West, a direct connection of the two communities*** *would seem to be quite reasonable, which is pointed out by the bridge supporters' association. Furthermore, the economic benefit should be addressed, because the bridge would also allow companies on both sides to cooperate more closely and easily, and job capacities would also increase on both sides, since the time-consuming and unsafe ferry connection would be eliminated, which the Lüneburg-Wolfsburg Chamber of Industry and Commerce also discovered through its business survey.* ***The ferry is dependent on optimal conditions [of the water level] for its operation****, which could increasingly become a problem in the course of climate change and drought. A bridge would also be a relief for the citizens, as* ***both places are rather rural*** *and a connection would improve the infrastructure and increase the quality of life. However, there are also some disadvantages that speak against the construction of a bridge. For example, the environmental damage that the construction of the bridge will bring, because according to the citizens' initiative "Yes to the ferry, no to the bridge",* ***there is a biosphere reservoir*** *in the Elbe, which will be severely damaged by the construction."*

Fig. 13. Excerpt of student XX's argumentation from Study 2 with source references (underlined) and spatial references (in bold); translated from German into English.

geographic internet searches and the processing of the information found in the form of argumentations can be promoted with the digital learning unit "Internet searches as a basis for argumentation in geography." We wanted to draw conclusions on the effectiveness of the learning unit which was designed for secondary school students and university students of geography with the goal of teaching targeted strategies for internet searches and subsequent argumentations on geographical conflicts. Therefore, 39 students completed the digital learning unit and we analysed and evaluated their conducted internet searches and their subsequently written argumentations. Also, the students evaluated the learning unit by means of digitally provided questionnaires. In the following, the research questions raised in the introduction will be answered and discussed.

(I) *How do students evaluate the digital learning unit in terms of realisation and usability, content and structure, and (perceived) learning effect?*

The digital learning unit has been evaluated rather positively concerning all of the above mentioned aspects. It did not seem to pose any major obstacles for the students in terms of technical usability and it was visually appealing in terms of layout. The structure of the learning unit seemed logical to almost all students and the vast majority were able to practise the contents of Part I of the learning unit, *Learning about strategies*, in Part II, *Applying the learnt strategies.* The working materials which were designed to support the internet searches, opinion formation and argumentation were predominantly assessed as useful, apart from the opinion ray, which was supposed to enhance the formation of students' opinions. Around 80% of the participants stated that they had made learning progress through the learning unit in all three sub-areas of internet searches, opinion formation and argumentation on geographical conflicts.

Our learning unit is available as OER, which can basically be put online without review, unlike for example textbooks, which go through a publication process. Thus, the responsibility for ensuring the quality of an OER ultimately lies with those who provide it ([13], p. 12). We had the learning unit assessed by those who are supposed to use it and whose competences are supposed to be enhanced: secondary school students and prospective geography teachers. The mostly positive evaluation in terms of content and structure were particularly important as we are dealing with a digital learning format. In contrast to face-to-face teaching, the content of digital learning formats must be clearly understandable, as cognitive overload cannot be recognised and compensated for by attending teachers ([35], p. 35). Also, the fact that the students predominantly assessed their learning gain as high, probably allows positive conclusions to be drawn about the content and structure of the course unit: Research on satisfaction and perceived learning gains in university online learning environments identified a significant relationship between course structure and perceived student learning [23]. Furthermore, an appealing layout and high usability are not just a nice-to-have in the learning context, since an ill-designed user interface can be a barrier to learning effectively ([1], p. 281). However, even if the students' evaluation of the learning unit was mostly positive, when implementing the digital learning unit with courses, consideration should be given to the fact that also in online learning environments personal contacts, such as instructor caring ([30], p. 9) or interaction ([3], p. 288) can affect learner effort, motivation and performance. Restrictively, we did not compare the medium of the digital learning unit with another medium for teaching internet research and argumentation on geographical questions, e.g. worksheets. Therefore, it can only be shown that the digital learning unit is positively assessed by the participants and not whether it is more positively assessed in comparison to the use of other media.

(I) *To what extent can the digital learning unit improve students' internet searches and subsequent argumentation on complex geographical conflicts?*

In Part II of the digital learning unit, *Applying the learnt strategies,* students conducted an internet search on a geographical conflict and subsequently wrote an argumentation using the information they had found. The analysis of the internet searches showed that each student found, on average, almost 8 pieces of information that they could use as evidence in their arguments. Based on this amount of information, the students were able to form their opinion on the conflict and to write multi-dimensional argumentations. The results of the subsequently written argumentations were considered to be satisfactory. The students were able to justify their opinions in multi-dimensional argumentations with numerous justifications, counter-arguments, rebuttals, and spatial references. When comparing the studies from 2018 (without usage of the learning unit) and 2020/2021 (with usage of the learning unit), it is noticeable that the average number of pieces of information found by the students on the internet and the average number of websites used to extract information were almost identical in both studies. This suggests that this amount of information and websites was probably the amount needed by the students to form an opinion on the conflict. The students in the recent study of 2020/2021 increased the number of websites of private action groups used for information retrieval, where the authors' interests in the conflict are usually described in detail, instead of mainly relying on overview information on news websites. This may have positively influenced the subsequent argumentation. The results suggest that the learning unit seems to have a beneficial effect on the quality of the processing of the information found in the form of geographical argumentations. The number of counter-arguments, rebuttals of

counter-arguments, perspectives and spatial references that the students integrated into their argumentations increased by conducting the learning unit in comparison to the performance of students in the study in 2018, who did not carry out the learning unit. Different from what we would have expected, in the study of 2020/2021, university students performed slightly less well in the argumentation than secondary school students, though they still performed better than the study participants in the study of 2018.

There are different possibilities as to why students' argumentations have improved as a result of the digital learning unit. First, in Part I of the learning unit, *Learning about Strategies*, the students were introduced to the aspects that are important for high-quality geographical information by means of a presentation, the contents of which were repeated in a digital cloze test. The students were thus able to independently check their newly acquired knowledge. Even if self-tests cannot necessarily reach the quality of face-to-face feedback, they are still valuable support for learners, especially in e-learning scenarios, as feedback from fellow learners or teachers is missing and they can be used for self-assessment ([28], p. 129). Second, during their internet searches, the students noted down the information they found in a table and thus embedded it in background information: for each piece of information found, the students were asked to note the source, the author, the year and the actors involved. As the actual evaluation of source information is often a very demanding task ([47], p. 176) and particularly difficult for readers who lack content knowledge ([21], p. 404) the students of this study thereby took first steps in engaging with the sources used. Writing down the author, source and actors may have led students to question or recognise the authorial interest of the source, as often the interests of digital sources are not questioned or recognised [10,38]. The engagement with the digital information and sources (websites) laid the foundation for the argumentation that followed, where they were able to integrate this information and make the argumentation of high quality. Among other things, we saw a noteworthy improvement in terms of source citation in the argumentation, compared to Study 1 in 2018, where students generally did not note down their sources while researching and accordingly did not integrate them into their arguments. Existing research confirm that there is a positive interaction between the evaluation of credibility during internet searches and the engagement with sources in the subsequent written products ([34], p. 9) and well-justified argumentations ([5], p. 760). Third, organising the arguments in the pro/con table may have had a positive impact on the cognitive processing of the information and on the final writing of the argumentation. This has been confirmed by the students' positive evaluation of the pro/con table. This strategy of writing down structured notes in pros and cons was only applied by some of the participants in Study 1. Some of the individual answers in an open answer section of the post-task questionnaire also confirmed the usefulness of the pro/con table: "*It was clearer and more sorted, giving a better view of the pro and con arguments. This led to an easier and faster formation of the opinion.*" "*I was better able to weigh the arguments for and against the bridge.*"[5] Fourth, students wrote their argumentations in a structural framework (scaffolding) that listed the main structural and content elements of a geographical argumentation in a structured way. Scaffolding is a learning support that enables learners to cope with tasks that they would not be able to deal with on their own and thus promotes independence in the processing of tasks ([27], pp. 15–17). In our digital learning format, where students are expected to apply new content without the support of a teacher, we felt that a structural framework was useful here to support the students in applying the strategies presented earlier. The aim would be for students to be able to write high quality geographical argumentations independently in the future without the scaffolding.

Existing research showed that internet searches on geographical conflicts and writing subsequent argumentations require different skills that need to be fostered ([18,20]). The results of our study show that both, subject-specific internet searches on geographical conflicts and the processing of information in the form of argumentation, can be didactically promoted using our digital learning unit. Learning about targeted strategies and the usage of supporting learning material seem to have helped students to engage more deeply with the online information and sources, and to considerably improve their subsequent argumentations. This suggests that for writing a geographical argumentation on the basis of internet searches not only cognitive skills, but also methodological competencies are needed and can be learned. Thus, our study represents a component for the promotion of students' digital information literacy. Further research has shown that, for our purposes complementary skills, such as evaluating digital information and sources [43,50] can be fostered through educational interventions. These and our findings show that it is worth using new learning methods to teach students the information skills required in the 21st century, but there is a need for teachers who are willing to integrate digital methods into their teaching and who are able to use digital technologies profitably to teach subject content ([36], p. 923).

6.1. Limitations and implications

We are aware, that our research may have some limitations. The first is, that our findings provide initial insights into the promotion of internet searches and subsequent argumentation in geography education. Our study group is not large enough to obtain representative results and further feedback from teachers and students using the learning unit in their geography courses should be sought to verify our findings. The second limitation is a methodological one. Our study was embedded into a design-based research approach which lent itself very well to our purposes. Since we opened up a new field of research, we first found out about the strategies and problems in internet searches and subsequent argumentation among students in a first study ([18,20]) and, on the basis of these findings, developed supporting measures and now tested them in a second study. Of course, this entails inaccuracies because the two study groups of the initial and follow-up studies are not identical. However, a pre- and post-test with the same study group would entail other inaccuracies, e.g. that different research tasks would have to be worked on, which would make the evaluation difficult to compare. It seems all the more interesting that both of our study groups found an almost identical amount of information on the conflict on the internet, but then processed this information differently in their argumentations. Nevertheless, in retrospect, it would have been useful to test the argumentation competencies of the study participants in advance. It cannot be ruled out that the participants in Study 2 already had higher argumentation competencies than the participants in Study 1. Third, our study findings are based on the working results of a specific geographical question that the students were asked to research and answer argumentatively, which was whether a bridge should be built between the towns of Darchau and Neu Darchau. It cannot be ruled out that a different geographical question would yield different results. Also, factors such as interest in the question or personal attachment to the researched geographical conflict could influence the results. However, with the example of the bridge construction in Neu Darchau, we have chosen a conflict that has typical characteristics of geographic conflicts in order to thus increase the transferability of the results. The fourth limitation relates directly to our digital learning unit, which is the subject of this study. In order to complete the learning unit, students are required to have basic knowledge of digital information and internet skills, such as basic knowledge of using search engines and digital map programmes. The learning unit further does not provide students with in-depth information on the problem of fake news or address the topic of the filter bubble, the fact that search queries are personalised by machines and that previous choices can influence current search results ([48], p. 68). Our learning unit trains students in the specific challenges when dealing with digital information on multidimensional,

[5] The quotes were translated from German to English

geographical conflicts, such as to question the interest of the source by identifying the author, the actors named and their opinions. However, there is a need for further interdisciplinary courses or projects that educate students about specific internet competencies, such as knowledge about the peculiarities and dangers of information extraction on the internet or skills in checking the credibility of websites such as *lateral reading* [52].

The results of our study may not only be interesting for teachers of geography, but also be of interest to teachers and educational researchers of other disciplines, such as politics or history, where complex, multi-dimensional problems are also addressed in class and researched on the internet. Our learning material can help structure information from the internet when students are dealing with multiple documents on critical topics. As we include newly developed teaching content and materials based on recent findings in our digital learning unit, it may also be useful for experienced (geography) teachers and for other educators to gather ideas, inspiration, and examples for teaching information literacy (see [45], 17). This study has taken a big leap forward in our project to develop subject-specific teaching concepts and materials for geographical internet searches and subsequent argumentation. The learning unit should now be carried out with larger learning groups and be made easily accessible to teachers at universities and secondary schools.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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