

The Potential and Limitations of the Wadden Sea in University, School, and Out-Of-School Contexts From the Perspective of Biology Education

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ABSTRACT

This study explores the potential and the limitations of the UNESCO World Heritage Wadden Sea in terms of its relevance for teacher training in higher education and for teaching in schools and as an out-of-school place of learning. Interviews with experts from these three areas were conducted. The analysis was performed through qualitative content analysis. Within this framework, various factors were identified that should be considered in further biology didactics studies. The findings indicate that out-of-school learning receives too little emphasis in teacher education and that the Wadden Sea offers opportunities to address this deficit. In addition, clear limits were set for school lessons on this ecosystem in contrast to practical explorations of the Wadden Sea. Nevertheless, incorporating Wadden Sea content in the classroom makes sense since diverse topics can be vividly explored. Out-of-school learning at the Wadden Sea was found to have an immense potential in education for sustainable development and in environmental education. One obstacle is the students' reported disgust towards the Wadden Sea. Based on the results, conclusions are drawn for all three areas considered in this study, providing concrete implications for related studies with a focus on biological education on the Wadden Sea.

Keywords: biology education, Wadden Sea, expert interview, education for sustainable development, environmental education

INTRODUCTION

More than any other scientific discipline, biology can be characterized by multifaceted references to the living world (Campbell et al., 2020). The earliest expositions of the "doctrine of life" can be traced back to Aristotle (Föllinger, 2012; Henry, 2006; Lennox, 2006). Based on texts that are more than 2,000 years old, concrete connections can be drawn to modern biological research (Delbrück, 1976; Vinci & Robert, 2005). Even Charles Darwin referred to Aristotle (Gotthelf, 1999). The school subject biology presents topics and ways of working within the school lessons. Among other things, ecosystems such as the forest are addressed. Content on this habitat is a requirement for the high school graduation exam in Germany in the state of North Rhine-Westphalia (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2014). The forest has been extensively considered in biology didactics studies from various points of view. Other natural areas have received much less attention, despite their significance. One of them is the Wadden Sea.

The Wadden Sea in Europe is the world's largest contiguous mudflat area, extending from the Netherlands across the entire German North Sea coast to Denmark (Hofstede, 2005). In doing so, this habitat has far-reaching ecological importance for thousands of different species (Hofstede & Stock, 2018). The relevance of the Wadden Sea is particularly evident in the North Atlantic bird migration (Rösner, 2018). This is one reason why areas of the Wadden Sea in Germany have been biosphere reserves since 1990 (Gätje, 2004). The tidal flats are protected in all three countries. The first area to protect the Wadden Sea was established in Denmark in 1979 (Laursen & Frikke, 2006), followed by the establishment of a similar area in the Netherlands a year later (Nehring & Hesse, 2008). Germany established the first Wadden Sea National Park in 1985 (Rupprecht et al., 2015). Internationally, the tidal flats of Germany and the Netherlands received the highest protection status in 2009 when they were designated UNESCO World Heritage Sites (The World Heritage Committee, 2009), and the tidal flats of Denmark received the same designation five years later (The World Heritage Committee, 2014).

Despite this relevance, the Wadden Sea has hardly been considered in didactics biology research (for detailed descriptions of the state of research, see Schmäing & Grotjohann, 2021a, 2021b). The present study contributes to research on incorporating the Wadden Sea in biology education.

OBJECTIVES AND RESEARCH QUESTIONS

In this study, guideline interviews were conducted with experts from different pedagogical areas with respect to the Wadden Sea. To gain the broadest possible understanding, the Wadden Sea's relevance in biology didactics was examined within various contexts, including university education as well as school and out-of-school education. The study starts with teacher training, continues with school practice, and ends with educational offerings at out-of-school places of learning. The objective of this study is to explore the potential and limitations of the Wadden Sea in biology education from these three perspectives. Furthermore, implications for a more in-depth study of the Wadden Sea in this subject area are given and linked to the results. Based on these objectives, the following research questions can be formulated:

What is the potential and what are the limitations of the Wadden Sea

1. in teacher training (university dimension)?
2. in school teaching (school dimension)?
3. as an out-of-school place of learning (out-of-school dimension)?

When formulating the research questions, we deliberately refrained from specifying them in terms of a specific target group. This approach should not lead to pre-selection, guaranteeing a maximum degree of openness. In addition, this approach can be justified by the methodological explanations given in the next sections on the basis of specialist literature.

METHODS

To capture the three perspectives, guideline interviews were conducted. A special form of guideline interview is the expert interview, which is characterized by a small number of interview prompts and specific questions (Helfferich, 2019). In an expert interview, respondents are approached as experts in a topic area, and their specialized knowledge is tapped (Döring & Bortz, 2016). From a sociological point of view, this special knowledge can be called specific role knowledge (Przyborski & Wohlrab-Sahr, 2014). In this context, the interviewees are not the exclusive focus in the analysis but instead represent a factor on a meta-level in the life context under consideration (Meuser & Nagel, 1991).

The selected methodological procedure is ideally suited for this study because it is used in the exploration phase of a superordinate research project, providing optimal access to the field (Bogner & Menz, 2002a). Since the research focus is directed on the shared knowledge of the experts, the applied methodology can be called a theory-generating expert interview (Bogner & Menz, 2002b). The selection of the

experts is of fundamental importance for this research project. In order to address the risk of disproportionately expanding the term expert, the possession of advanced knowledge is presented as a requisite criterion for the classification as an expert (Meuser & Nagel, 2009). A potential expert's possession of advanced knowledge must in turn be recognized by outsiders (Liebold & Trinczek, 2009).

For the present study, two experts were selected from each of the three fields under consideration. This procedure results in a synergy effect: It is possible to gain a deeper insight into the area by interviewing two people. Moreover, any potentially arising contradictions could be identified and discussed. The selection of the experts (which cannot be explained further for data protection reasons) was made by identifying the potential experts' experience in terms of the three following dimensions:

- *University dimension:* University teachers who have decades of experience in teaching marine biology courses related to the Wadden Sea. This includes theoretical thematizations as well as practical educational implementations during field trips. The teaching activities of the interviewees are focused on biology didactics courses.
- *School dimension:* Teachers who teach in secondary schools in the immediate vicinity of the Wadden Sea. Within these activities, they have addressed the Wadden Sea with different learning groups in school lessons. In addition, they accompanied students on numerous excursions with different thematic focuses.
- *Out-of-school dimension:* Professionals in education for sustainable development and environmental education who have conducted environmental education interventions at out-of-school locations at the Wadden Sea. For decades, they have led excursions with diverse learners from all over Germany (from kindergarteners to adult education learners) and international groups of visitors.

It must be kept in mind that due to their occupations and their academic training, all persons have experience with all three dimensions. Therefore, all the six experts were interviewed about all three dimensions. Synergy effects can also be used here since this approach allows all perspectives to be explored in depth.

An interview guideline includes the relevant topics and the questions about them (Loosen, 2016). The project was conceived considering cues from general research methodological literature (Döring & Bortz, 2016; Flick, 2007), and modifications for expert interviews (Goldberg & Hildebrandt, 2020) were made. The interview guideline reflects the three dimensions. In addition, implications for biology didactics topics are given. The guideline development took place within a communicative process within the working group and with external methodological experts. The total length of the interviews conducted ranged between 12:45 and 45:43 minutes.

Qualitative data can be analyzed with different types of interpretation processes (Mayring, 2015). Since the research questions are answered on a content level, qualitative content analysis was selected as the analysis method for the data

obtained. Following preliminary considerations by Rust (1980, 1981), Mayring (2015) concludes that a category system is greatly relevant for qualitative content analysis. Also with regard to guided interviews, a comparable procedure is suggested (Schmidt, 2017). In biology didactics, the formation of categories for the interview analysis is also of great importance (Gropengießer, 2005; Krüger & Riemeier, 2014). After transcription, the six interviews were analyzed with inductive category formation following Kuckartz (2016). MAXQDA software was used for this process (Kuckartz & Rädiker, 2020; Rädiker & Kuckartz, 2019). **Appendix A** illustrates the procedure through examples and provides insight into the coding guide. This contains the names of the respective (sub-) categories and gives clear definitions as well as basic examples. Each subcategory has a clear coding rule. The example shown looks at the subcategory “possibility of scientific work”.

To ensure interrater reliability by following research methodological recommendations (Bortz & Döring, 2006), 10% of the data material was coded independently by two individuals and Cohen's kappa was calculated. The value is 0.95 and can thus be judged as excellent (Altman, 1991).

RESULTS

The following presents the results within the framework of the category system that was inductively formed in the qualitative content analysis. The aim is not to present each individual subcategory in detail. Rather, the emphasis will be on the central results. In this process, quotations from the transcripts are used as support. The respondents are quoted according to their main affiliation [experts (E) for the university dimension (UD), school dimension (SD), and out-of-school dimension (OSD)]. The verbatim categories are highlighted in italics and have been grammatically adjusted for the continuous text.

As a result of the in-depth explanations provided by the experts, the interviews focused on the out-of-school dimension. Accordingly, the presentation of results in this area is more detailed.

University Dimension

It was emphasized during the interviews that out-of-school learning should be taken into account in *teacher training*. In this way, *potential cooperation with out-of-school places of learning* could already be established in this phase of the training process. *Training with school classes* would also be useful to gain insight into the profession. In this regard, the *Wadden Sea is suitable as a possible learning place* but *time limitations* in the area of teacher training represent restrictions.

Other challenges would be *the prior knowledge of student teachers*, as *only basic knowledge* is available:

“They have little prior knowledge, perhaps what is written in Campbell, that is, only very basic things. (...) You can't expect any great prior knowledge. Unless you have attended a seminar beforehand” (E_UD_II, pos. 20).

This, in turn, is a *problem for the implementation of excursions*. Another expert emphasizes that there are also groups whose prior knowledge is *high*:

“But they even made the mudflat guides on Spiekeroog almost doubt themselves because they had such great prior knowledge” (E_UD_I, pos. 26).

Finally, *scientific research* in this area should be conducted, which is understandable on the basis of this discrepancy. Further stipulations go hand in hand with the wish for *more marine biology courses* in teacher training and a *higher importance of hand-on phases*. For this, *education for sustainable development (ESD)/environmental education* should have a *higher priority*. From the practice of out-of-school learning, it is suggested that the *lack of knowledge of some teachers of ESD* is a central obstacle to implementing excursions:

“The problem is that I keep experiencing is teachers when you say ESD, I thought teachers basically know what ESD is. No. Teachers basically only know what ESD is from time to time” (E_OSD_I, pos. 76).

School Dimension

Following on from the discussion above, it can be argued that *the lack of professional competence of teachers* is an obstacle to implementing biology lessons at the Wadden Sea. One teacher stated:

“I have certainly had teachers who did not feel competent to teach it. (...) That we had just said so and so should run in class level so and so and then was all ready, yes but no I can but not alone. Why not? Yes, I don't know enough about it. (...) And then I was like, you're a biologist, you must know what it's like. So (laughs)//” (E_SD_I, pos. 52).

With regard to the subject area of *ESD/environmental education*, the expert participants mention that this should be given a *higher priority* or be a *separate school subject*. The interviewees say that lessons about the Wadden Sea ecosystem *cannot replace an excursion* and are *not comparable to an out-of-school experience*. Nevertheless, a thematization in class could be *useful*. As a basis for this, the *creation of practical references* as well as *experiments* are suggested as a possibility for implementation. In addition, and the possibility of *inviting experts* into the classroom is discussed. *Feeding relationships*, *environmental pollution*, and *bird migration* are identified as special topics that could be addressed in class.

While carrying out a teaching unit on the Wadden Sea, formal requirements have to be observed. Whereas there is a *lack of flexibility in the requirements* in one federal state, there are *connecting points* in another. Another challenge is the *lack of teaching materials for secondary schools*. The *students' horizons* could be broadened by teaching about the Wadden Sea, especially because the Wadden Sea is an *alternative to other “classical” ecosystems*. In terms of *knowledge transfer*, a comparison with the out-of-school dimension was anticipated:

“Maybe because learners are more used to these forms of learning, automatically, more knowledge is kept than with field trips” (E_SD_II, pos. 36).

With a reference to teaching, regarding *ESD/environmental education, knowledge of the natural area* is judged to be a central prerequisite. It would be possible to *fundamentally promote* awareness of the Wadden Sea in the classroom. In doing so, *motivation* and *interest* could be increased with *certain methods*, but again a discrepancy compared to out-of-school learning is described:

“It’s much better if you can touch things like that outside, absorb them with all your senses. The motivation will be greater, in any case” (E_UD_II, pos. 30).

Another comparison with the out-of-school dimension is found with respect to *disgust*. This has *no meaning in the classroom*.

The experts particularly emphasize *excursions as a way of embedding* the learning contents in school lessons. This involves a *great deal of organizational effort*. In addition, there is the risk that the contents of the excursion might not be covered in the lessons and that a corresponding event is often only used separately as *entertainment* and as a *pastime* for the students. The extent of this problem can be described from experience:

“This also depends on the commitment of the teachers, to what extent they really want to embed the excursion in their lessons or whether they just see it as a leisure activity during a class trip. This is from my point of view the predominant part, many teachers do not use this excursion even really conceptually but rather like an excursion into the city center of somewhere and simply say that this is a program point which one makes here and what comes out in the process is also not so important, the main thing is that we get the time” (E_OSD_II, pos. 42).

Another obstacle to teaching about the Wadden Sea is the *unfamiliarity* with the mudflats. This is accompanied by the *low impact of the Wadden Sea at first sight*, so that a field trip can even be a *prerequisite* for successful school lessons. The *activation of known habitats* is much easier.

Out-Of-School Dimension

As already stated above, a focus was placed on the out-of-school dimension by the experts interviewed. The subcategories for the categories “potential as a place of learning” and “limits as a place of learning” are elaborated below, each in its own section.

Potential as a place of learning

The Wadden Sea as a place of learning offers *versatile possibilities* and a *very large potential*, also for *various out-of-school activities*. This potential is directed at *versatile various target groups*. With regard to out-of-school learning, several advantages are mentioned: that the event implementation is done by *external persons*, that there are *possibilities to focus on specific topics*, and that there are different *starting points for*

interdisciplinary lessons. In addition, from the perspective of school-based learning, one of the participants touches upon the idea of scientific work:

“You can also work very well in a scientific way. Show the students how a scientist works” (E_SD_I, pos. 12).

It is emphasized that the *Wadden Sea experience cannot be replicated indoors*. A special highlight is the walk to the *tideway*. At the tideway, a *deeper understanding of the tides and a deeper understanding of the ecosystem* can be conveyed, and an *awareness of the national park* can be gained.

The relative lack of species represents a *didactic advantage* for teaching the contents, so that *ecological relationships can be presented very simply*. A comparison is made to other ecosystems:

“Also relatively simple and clear due to the species poverty, a Wadden Sea excursion is also a feasible option compared to other habitats, which are extremely diverse. The Wadden Sea is also diverse but rather at second glance. But everything is also easy to convey because it is not too much” (E_OSD_I, pos. 18).

With regard to *interest*, the experts’ comments affirm that this *must be awakened*. This can be promoted with *the discovery of the unknown*. Although interest *varies from person to person*, a *fundamentally positive effect* can be determined for Wadden Sea excursions. This effect varies in relation to the *content*. The effects of Wadden Sea out-of-school learning on *motivation* were *fundamentally positive*, but they *varied from individual to individual*. *Primary experiences* were of great relevance.

For *the transfer of knowledge*, the *experience of nature* is an advantage. Nevertheless, *didactic reductions and deepening of knowledge* must be made. Optimally, learning should take place *unconsciously* against the background of experiencing nature. The effect on the knowledge acquisition of the learners is described as *fundamentally positive* and as *higher than with a school thematization*. This requires *preparation and follow-up in the classroom*. This effect only applies to a *small proportion of the content* taught, since *details can hardly be memorized*. Another advantage is that despite the *short minimum duration of excursions* a lot of content can still be covered. Regarding knowledge transfer, the *prior knowledge* of the students is decisive. However, *hardly any students have prior knowledge*. This depends on *the personal interests* of the learners, but also on *the parents’ household*. It is independent of the *place of residence*:

“There are always children with them// or quite often I have experienced that one or two from the class already have enormous previous knowledge, because they regularly vacation with their parents at the North Sea” (E_OSD_II, pos. 20).

Prior knowledge can hardly be determined by *age* or *type of school*. For out-of-school learning, it is necessary to make *concrete references to school lessons* to impart knowledge.

ESD/environmental education is illustrated as a central objective of out-of-school activities at the Wadden Sea and is *implemented in the educational institutions*. The Wadden Sea

has a *special suitability* for this. Its suitable attributes include a *special vividness*, *connections in the ecosystem*, as well as the *global connection of the seas*. At the center of ESD/environmental education is the *experience of nature*, as this is a *prerequisite for sustainable action*. The Wadden Sea is ideal for this in part because it is *accessible*. The *joy of being outdoors* and the *experience with all senses* are relevant for the implementation of educational content. Field trips to the Wadden Sea provide *special access to this ecosystem*. This not only awakens learners' *enthusiasm for nature* but also lays the *foundation for sustainable knowledge transfer*:

"If you then make it clear to them and if these microscopic algae didn't exist, if they didn't exist, you wouldn't be sitting here today (...) To make it clear to them how much we depend on nature being intact, because we depend on these darned plants as animal living beings (...)" (E_OSD_I, pos. 44).

ESD/environmental education is additionally understood in relation to *the teaching of respect for living beings*, so an Wadden Sea excursion demands *prudent behavior*. In addition, *discussions with the students* would encourage the students, for example, *to reflect on their own actions* or on *concrete environmental problems*. In order to support these interventions in the best possible way, it makes sense to *link them with other events*; above all, *school lessons* must be related to ESD topics:

"We have the possibilities of conveying the contents and that is why it is a great concern for us to implement this. (...) But ultimately it is the teachers who have to do something out there. (...) that they actually take this with them and in the future, as already mentioned, visit nature areas more often with the classes and deepen this knowledge in the lessons again and again (...) and bring ESD into it, and you can't just bring ESD into biology" (E_OSD_I, pos. 76).

Limits as a place of learning

There are *organizational challenges* in the implementation of an excursion. In particular, safety aspects have to be taken into account. *Knowledge of the tides* is important, but *not every teacher has sufficient knowledge*. For example, the *times of tidal flats* have to be observed, also with regard to *the implementation of specific activities* during excursions. In addition, there are various *dangers* at the Wadden Sea that emanate from *tideways*. To be able to guarantee safety for all, the *accompaniment of a certified expert* is not only recommended, but in some areas *required by law*. Nevertheless, the *responsibility remains with the teacher*. Dangers could also arise from the *weather*, including *fog* and *thunderstorms*.

The limitations of the Wadden Sea as a learning site lie in *the challenges of practical work*. For example, the *wind is an obstacle to mediation* because pointing cards could *fly away*. Also, the water might not run off *as strongly as expected*, so that investigations cannot be carried out. Additionally, certain phenomena can only *be viewed temporarily*. With regard to practical investigations, *sinking into the silt* is a hindrance:

"(...) that was actually a practical problem then, where they say, 'Well. Hm. At this point, we have not obtained the correct data because we always sink in the silt and the measurement is therefore not quite right'" (E_SD_I, pos. 18).

However, these restrictions are ultimately *not a criterion for excluding an excursion*.

Another challenge is the *distraction of the students*, for which can be attributed to the *missing supervision of the teachers*. Some students are *not concentrated*, there is a *lack of attention*. The *fear of contact with nature* is particularly significant. In addition to *panic*, *disgust* is of particular importance. There is *disgust for mud* as well as *disgust for animals*. This must be *respected* but can *usually be overcome relatively quickly* on site. Even so, some students only went into the Wadden Sea *on tiptoe* or insisted on *wearing rubber boots* or even *gloves*. With respect to disgust, a dependency on *gender* (more likely female students), *age* (more likely young students) and *place of residence* (more students from a big city than from the countryside) could be identified. Disgust is highlighted as an *obstacle to the acquisition of knowledge*. This feeling was not explicitly related to the Wadden Sea due to a *missing experience with nature*. Although corresponding behavior in teachers is only present in *rare cases*, there is *fear* among a few teachers:

"There was a young teacher who was afraid and therefore did not want to do a guided tour of the tidal flats (...) She had just finished her studies. That her school class, when it then comes, (.) goes at least 100 meters into the tidal flats. So a groyne is only a few meters further. I don't know where she got these fears from" (E_OSD_I, pos. 56).

Another challenge is *the participants' lack of suitable clothing*. *Despite announcements in the parents' letter*, the students often do *not wear suitable clothing*. The experience of nature is also limited by the *cold*. Another problem is the *absence of accessibility*. Many facilities have a *special wheelchair* that can be borrowed free of charge if needed.

DISCUSSION

In order to answer the research questions, the results presented are discussed in the following sections with the aim of contributing to the literature and placing the results in a superordinate context. Several implications for further research projects are also given.

At this point, it is necessary to emphasize that the results of the present study are an important basis for developing and implementing further biology didactic studies with regard to the Wadden Sea. Nevertheless, these are the views of six experts, so that no generalization may be made.

University Dimension

The experts emphasized the low relevance of out-of-school learning in teacher training. At the universities, there are various structures in the corresponding courses of study. Within these, students can choose courses. In most cases, there are also courses that focus on out-of-school learning.

However, the legally required practical elements in the teaching degree programs refer to phases within the school-based teacher training (e.g., in North Rhine-Westphalia: Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2012). This area should be explored in more detail in empirical research in biological education. Thus, it is possible to take a general look at the attitudes of prospective teachers toward out-of-school teaching and learning processes. As the results of the present study show, it makes sense to be more specific and to focus on the Wadden Sea. In this context, excursions to the Wadden Sea could be carried out within the framework of university teacher training courses and practical work could be implemented on site. With this approach, teachers could already be prepared in this training phase to implement out-of-school learning at this UNESCO World Heritage Site as part of their future profession. In this respect, it is also possible to revisit the suitability of the Wadden Sea and examine the perspective of prospective teachers.

Furthermore, the lacking expertise of (prospective) teachers was judged to be problematic by the experts. There are no studies available that have assessed the knowledge of student teachers about the Wadden Sea. There are some studies, however, that have assessed teachers' knowledge of selected content related to the Wadden Sea. To determine content-related knowledge, questions were asked with a focus on the blue mussel (*mytilus edulis*). The results suggest that the selected topic is not a focus in university teacher education (Großschedl et al., 2014; Mahler et al., 2017a). These questions were also used to make a comparison of students' knowledge (Mahler et al., 2017b). In other biological subject areas, a low subject knowledge level was shown for prospective biology teachers (e.g., in cell biology: Hesse, 2003). Considering that subject knowledge is a basis for subject didactic knowledge (Baumert et al., 2010), the relevance of teacher training—also on the Wadden Sea ecosystem—becomes clear. Therefore, this field should be addressed in educational research in the future. Based on the results of the interviews with the experts, research on the knowledge of prospective teachers about the Wadden Sea ecosystem can be considered relevant. Concrete out-of-school and in-school educational programs on the Wadden Sea can only be developed or optimized in a targeted way if findings are available in this area. A possible concrete study would be surveying the species knowledge of student teachers. This would be a useful starting point for gaining insight into this dimension.

In the interviews, the lack of knowledge about education for sustainable development among teachers was also mentioned. In northern Germany, content on the Wadden Sea with a reference to climate change and biodiversity loss is used in an interdisciplinary teacher training seminar to promote systems competence (Müller & Elster, 2018). This demonstrates the highlighted special suitability of the Wadden Sea. In other contexts, ESD training of teachers is also of central importance (Mrazek et al., 2018). The fact that this project offers additional training for already trained in-service teachers is an indication of the identified need for (further) education. Therefore, the conclusions drawn from the results should not only be related to student teachers but should also be extended in general to trained in-service teachers. It makes

sense to take the research on attitudes towards out-of-school learning places (with or without a reference to the Wadden Sea) into account among teachers. This also applies with regard to knowledge about this ecosystem. Precisely because the Wadden Sea is exposed to many threats (such as global climate change or litter pollution) despite its protection as a national park and its designation as a UNESCO World Heritage Site, there are numerous possibilities for implementing ESD. However, teachers must have the necessary prerequisite knowledge for this.

School Dimension

The knowledge deficit of the (prospective) teachers was again emphasized, as well as that of the students. In fact, there are students from secondary schools in Germany who are completely unfamiliar with the Wadden Sea (Schmäing & Grotjohann, 2021a). This realization is another argument for thematizing the Wadden Sea in school lessons. For with school education about the Wadden Sea and its threats, it may be possible to counteract this state of affairs. Especially because the Wadden Sea in Germany is a very important ecosystem, this is in the interest of various actors. For example, to be able to determine the effects of teaching an environmental education program on the Wadden Sea, accompanying research is necessary. This could focus on the development of the students' knowledge. In addition, there are also links to research projects that are not exclusively relevant to the field of biological education research. For example, from the perspective of environmental psychology, it would be interesting to investigate what influence a school-based lesson about the Wadden Sea could have on the students' connection with nature (Schultz, 2002).

It was emphasized that out-of-school learning cannot be replaced by school lessons and at the same time, the meaningfulness of teaching about the Wadden Sea was presented. Experiments were suggested as a means for establishing a practical connection. It should be pointed out that these are not given sufficient importance during teacher training and therefore too little experimentation is done in school lessons (Preisfeld, 2019). In this respect, the importance of a high-quality teacher training is illustrated once again. This is the only way to ensure that future teachers will be able to deliver high-quality education in their classrooms. Taking the previous conclusions about the Wadden Sea into account, this means that experiments should be included in school lessons on this ecosystem. Specifically, it is possible, for example, to illustrate the filtration performance of mussels or the adaptation strategies of different plants with experiments in school. The effect of these interventions should be investigated using methods of empirical educational research. A focus can be placed on the students' acquisition of competencies. Furthermore, despite the limited possibilities of teaching in school compared to learning out of school, it is feasible to use specimens. For example, mussel shells, empty snail shells, or preserved crabs can be included in lessons on the Wadden Sea. This would allow the effect of classroom use on affective variables to be researched.

School instruction should incorporate out-of-school activities to make the most of them. This postulation, derived

from the interviews, is consistent with the literature (Diersen & Paschold, 2020). Linking these two instructional forms can allow foster the students' interest (Scheerso et al., 2019). Educational interest theory (Krapp, 1992; Schiefele et al., 1983) can be used as a theoretical reference standard for further research. In addition to studies on interest, there are studies on motivation and knowledge. With regard to knowledge, it is necessary to concretize the form of knowledge to be measured before conducting a corresponding investigation. In the design of corresponding studies, the theory of Kaiser et al. (2008) provides a basis. A theoretical anchoring of motivation is offered by the self-determination theory (Ryan & Deci, 2017).

The necessity of referring to formal requirements was reported as a challenge for school-based thematization. With all the potential of the Wadden Sea for school education as stated by the experts, these requirements are unavoidable in the implementation of educational interventions. Hence, it is important to identify clear starting points for considering the Wadden Sea in school lessons in the curricula of the respective grade levels and school types. The special suitability for a lesson within ESD, which was emphasized in the interviews, illustrates the possibility of connecting. Even in the inland of Germany, it is possible to address the ecosystem in school lessons according to the formal requirements. As an example, this can be implemented within the context of the content area "ecology and nature conservation" (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2019). Within this field, characteristic species and their adaptation to an ecosystem as well as feeding relationships and food webs should be examined. The Wadden Sea offers a very convenient context for this. Furthermore, the changes in ecosystems due to human influence and the protection of species are the focus of this content area. As already mentioned, there are also profound connections to the Wadden Sea on this level. Additional connections can also be found in the content areas "diversity and adaptation of living organisms" and "evolution" (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2019).

Out-of-School Dimension

As for school lessons, various links for studies on connection with nature, knowledge, interest, and motivation can be given for out-of-school interventions. The presumed fundamental positive effect from out-of-school interventions by the experts can be linked to existing research findings. For example, the positive impact of primary experiences on motivation has been demonstrated (Wilde & Bätz, 2010). The effects on knowledge acquisition are relevant from a biology didactics perspective. Interventions at other out-of-school learning places have demonstrated a positive effect (Sellmann, 2014). Regarding prior knowledge, there is evidence of place dependencies in the context of word associations to the Wadden Sea (Schmäing & Grotjohann, 2021a). Nevertheless, the relevance of the implementation of empirical research projects in this specific area must be presented here. Despite the special potential of the Wadden Sea for out-of-school learning, which can be deduced from the results of the present study, it has not yet received any form of attention as a learning place in educational research. From a research point

of view in biology education, excursions to the Wadden Sea should therefore be made. For this purpose, the influence on the constructs already mentioned could be determined.

One of the central topics mentioned by the experts for out-of-school learning is ESD/environmental education. Basically, out-of-school learning has been associated with this topic for decades (Giesel et al., 2002). Thus, there are environmental education programs at other learning sites, some of which have been researched from a subject didactics perspective (e.g., on botanical gardens: Sellmann, 2011). As already pointed out, there are no explicit research studies for the Wadden Sea learning site. However, various activities have already been conducted in the Wadden Sea for many years, offering students (and also tourists during their free time) a special opportunity to explore the Wadden Sea. The implementation is carried out in part by educational institutions of the national parks, so-called national park houses and national park centers. For example, the Lower Saxon Wadden Sea National Park has developed its own environmental education program. This program includes references to ESD, environmental education, and wilderness education (Nationalparkverwaltung Niedersächsisches Wattenmeer, 2017). As a future step, the studies conceived based on the experts' recommendations, which have already been indicated in this discussion, should be conducted. Moreover, out-of-school teaching and learning processes in the Wadden Sea have to be explored.

As to limitations of the Wadden Sea as a place of learning, specific safety aspects were raised in addition to various organizational aspects. The relevance of these can be illustrated by the fact that even in the regulations applicable to inland areas, the Wadden Sea is specifically mentioned as well as provisions for out-of-school activities (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 1997). As presented in the results, the experts derive several conclusions for implementing excursions to the Wadden Sea. These must also be taken into account in future research projects, especially in view of out-of-school learning. There are many more factors on site in the Wadden Sea that have an influence on the mentioned constructs than in school lessons. It is obvious, for example, that the perception of a mudflat hiking tour depends, among other things, on the weather (sunshine/drought, temperature). Consequently, these aspects should also be considered in studies that explore out-of-school learning at the Wadden Sea.

The most significant factor that was judged to be an obstacle to out-of-school learning processes in the Wadden Sea is disgust. Disgust is considered in subject didactics research mainly in relation to certain animal species, and the dependence on gender was described by the experts (Gebhard, 2020). Teachers should also be sensitive in this regard when conducting lessons with animals (Polte & Wilde, 2018). Corresponding studies are also necessary to empirically determine the meaning of disgust for learners. So far, no results are available on the disgusting sensation students experience during contact with the Wadden Sea. Also at this point, it is reasonable to extend the examination of disgust to all three perspectives in this work. The relevance of disgust for out-of-school learning in the Wadden Sea is of particular interest. It should be determined how pronounced this is for

students and what influence it has on the students' experience of the excursion. In this regard, it is possible to examine the influence of disgust on the motivation or situational interest perceived during out-of-school learning, for example. This aspect can also be relevant for school learning. This could be especially the case if, as called for in the second section of the discussion, school lessons on the Wadden Sea are designed to be very concrete. Since the sensation of disgust is not only relevant for children but also for adults, this area should also be included in the proposed studies with (prospective) teachers.

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APPENDIX A

Table A. Example description of the coding of the text material

Category	Definition	Subcategory I	Definition	Subcategory II	Definition	Basic example	Coding rule
The Wadden Sea as a place of learning	Content-related reference to the out-of-school dimension	Potential as a place of learning	Wadden Sea as a place of learning offers opportunities for learning and teaching.	Possibilities for scientific work	Scientific work is considered.	"You can also work very well in a scientific way. Show the students how a scientist works" (E SD I, pos. 12).	The definitional requirements of all (sub-) categories must be met.