Supplementary material for GC Insights: Designing for full-phase inquiry in virtual fieldwork - upper secondary school students' exploration of extinction events

S1. Introduction

This supplementary material contains the full-phase inquiry lesson introduced in the GC Insights paper and here made available for inspiration and use in upper secondary school and undergraduate Earth science and geography courses. The material is designed and developed by Rie Hjørnegaard Malm, Kristen Rune Skalborg Hansen, Robert Evans, Lene Møller Madsen, Jesper Milán, Nicolas Rudolph Thibaut, and Ben Kennedy. The GC Insights paper introduces the aim, theory and grounding pedagogical intentions. Here, we make the inquiry lesson available so that geoscience teachers can adjust and add content to fit their student population and local curriculum.

S2. Virtual fieldwork and inquiry

In this material, we are intentionally designing a blended inquiry lesson *with* technology that allows for exploring on multiple scales and across geographical distances. The goal is to utilise the virtual reality technology to provide students with experiences beyond what they can achieve in the classroom, getting added value from aspects of the field and the laboratory. The design includes an open explorative phase in a virtual reality environment combined with physical in-class exercises to increase teachers' flexibility and reduce the reliance on virtual reality. Our starting point has been to identify and overcome the limitations of physical explorations in the field, such as what humans can observe, like geochemistry or microfossils, both of which are invisible to the human eye. Therefore, we have designed an inquiry lesson where students can explore beyond the classroom on their own and simultaneously on multiple scales.

The explorative nature of the lesson is supported by using *inquiry* as a guiding framework. The ideas behind learning science through inquiry can be traced back to the early twentieth century, when John Dewey described five phases of reflective thinking (Dewey, 1933). Inquiry models are based on learners exploring for themselves as they create valid arguments based on observations or data (Anderson, 2002; Bybee et al., 2006; Bybee, 2009). Within the field of geoscience, inquiry has been adopted both for the constructivist subject affordances it provides and for offering a sequencing structure for student experience with the processes of learning during fieldwork (Madsen et al., 2021; Piper et al., 2025). Consequently, we used this learning model for our inquiry virtual fieldwork activity, as it cognitively activates students by putting them in the role of cliff explorers where they can be sensorially motivated by the virtual reality experience and mentally engaged by trying to figure out how their observations might help explain the history of the cliffs.

S3. Developing a virtual field module

In this section, we address our ambition to design a virtual fieldwork with a full-phase inquiry as a teaching innovation. Our activity uses a full-phase inquiry approach (see Figure S1) where we first motivate students with the 360 virtual experience and a problem-solving goal. Then, before traditional teacher explanations about the geology of the cliffs, the lesson allows students to explore both the geological characteristics of the cliffs and the fossils embedded in them, with the goal of telling a story about the cliffs. After sharing their diverse stories based on their own observations and inferences with everyone, the teacher uses these student explanations along with geological research to develop the current ideas of scientists about the history of the cliffs. Rather than seeking 'the correct answer' the students are rewarded for good ideas based on their findings. Building on student ideas the teacher acknowledges the value of the student observations and inferences, and recognises all reasonable ideas, rather than just rewarding students with the 'right' answer. Our full-phase inquiry continues after the student and teacher explanations of the structure and fossils from the cliffs are shared, by challenging the students to use their new understandings to solve several relevant and motivating problems (see 'Extends' in Figure S1). Throughout the full-phase inquiry, students get continuous feedback from peers and teachers since multiple instances of feedback have been shown to be essential for students to work with inquiry, because it often requires more thought and can therefore be more challenging for students used to 'teaching-as-telling'. Concurrently, continuous teacher feedback about how the students is doing is important since the challenges of teaching with inquiry can discourage teachers with limited inquiry teaching experience (Evans et al., 2014). With use of inquiry teaching and learning, such as the full-phase inquiry applied here, students can be motivated to explore openly and reason as scientists since the goal is not just to get the correct answer. The full-phase inquiry is an especially useful fieldwork activity since the 'correct' answers are usually the ideas of others and are often not easily proved. This lack of traditionally taught knowledge, in the beginning of the lesson, allows the ideas of students to be valued instead of only praised if they match known science.

S4. The context

The inquiry lesson is designed for Danish upper secondary students enrolled in an elective course of Physical Geography with 74 hours allocated, most often taught over a year. In our study schools, students can be enrolled in both social science and natural science study programmes. Experimental work, fieldwork, and other empirically based work make up approximately 20 percent of the teaching time in the Physical Geography curriculum. However, as in many schools, the opportunities for teachers to take students on fieldwork outside their local area are limited due to time and financial constraints. Hence, the idea of the virtual field module is to provide students with a geoscience fieldwork experience, focusing on geoscience fieldwork methods like locating and describing fossils, interpreting them within the context of the rocks, and reasoning skills of creating a geological story of a field site inferred from their classification of data. In addition, the virtual field module will provide students with access to microfossils not visible in the field as well as research knowledge, expanding their understanding of how their inquiries in the field site relate to current research. The virtual field module can be run as one module of 1,5 hours, however in classes with no experience of inquiry and/or virtual environments two modules of 1,5 hours seems more feasible.

Learning goals of the virtual field module:

1. Make virtual observations and inferences of three field-site localities and be able to differentiate between them.
2. Classify various types of rocks and fossils into known groups based on observations.
3. Determine the relative age of three field-site localities and, on this basis, establish an age-related relationship between them.
4. Infer about past environments and geological time from characteristics of rocks and fossils and drivers on environmental change.

Possible further learning goals:

5. Hypothesise about current and future changes in climate based on collected and classified data from the past.

S5. Design process

The core design team included four science education researchers (two geologists, one biologist, and a geographer) and a geography teacher from an urban high school, with a background in physics and geology. The researchers considered it important for the inquiry exercise to be authentic. Therefore, two palaeontologists, one from the local geoscience museum and one university faculty member were included as experts in the design process and contributed materials and specific content to classifications of fossils, past environments, and field- and laboratory methods.

The design team co-created the virtual inquiry lesson and teaching materials including an on-line learning environment in an iterative process over a two-year period. We started out with field visits to the sites establishing common knowledge of the learning potentials to include in the virtual environment. A period of producing learning goals, teaching materials, and the virtual environment followed. During this period, the geography teacher tried out different modified versions of the lesson in four different high school physical geography classes. Members of the design team made observations of the first of these teaching sessions to support the iterative process of modifying the lesson based on students' experiences. In particular, the developed classification tool was specified by adding QR codes for the virtual fossils but also the importance of splitting the explain and explore phases into several separate phases became clear. The resulting inquiry lesson has been tested in a Danish science teacher programme giving feedback to the sequencing as well as content of the different phases. The following inquiry plan that we present is a result of this process and is designed so that geoscience teachers can adjust and add content to fit their student population and local curriculum.

S6. Inquiry for the virtual fieldwork module

The fieldwork setting consists of three separate field sites in Denmark named Faxe Kalkbrud, Møns Klint and Stevns Klint, the latter being an UNESCO world heritage location of the Cretaceous–Paleogene (K–Pg) boundary (Surlyk et al., 2006; Geoviden, 2014). The three fieldwork settings were virtually created by recording the three locations with a 360-degree video camera, which simultaneously saved views and sound in every direction. The goal was to provide full visualisations of the fieldwork sites and geologists interacting with a field site for students to explore all three sites. The 360 videos allow the students to continuously control their direction of view. We modified the 360 videos using the software *Thinglink* which allowed us to embed 'clickable' icons and still images within the 360 videos so students can hunt and collect still photo close-ups of fossils at places within and outside a normal straight-ahead view as they explore. After students make observations of the three sites and of the fossils, they then use a classification tool for the fossils presented in 360 videos of laboratory sessions to determine the fossils' geological age range as well as their living environment.

Subsequently, using their classification of fossils, the students use their observations of the position where they collected the fossils to place each fossil image at an appropriate depth (stratigraphic) position in the cliff. Only with this step complete, are the students able to infer the relative age of each of the three separate locations and make a full geological story of the fieldwork setting. Hence, the virtual field and laboratory spaces are integrated into the classroom teaching material. In addition, the students meet virtual geologists working in the field and lab settings who guide what to observe and do in the field and lab, providing an element of authenticity to the experience.

For our inquiry plan we use the multi-phase model which can be used to plan, organise and document teaching. It has been developed and improved continuously – always based on international research on inquiry-based teaching for the past 15 years (Madsen et al., 2020). In the multi-phase model we use a derivative of the 5E-model (Engage, Explore, Explain, Expand, and Evaluate) in the form of a multi-phase inquiry model (Elicit, Engage, Explore, Explain, Extend, and Feedback) that adds a brief early Elicit phase to discover students' prior knowledge and exchanges the 5E's 'Evaluation' for 'Feedback' which is formative and essential for inquiry learning (Madsen et al., 2020). Learning objectives govern the content of the individual phases and the connections between them. Thus, the students' work is framed within the learning objectives set by the teacher for the activity and are continuously adjusted by the teacher's guidance. We have used this revised model both in science teacher training and in developing inquiry lessons for upper secondary teaching, e.g. to transform the subject of climate change into an inquiry of a challenging geoscience problem, thereby engaging students in geoscience processes and an awareness of long-term implications (Madsen et al., 2021). In the following, we outline the development of the virtual field module and the multi-phase inquiry design with the constraint of making student explorations possible.

S7. The Inquiry lesson

The following sections (S7.1- S7.8) describe how students can explore and engage in constructing viable scientific ideas of extinction events and outline possible teaching and learning activities aligned with each phase of a full-phase inquiry. For an overview of the inquiry and its phases, see Figure S1, showing key illustrations for each phase and the entry and exit questions for students to engage with.

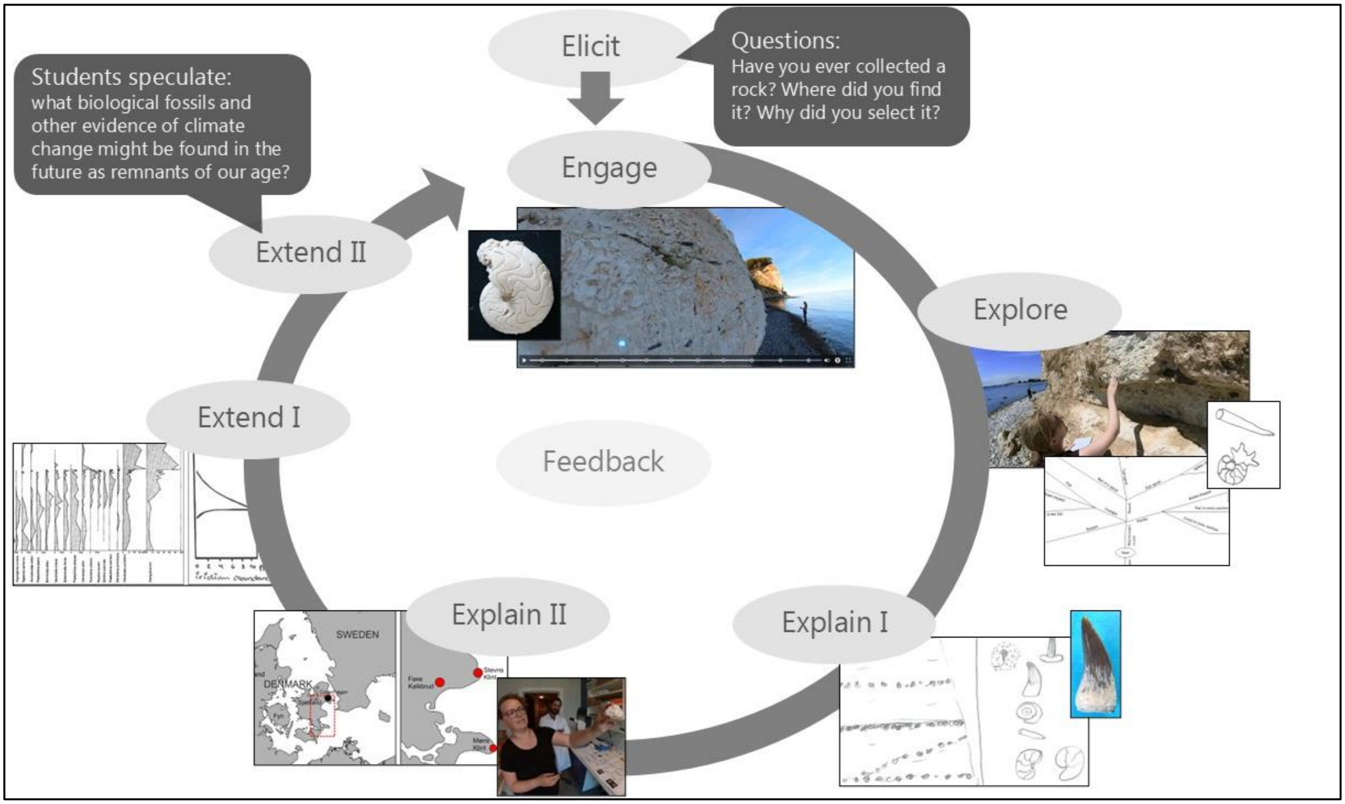

Figure S1: **Overview of the inquiry phases of the lesson, as presented in the GC Insights paper, with *Elicit*: Students prior knowledge, *Engage*: Creating interest in working out the geological story, *Explore*: Students independent exploration, *Explain I*: Students interpretation, *Explain II*: Teacher validation and expansion, *Extend I*: Teacher introduces data-sheets, *Extend II*: Students design future geological deposits, and *Feedback*: Continuous formative feedback for students and teachers during the activity.**

S7.1 Elicit: Students prior knowledge

We designed the elicit phase to be short, as most of the students will have had little exposure to geological concepts. The teacher poses questions to the class and students reveal what they know about rocks and fossils. For example: *Have you ever collected a rock to bring home? Where did you find it? Why did you select it?* The teacher uses individual students' knowledge for brief reflections about shared knowledge in the class of rocks and fossils. If there is knowledge in the classroom that can be used to date deposits, as in a forensic case, the teacher can use this as a transition into the Engage phase of the lesson.

S7.2 Engage: Creating interest in working out the geological story

The teacher engages the students in doing fieldwork: *Today we are going to do some of the same things geologists do in the field to solve geological mysteries, we will explore three different areas in Denmark and based on our examination of what we find, we'll establish a case to determine the geological age of the deposits and establish when and why they were made.* The lesson begins with an image of Møns Klint, one of the sites in the virtual environment (Figure S2), and the teacher engage the students to virtually explore Møns Klint and two other geologic locations in Denmark, Stevns Klint (Figure S3) and Faxe Kalkbrud (Figure S4). The teacher explains that they will be playing the role of scientists, and based on an examination of what they find, they will create a possible 'science story' of when and how the deposits were made and determine their geological ages.

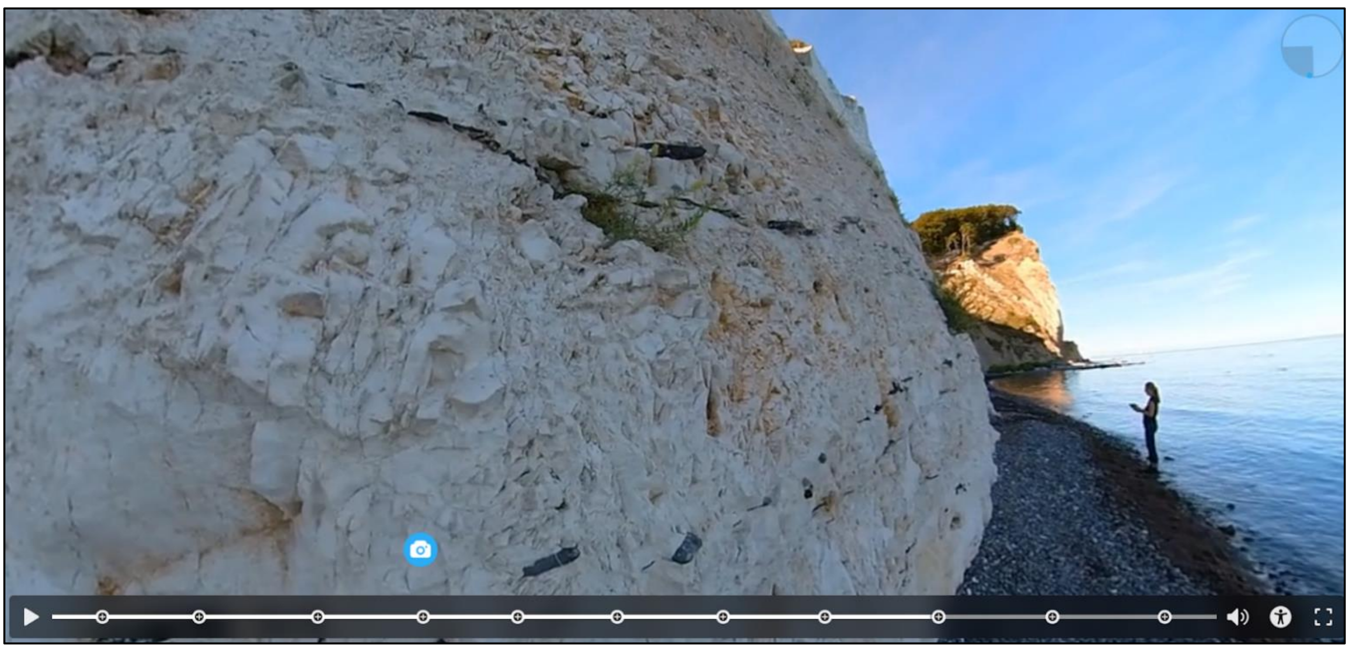

Figure S2: **Screen capture from Møns Klint, as experienced in the virtual environment, showing students' view of the screen, a geoscientist working and a timeline of the 360 video at the bottom. Students can start observing the outline and colours of the cliff.**

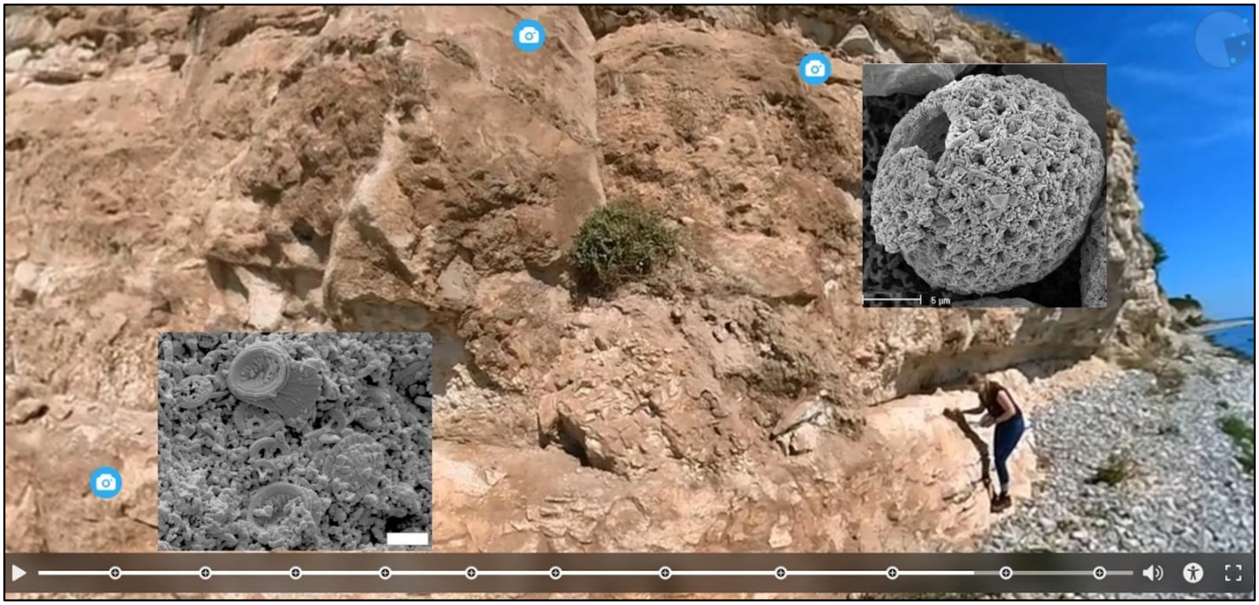

Figure S3: Screen capture from Stevns Klint, as experienced in the virtual environment. Illustration of the 360 video interface with blue clickable camera icons. When students click an icon, a picture of that fossil will show, here illustrated with two images of microscopic dinoflagellate and coccolith.

Figure S4: Screen capture from Faxe Kalkbrud, with geoscientists working and a truck passing by. The videos include the sounds from the recording, including footsteps, the wind, hammers hitting the rocks and here at Faxe Kalkbrud, trucks passing by in the active open mine.

S7.3 Explore: Students independent exploration

Students begin the VFT (Virtual Field Trip) to the three Danish geological sites by exploring the virtual environment. The teacher encourages everyone to randomly explore it to get an overview of where they are visiting. The 360 videos can be viewed in headsets or on flat computer screens where the view is adjusted using a mouse. Students are encouraged to both individually explore wearing a headset and with a group, maybe with multiple students using one screen. As the students explore, they are encouraged to focus on finding as many fossils as they can (Figure S3). For each fossil they discover, they are asked to note where and in which part of the cliff it was found. As discoveries continue, the students are shown an example of a vertical cliff column (Figure S5) and asked to draw a similar column themselves and record the location on the cliff (high, middle or low) for each of their fossil finds along with a simple sketch of it.

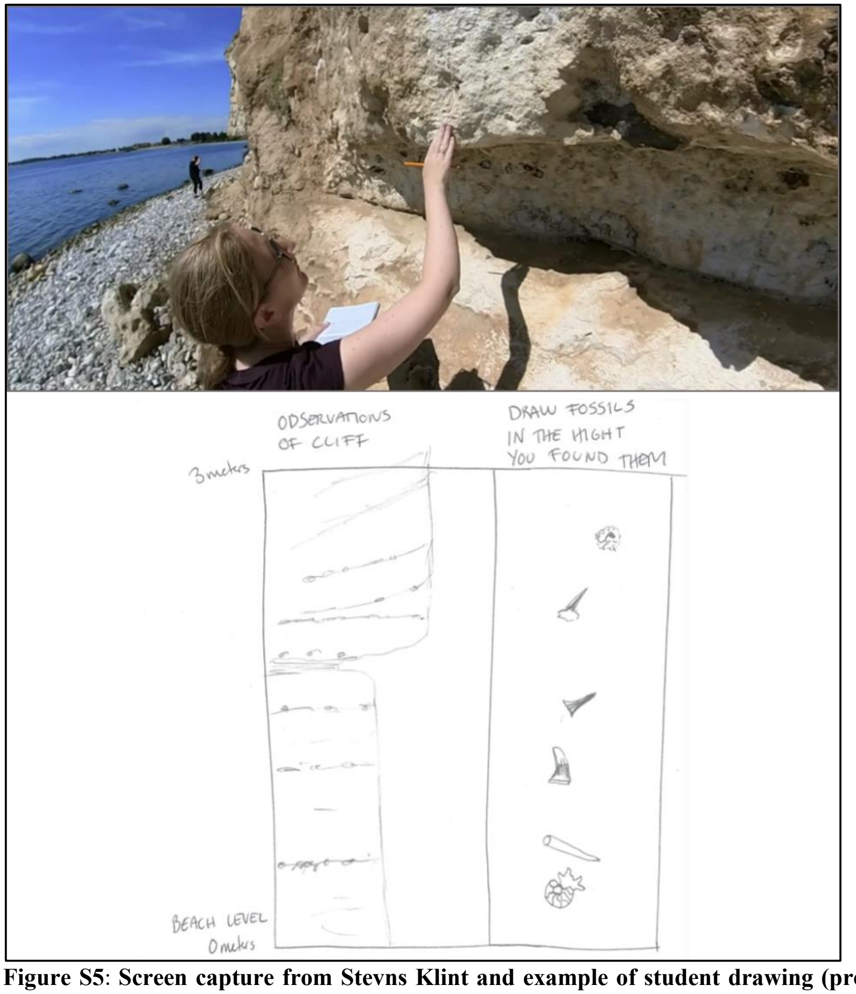

Figure S5: **Screen capture from Stevns Klint and example of student drawing (produced for illustration purposes). The students meet various geoscientists working in the field when moving along the cliff in the virtual environment. The geoscientists are working on observations, sketching or measuring the cliff. Here, students can observe how the scientist looks for fossils at different heights of the cliff. The example of student drawing from the Stevns Klint locality shows an outline of the cliff face, the placement and drawings of found fossils. The students are encouraged to draw the fossils to enhance their attention to detail and produce a physical product.**

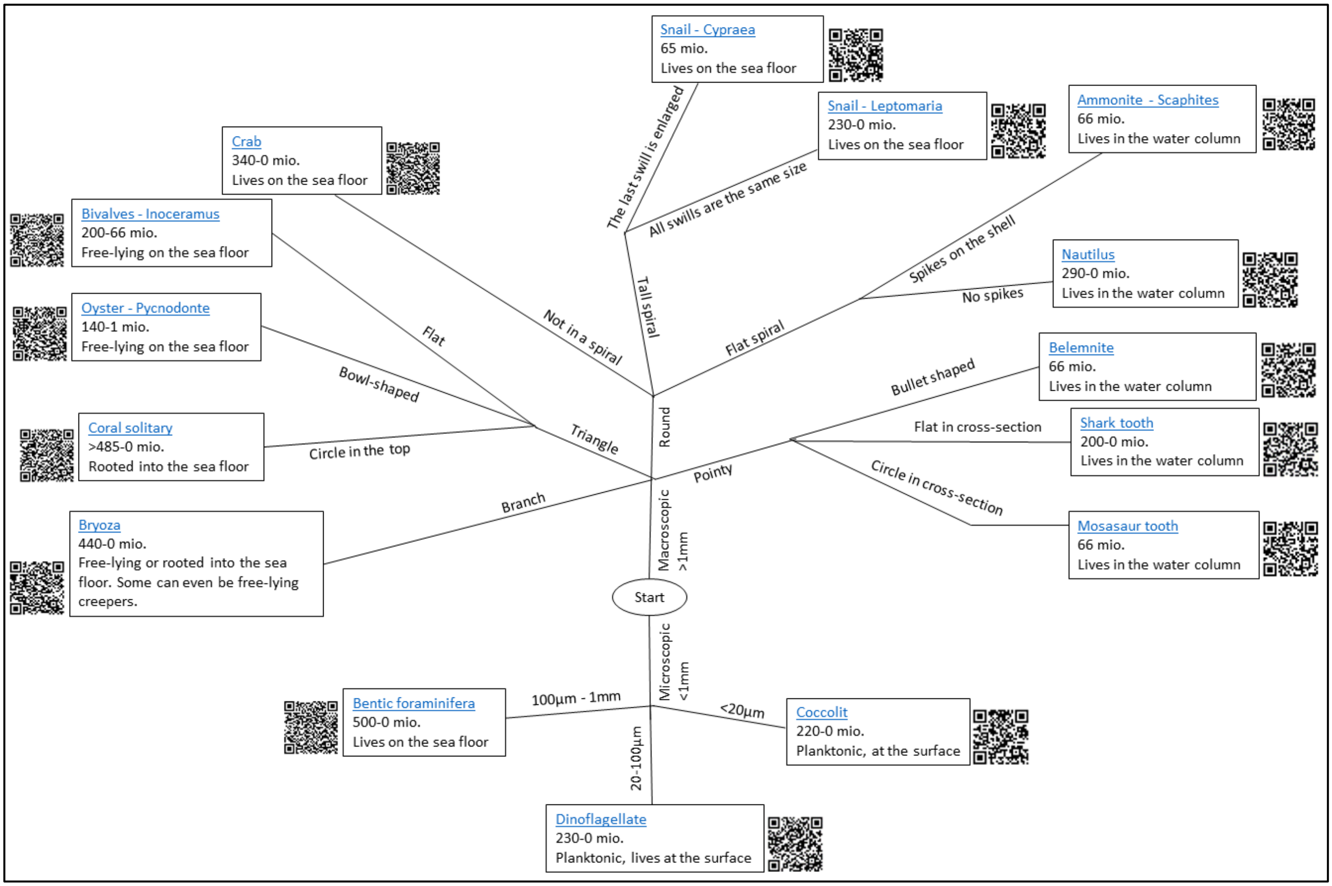

Figure S6: **Classification tool provided by the teacher. Using this, the students classify the fossils based on morphology and find the age interval of each of their fossils. QR-codes link to 3D interactive models of exemplary fossils to help students identify their fossils. Access to this tool during the inquiry adds significantly to the students' possible geoscientific reasoning.**

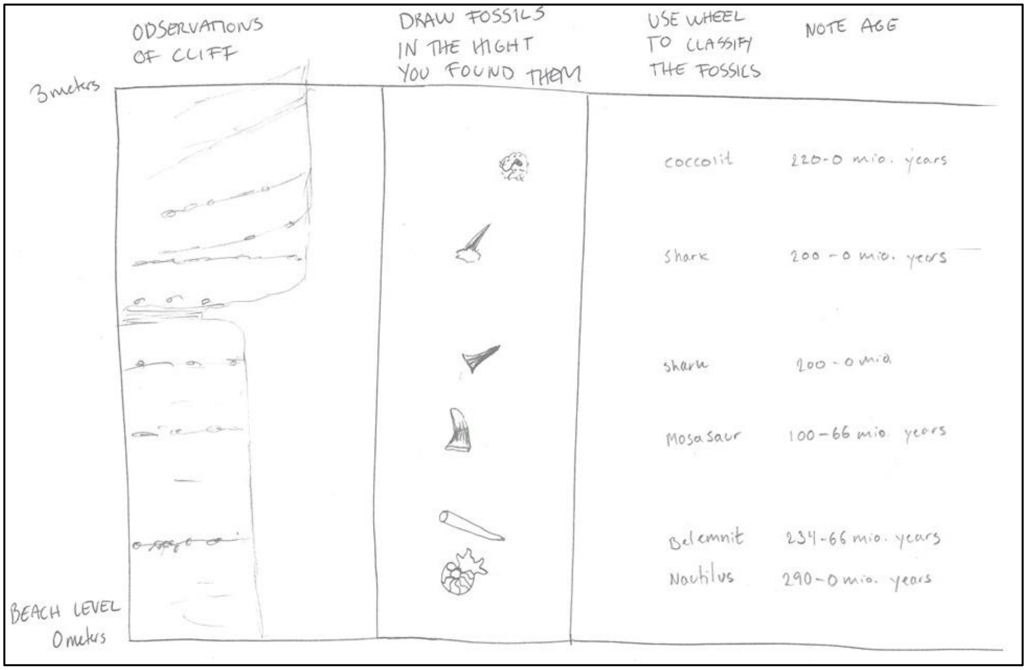

Figure S7: **Exemplified student drawing from Stevns Klint. The fossils are classified with the name of the fossils and the age interval of the animal, based on the morphological classification tool (figure S6).**

S7.4 Explain I: Students interpretation

This phase involves the students gathering the observations and maps that different class groups have collected for the three locations. The teacher initiates a dialogue with the groups (perhaps via an online application where different groups show and explain what they have found in their various explorations). Without being explicitly told, the students gradually realise that there is a relation between the three locations, as some of the same fossils are found in more than one of the locations. The teachers guide the students to notice the different age of the fossils found at the three locations and the students now work out together the relative age of each of the three locations (Figure S8). One of the key observations is that many of the fossils died around 66 million years ago named the sixth mass extinction event (Kolbert, 2014) and none of these fossils were found neither at Faxe Kalkbrud nor in the top half of the cliff at Stevns Klint. A second key observation is that different creatures lived at the three locations indicating different environments (see also Figure S9 for further explanation). The teacher should note that this is how geologists work: make observations, draw a profile - find fossils indicating where you find them, determine their age and create the geological history and interpretation.

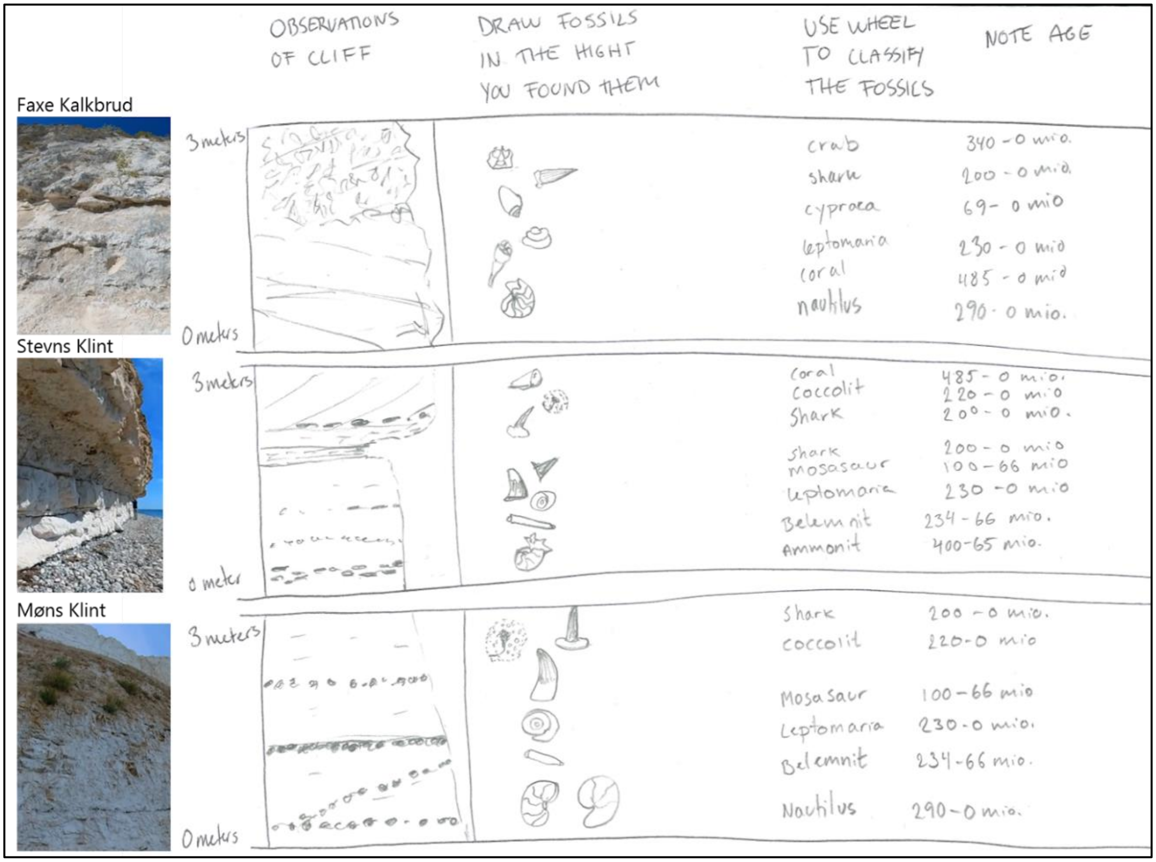

Figure S8: **What the students may establish in Explain I. Illustration of the three localities and their relative age, with drawings of profiles, found fossils, classification and age intervals of animals.**

S7.5 Explain II: Teacher validation and expansion

In this phase, the teachers affirm and build on the student explanations. They now include the geological description of the three areas, a map and the relative age (Figure S9) as well as methods of calculating the relative age of the three areas (Figure S10 and S11) showing how reasoning of a valid geological history of an area is made by scientists. The teacher might want to show how Møn exemplifies a deep-sea environment by pointing student attention to their drawings of the cliff showing a very evenly distributed chalk cliff shattered with flint cutting the cliff in lines and how the fossils in this area are not very detailed and small, but of a rich variety and abundance. Faxe Kalkbrud exemplifies water deposits at 150 - 200 metres and the teacher draws the student's attention to their observation of very detailed and rich fossils indicating a coral sea.

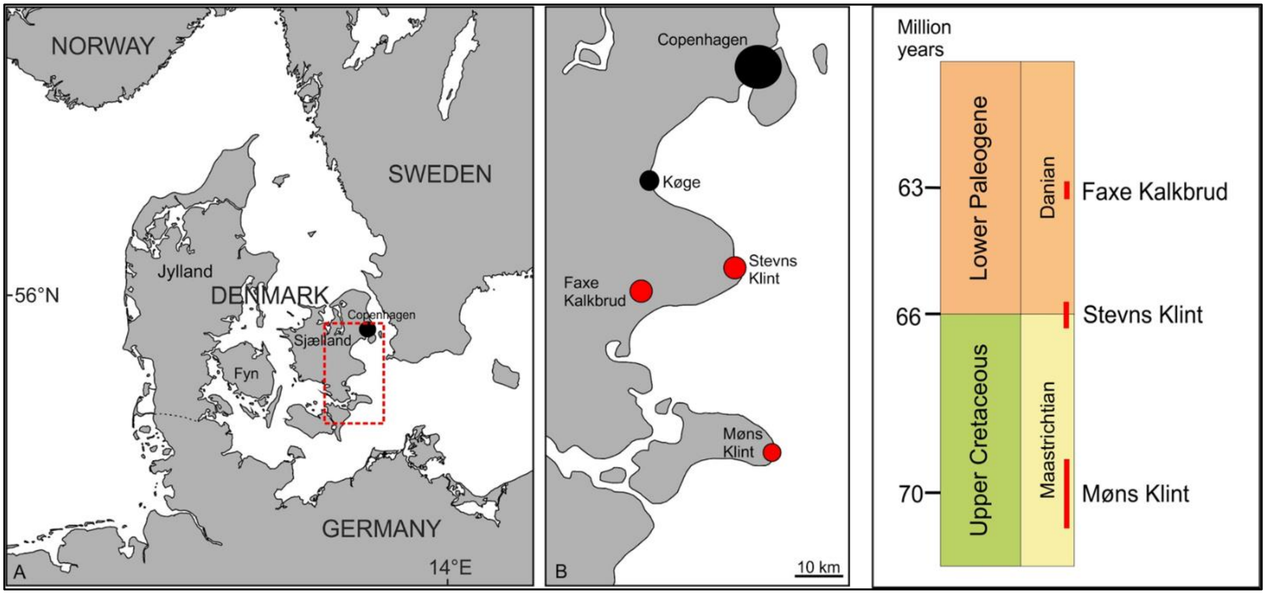

Figure S9: **Map of case localities. The three selected localities for the project are Møns Klint, Stevns Klint and Faxe Kalkbrud which represent three connected but distinct geological periods around the end of the Cretaceous period, at the Cretaceous-Paleogene boundary, where life on earth was subject to a severe mass extinction 66 million years ago. At Møns Klint, the chalk represents the pre-extinction ocean conditions, around 70 million years ago. At Stevns Klint, the cliff faces expose the actual geological boundary layer, the 'Fishclay', that represents the geological boundary and mass extinction between the Cretaceous and the subsequent Paleogene period 66 million years ago. The limestone in Faxe Kalkbrud was deposited around 63 million years ago, about 3 million years after the end Cretaceous mass extinction and represents the period where the surviving life has recovered and built new complex ecosystems on the Earth. Faxe Kalkbrud is unique in that it has preserved the remains of a large deep-water coral mound complex, with an extensive associated fossil fauna.**

Figure S10: **Screen captures of geoscientists working in the field: measuring the flint layers in the profile and note the locations of fossils (top image) and use of hammer to dig into the cliff for fossils (bottom image). Students have the option to explore the geological methods further by watching short videos explaining how geoscientists work in the field, including what they notice when they observe, what they measure and what the hammer is used for.**

Figure S11: The students can choose to jump into the laboratory with a geologist explaining how they work with chalk samples in the laboratory and how microfossils are classified.

S7.6 Extend I: Teacher introduces datasheets

In this phase, the teacher introduces new datasheets (Figure S12a, S12b) engaging the students with*: There is one layer in one of the locations, namely Stevns that for many years puzzled scientists. It's one that I see you also noticed in your* *explorations of the cliffs and coincides with the age that many of the fossils disappeared.* The next task for students is to make explanatory hypotheses about how this abrupt change could have been created. Students will need to discuss the datasheets, find the place in the virtual environment, make observations and relate them to their observations in the datasheet and their previous drawings of the layers in the cliff at that location. Based on this they can create one or more hypotheses of explanation of the abrupt change in the geological history of the cliff.

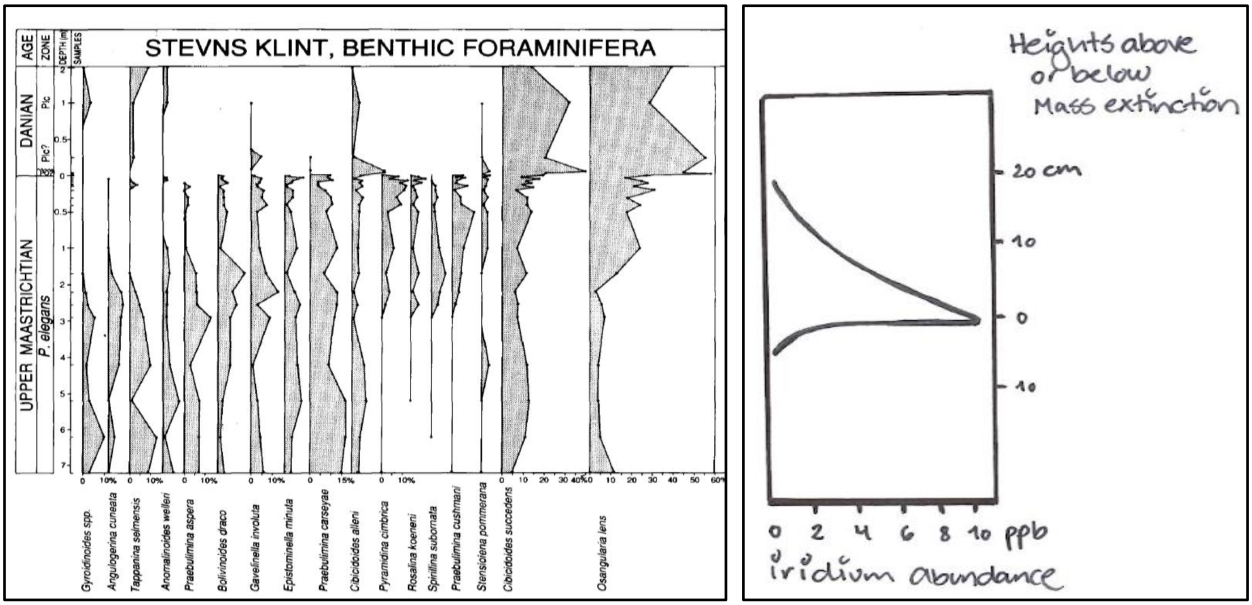

Figure S12a: Abundance of microfossils at Stevns Klint, variation in depths. Figure S12b: Iridium (Ir in the Periodic Table) concentrations over the 'abrupt change'. Modified versions of the original data for teaching purposes. Find the original illustration for S12a in Schmitz et al. 1992, p. 246 and for S12b in Alvarez et al. 1980, p. 1099. Figure S12a has been modified from a Danish version in Geoviden (2014) created by illustrator Christian Rasmussen.

This Extend phase activity will be a challenge to most students unless they have prior knowledge of the location and Cretaceous-Paleogene extinction event (Kolbert, 2014). We therefore suggest some classroom discussion that facilitate interpreting the datasheets, before letting the students make explanatory hypotheses about the abrupt change in the cliff.

For example, in exploring the abundance of fossils in Figure S12a: *Why could the number of fossils be different at the top and bottom of the cliff? What do you observe as the main difference between the top and the bottom of the cliff and the datasheet?* As students examine Figure S12a more closely, they may realise that at one point in time - there seems to have been an 'abrupt change' where the abundance of microfossils changes, thus creating a boundary. They are prompted to explore if the boundary aligns with their fossil ages in their own annotations (Figure S8) and find that it does.

In figure S12b, students may now hypothesise that the abrupt change is linked to the unusual increase in Iridium. The teacher can extend further by saying that it is very unusual to find high concentrations of Iridium on the surface of planet Earth; it is an element normally associated with the cores of planets. We emphasize that teachers allow for a full-phase inquiry by not giving the game away beforehand and see if students can have an Aha-moment and link planet cores and the abrupt change in fossil content on Earth to asteroids. This could lead into a discussion on how asteroids form when planets are smashed apart. This may help explain the different fossil numbers and types above and below the Iridium point. *Are there any other explanations for catastrophic events?*

Based on the students' interpretations of the datasheet and their observations of Stevns Klint showing distinct layers of chalk and flint including a small layer of clay (the Fishclay), the teacher can show how Stevns exemplifies an environment abrupted by a catastrophic event, for example the mass-extinction of the Cretaceous-Paleogene boundary. The interpretations of the decline in both the variety and number of species and the levels of ashes in the deposit (indicating increasing volcanic activities) and the presence of Iridium results in valid evidence of a sudden change in the environment and hence deposit.

S7.7 Extend II: Students design future geological deposits

To further engage students in applying what they have learned in this activity, we suggest a motivating extension to challenge them to hypothesise with a labelled drawing of what future layers during the next 10.000 years might contain (see Madsen et al., 2021 for details). For example, prompted by this question: *What biological fossils and other evidence of climate change might be found in the future as remnants of our age?* In designing their future layer, they take clues from what they found in ancient layers in the virtual environment and what human activity today might be adding to the layer. They can base their ideas on possible biological fossils, evidence of climate change and even current remnants of our age so called 'techno fossils' such as plastic, chicken bones, synthetic garments and concrete (Gabbott and Zalasiewicz, 2025). They might write or narrate a short essay about the components of their projected future layer and share their ideas with others. In the lesson presented here, the fossil population that marks the change of environment is central to this understanding.

S7.8 Feedback: Continuous formative feedback for students and teachers during the activity

Throughout the phases of this inquiry lesson, the students as well as the teacher should get and provide oral and written feedback which will help them continue their work and achieve success. The students will have many questions for the teacher as they collect images and match them to the handouts. They will be insecure about identifying the microfossils and need reassurance or realignment. Without providing answers to content questions from the students, the teacher needs to prompt their hypotheses about their observations and to encourage peer feedback so small groups can help one another with peer formative feedback. Experts can also be invited to the classroom to provide additional feedback and answer questions and facilitate discussion.

There are several examples of the value of *Feedback* in physical fieldwork (Malm and Håkansson, 2021; Stokes and Boyle 2009) and some virtual environments also try to achieve this (Watson et al., 2023). *Feedback* provides an opportunity for reflection which is a critical skill as a scientist and in field situations. In virtual and physical fieldwork, the novelty of the environment (Orion and Hoffstein, 1994) will provide distractions that hinder linkages with other learning and therefore reflection needs to be an explicit component of any inquiry virtual field exercise. As illustrated in our model, we strongly recommend that feedback is implemented through the exercise, both formally with written feedback and informally through dialogue during the whole lesson. Concurrently, the teacher who is interacting with the groups of students will recognise common problems the students are having and be able to ameliorate those issues for the entire class. The teacher will also get feedback on the difficulty of the content and make concurrent adjustments. Teachers who are uncertain about inquiry teaching will use the continuous feedback from interacting with pupils to assure themselves that they are succeeding with the lesson.

S8. Our invitation

As technological advancement has made it possible to produce low-cost, user-driven virtual fieldwork we set out to combine these new possibilities of virtual fieldwork with an inquiry approach to learning in an upper secondary geoscience setting. Further, by making this full-phase inquiry lesson available we hope to inspire others to experiment with virtual reality and inquiry and invite the community to create engaging learning experiences for Earth science teaching.

References

Alvarez, L., Alvarez, W., Asaro, F., and Michel, H.: Extraterrestrial cause for the cretaceous-tertiary extinction. Science, 208, 1095–1108. https://doi.org/10.1126/science.208.4448.1095, 1980.

Anderson, R. D.: Reforming Science Teaching: What Research Says About Inquiry. Journal of Science Teacher Education, 13(1), 1–12. https://doi.org/10.1023/A:1015171124982, 2002.

Bybee, R. W.: The BSCS 5E instructional model and 21st century skills. Colorado Springs, Co: BSCS, 24, 2009.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N.: The BSCS 5E instructional model: Origins and effectiveness. Colorado Springs, Co: BSCS, 5(88-98), 2006.

Dewey, J.: How we think. Heath, Boston, 1933.

Evans, R., Luft, J., Czerniak, C., and Pea, C. (red.).: The Role of Science Teachers' Beliefs in International Classrooms: From teacher actions to student learning. Cham: Springer, 2014.

Gabbott, S., and Zalasiewicz, J. A.: Discarded: How Technofossils Will be Our Ultimate Legacy. Oxford University Press, 2025.

Geoviden.: Stevns Klint - ny dansk verdensarv. Geologi og geografi nr. 3, Geocenter Danmark, 2014.

Kolbert, E.: The sixth extinction: An unnatural history. Henry Holt and Company, 2014.

Madsen, L. M., Evans, R., and Bruun, J.: Inquiry-based teaching: The 6F model - its origin and development in Denmark [Undersøgelsesbaseret undervisning: 6F-modellen - dens tilblivelse og udvikling i Danmark]. MONA, 1, 26–45, 2020.

Madsen, L. M., Evans, R., and Malm, R. H.: Using a Wicked Problem for Inquiry-Based Fieldwork in High School Geology: Addressing Climate Change and Mass Extinction Events, in: Addressing Wicked Problems through Science Education: The Role of Out-of-School Experiences, edited by: Dillon, J., Achiam, M., and Glackin, M. Springer, 167–188, 2021.

Malm, R. H., and Håkansson, L.: Developing an Arctic Geology course: exploring the role of fieldwork in a challenging learning space. Uniped, 44(3), 178-189, 2021.

Orion, N., and Hofstein, A.: Factors that influence learning during a scientific field trip in a natural environment. Journal of Research in Science Teaching, 31(10), 1097–1119. https://doi.org/10.1002/tea.3660311005, 1994.

Piper, M., Frankle, J., Owens, S., Stubbins, B., Tully, L., and Ryker, K.: A review of the inquiry and utility of mineral and rock labs for use in introductory geology courses. Journal of Geoscience Education, 73(2), 106-116, 2025.

Schmitz, B., Keller, G., and Stenvall, O.: Stable isotope and foraminiferal changes across the cretaceous—Tertiary boundary at Stevns Klint, Denmark: Arguments for long-term oceanic instability before and after bolide-impact event. Palaeogeography, Palaeoclimatology, Palaeoecology, 96(3-4), 233-260, 1992.

Stokes, A., and Boyle, A. P.: The undergraduate geoscience fieldwork experience: Influencing factors and implications for learning, in: Field geology education: Historical perspectives and modern approaches, edited by: Whitmeyer, S. J., Mogk, D. W., and Pyle, E. J. (Vol. 461, p. 291). Special Paper 461. The Geological Society of America, 2009.

Surlyk, F., Damholt, T, and Bjerager, M.: Stevns Klint, Denmark: Uppermost Maastrichtian chalk, Cretaceous-Tertiary boundary, and lower Danian bryozoan mound complex. Bulletin of the Geological Society of Denmark, 54, 1-48, 2006.

Watson, A., Kennedy, B. M., Davidson, J., Brogt, E., and Jolley, A.: The implementation of a virtual field trip to aid geological interpretation within an undergraduate volcanology course. Journal of Geoscience Education, 1-13, 2023.