Education in the North

UNIVERSITY OF ABERDEEN

ARTICLE

Embracing materiality as a core element of Arctic pedagogy

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DOI Number: https://doi.org/10.26203/vndw-h333

To cite this article: Conner, L. C. *et al.*, (2023). Embracing materiality as a core element of Arctic pedagogy. *Education in the North*, **30**(2) pp.50-65.

Embracing materiality as a core element of Arctic pedagogy

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Abstract

Arctic pedagogy has arisen as a distinct set of practices that are particularly relevant for learners in northern regions. Here, we advocate to expand notions of Arctic pedagogy by formally including theories of materiality and sensory engagement into the framework. We posit that materiality, especially when place-based, offers a route to mediate and connect learners with emotion and culture, as well as disciplinary content. This paper presents four different examples of learning activities in northern settings, three of which use specific place-based materials as the basis for investigations, and one that was place-based in narrative but did not focus on direct place-based material engagement. Data sources were different for each intervention, including pre and post data capture via postcards, questionnaires, and/or participant interviews. The findings across the first three cases indicate that the activities that richly drew from local materials and contexts and that included sensory elements afforded learning in the affective or identity-related realms. These results contrasted with the fourth activity, in which the learning was largely content based. The combined results underscore the value of direct, hands-on exploration of materials of local significance within northern pedagogical contexts.

Keywords: materiality, pedagogy, place, sensory learning, culture

Introduction

Communities in the far northern part of the world share a number of features, such as a high percentage of towns and villages in rural areas, continuing traditions of land-based livelihoods, and seasonal extremes of light and temperature, which affect biodiversity, ecosystem services, and human behavioural patterns. The concept of a distinct Arctic pedagogy has arisen to meet the needs of northern communities (those in northern regions both in and near the Arctic), founded on the pillars of community and culture, local knowledge and language, and access via distance learning (UArctic Thematic Network on Teacher Education, 2019). The position statement cited above offers tantalising hints about the ways in which materiality connects to these pillars. For instance, it states that education in the Arctic should "provide children with education that reflects, validates and enhances their ways of living and culture. Students need an educational experience in which they can feel, hear, taste and touch their cultural values" (p.3)—yet materiality is not called out as a central element of Arctic pedagogy to date.

Here, we argue that materiality should be formally elevated as an important pillar of Arctic pedagogy across learning contexts—formal, informal, and non-formal—due to its critical role in learning. We take up the idea of materiality in this paper as education via social interaction with artefacts, as experienced through "bodies, senses, relations, actions and positions" (Nordtømme, 2012, p.319). We posit that materiality, especially when place-based, offers a critical route in mediating and connecting learners with emotion and culture, as well as disciplinary content, and that it provides an important counterpoint to digitised learning. We present a theoretical perspective and three cases that illustrate the particular affordances of centring local materials and sensory engagement, contrasted with a fourth case that uses non-place-based materials.

Materiality as a core element of Arctic pedagogy

Physical objects and materials have long been acknowledged to hold an important place in learning. Sociomaterial theories of learning suggest that both the social and the material aspects of a learning context are inseparable from the learning itself, shaping both the nature of the experience and its outcomes (Fenwick, 2015). The idea of materials as critical to learning has deep roots, as exemplified by Piaget's (1977) notion of "concrete" learning (that which can be seen, touched, or experienced directly), as well as Vygotsky's (1978) idea that physical objects mediate cognition itself.

Materials have been shown to be important in terms of specific learner outcomes. One such outcome is a disciplinary identity (NRC, 2009). Such identities develop in response to repeated engagement in experiences in which learners start to feel a sense of competence and recognition with respect to the discipline in question (Bell, Tzou, Bricker, and Baines, 2013; Carlone and Johnson, 2007). Part and parcel of this pathway is coming to feel that one is a part of the community of practice, including gaining discipline-specific knowledge, taking on ways of being in the community, and performing disciplinary practices with material resources such as tools, clothing, and other material objects that have authenticity and salience for a given discipline (Barab and Hay, 2001; Lave and Wenger, 1991; Watkins, Coffey, Redish, and Cooke, 2012). For instance, previous work has shown that placing authentic

scientific instruments in the hands of learners was critical to their growing sense of "feeling like a scientist" (Perin et al., 2020). Affective connections to materials were critical in this pathway.

Material resources are important in aspects of learning other than supporting disciplinary interest and identity, as well. In particular, the consideration of what an object does in learning has been frequently considered in museum-related literature (Allen, 2002; Falk and Dierking, 1992; Gurian, 1999; Hein, 1998; Leinhardt and Crowley, 2002). Many have contended that the physical aspects of objects not only can serve as nodes for increased conceptual understanding, but that sensorially engaging with an object is an important form of learning in and of itself. That is, the physical qualities of materials, such as texture, colour, and even scent, can be the basis for rich visual, tactile or olfactory learning. As Dudley (2012, p.4) states:

> "The opportunity to be moved to tears, tickled pink, shocked or disgusted by a museum object, or simply to reflect upon it, as a result of sensory and emotional engagement with its physicality before necessarily knowing anything at all about it, is itself a powerful component of what a museum experience can offer – not just as a step on the journey towards cognitive understanding of the story the object helps to tell, but as a potent and sometimes transformative phenomenon in its own right."

This passage illustrates the emotional and affective components of material learning. Such affective connections can either drive, or be a result of, situational interest or personal relevance, which is well known to be key in learning. Importantly, such understandings develop in a particular context, or place, rather than existing as rootless experiences. Bartos (2013, p.90) argues for a vision of embodiment in which the self and the environment are inseparable, that the "lived body is an important conduit of knowledge." The living body connects with place through sensory engagement, which in turn cannot be separated from emotion. We argue, then, that materials are essential tools across pedagogical contexts and essential precursors to the development of abstract and hypothetical thinking through which wider understanding can grow. The process of meaning making with materials found in a particular location, and the associated cultural artefacts, provides space for an essential part of cognitive development and helps support the development of disciplinary identities.

Formal incorporation of materiality as an essential pillar of Arctic pedagogy will help enable educators across contexts to centre connections between community, culture and place during learning. An example of a material object with incredible sensory and evocative power that could serve as a node of place-based conceptual understanding might be a Fireweed blossom, common in Alaska. There is an inherent attraction to sensorial exploration of the texture, smell, and vibrant colour of the flower. Such sensorial exploration invites one into the practices of science and art, such as close observation and open exploration. Exploration of the flower could invoke prior knowledge, including cultural connections such as the process of making fireweed jam, and/or evoke learner questions around the form and function of the flower. Another example would be found in the exploration of tartan fabric, and how the texture, smell and colours of the cloth invite sensory engagement while also evoking cultural connections to family, place and memories.

Culture, materiality and material culture

Culture is a critical aspect of any pedagogy founded around ideas of materiality, as culture is integrally connected to, and capable of modulating, learning. We take up the notion of culture to denote a set of learnt values, beliefs, practices, and means of communication (Hall, Neitz, and Battani, 2003), which in turn are mediated by the artefacts, natural resources, and places that are collectively termed material culture (Lunn-Rockliffe, Derbyshire, and Hicks, 2020). Critical in this conception is the idea that materials become imbued with significance because they represent ideas, beliefs, or values (Brückner, 2019). In other words, their identity is changed by the observer because of the way in which they are understood whilst, at the same time, they become "structuring structures" that guide, or are challenged by, the practices of the observer (Bourdieu, 1977).

This framing of materials has two key implications for educators. The first is that the same object may be imbued with very different significance depending on the cultural background of the observer, and this needs to be factored into the use of objects in educational settings. Secondly, time spent handling, or otherwise engaging with, things that are of local importance can confer upon them significance that is shared with both peers and community. Put another way, engagement with materials is both a route to acculturation of the individual and, when openings are created for exploring meanings attached to the material world, the means to building cross-cultural connections. There is also evidence that enabling learners to express their cultural identity by material means may enhance their ability to create a sense of belonging within culturally hegemonic learning spaces (Valencia and Miranda, 2022). The power of material engagement may thus be especially important when learners from very diverse cultures work together, or where the learning activities pertain to ways of knowing that are perceived to be far removed from their daily life, as has often been demonstrated to be the case in subjects such as science (e.g. Archer et al., 2013; De Witt, Archer and Mau, 2016).

Below, we present four cases from different place-focused pedagogical contexts. Three deeply incorporate place-related materials through sensory engagement (Cases 1-3) while one links to place through backstory, but not through the materials deployed (Case 4). The similarities in learning outcomes between the three place-related materials cases (1-3), and the contrast with the kinds of learning outcomes seen in Case 4, illustrate the importance and affordances of a place-based approach to materiality.

Case 1: A STEAM summer camp infused with local materials

Colors of Nature [sic] was a two-week summer STEAM camp for girls conducted over a period of five years in two locations in the United States. We focus on the Alaskan version of the camp, as this paper focuses on experiences in the north. A team (including, but not limited to, authors 1 and 3) undertook this work to counter common ideas among girls that science is rote, uncreative, passionless (Miller, Blessing, and Schwartz, 2006; Calabrese Barton and Tan, 2009) and not relevant to their interests (Archer et al., 2013) –ideas that result in part from specific sociocultural practices that are often embedded in formal science learning settings (Brickhouse and Potter, 2001; Carlone and Johnson, 2007). The camp was designed to specifically integrate art and science around the theme of colour in an effort to test whether this strategy was efficacious in developing a disciplinary science identity among

girls who self-identified as interested in art. Accordingly, we incorporated strategies intended to support the development of a science identity, such as connecting science to youth's cultures and everyday lives, promoting learner agency in practice, focusing on process instead of product, and positioning youth as emerging disciplinary experts. We also drew on overlapping dispositions and practices of science and art (such as creativity, close observation, and experimentation).

To assess outcomes, we used a mixed methods approach, including pre surveys and immediate post surveys (with a Likert-like scale where 1= strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree), as well as a 1-year post survey that included open-ended items. The pre and immediate post surveys had seven constructs, all of which were reliable (Cronbach's alpha greater than 0.7). We also conducted pre and post interviews that asked questions pertaining to known identity markers, ideas about art, ideas about science, and ideas about their overlap. Finally, we videotaped the academy and collected artefacts, such as pictures of the daily art/science notebooks created by the participants. The research was approved by the UAF Institutional Review Board. Changes from pre to immediate post survey were analysed by means of paired t-tests, while qualitative data were analysed in a manner generally consistent with grounded theory (Charmaz, 2006).

Drawing on these data sources, our research and evaluation uncovered ways in which materials and materiality were critical to girls' developing science identities, blurring the boundaries between art and science and underscoring personally relevant connections to the everyday experiences and cultures of the girls (Tzou et al., 2014). For instance, in one activity, girls created marbleized prints by dropping suminagashi ink onto the surface of bins filled with water, experimenting with different colours, different kinds of papers, and different brushes to create designs. While they manipulated the materials and observed the process closely, they asked questions about the physical properties they noticed, such as the relationship between the surface tension of the water and the surfactant properties and densities of the inks, while simultaneously asking questions and exploring ideas about the aesthetic effects of the material interactions. Later during the camp, on a nature walk through a northern boreal forest, several girls noticed that birch pollen floating on the surface of a peat bog looked similar to some of the suminagashi prints they had made. The girls took out paper from their backpacks and began experimenting with creating marbleized prints directly from the surface of the bog, capturing the swirling pollen patterns of specific areas while noticing and wondering about the iridescent surface sheen on the bog and the rich brown colours of the tannic water which the paper seemed to absorb more intensely around the pollen lines. This vignette illustrates the ways in which materials and places can intersect to support learner-driven explorations.

In another example of ways in which place-specific materials were critical to learner-driven inquiry, the girls visited the University of Alaska Museum, where they observed and discussed the colours of a traditional Chilkat blanket, including a consideration of the sources and materials from which the colours derived, such as black from coal, yellow from wolf moss, and blue-green from copper. This led to a consideration of what kinds of local materials could be used in their own art/science inquiries during the camp. Just outside of the museum, the girls noticed a cut bank along the road where multiple layers of soil strata were exposed, each of which had a different colour based on geologic origin. Inspired to

create their own paint, they dug out samples of several different layers which they mixed with an acrylic binder and used it to paint in their art/science notebooks.

Another activity used familiar foods, such as cabbage, berries, and tea, as dye sources to explore the chemistry of colour. After dying test strips with the provided materials, the girls expanded their inquiry, looking anew at the materials around them as potential dye sources. They also tested foods from their lunches, local plants that they collected, and additional materials that they brought from their home kitchens or gardens. They would mix these with a clear acrylic binder to create paints, crush them with mortars and pestles into a paintable slurry, or even crush them directly into their notebooks to draw with and keep track of "useful" colours and their sources. These pigment explorations continued organically for the rest of the camp session, in between—and sometimes integrated into—subsequent activities, further underscoring connections between learning, materials, place, and the everyday lives of the girls.

Survey results suggested that engaging in the activities of the camp was consequential in terms of building identity-related outcomes. Specifically, we saw significant pre to post score changes in several constructs, such as attitude about science, self-concept of science ability, interest in science, and ideas about the nature of science (Carsten Conner et al., 2019). Open-ended responses from learners on a longitudinal post survey given a year after the camp suggest strong, lingering connections to art/science practices embedded in material resources. That is, we saw that initial engagement in these activities prompted further, voluntary engagement over time. For instance, one girl stated: "I made a piece of art with objects I found from nature in my yard," while another declared: "I have been experimenting with creating my own paints with natural materials." Taken together, the initial and longitudinal survey outcomes suggest that participating girls engaged in "identity work" (Calabrese Barton et al., 2013), or small steps towards new disciplinary identities with science. If the girls continue to engage in such activities over time, this could lead to more stable disciplinary identities, as predicted by the cultural learning pathways model (Bell et al., 2013), which suggests that initial experiences that allow learners to participate in relevant, consequential identity work can drive repeated engagement, deepened social relationships, and over time, can result in deepened identities. We note that, as is consistent with sociomaterial theory, the outcomes that we documented in the surveys were embedded within, and inseparable from, the affordances of the material explorations experienced throughout the camp. In this case, the materials were local, specific to the geographical place in which the learning occurred, and thus aided in bridging science with aspects that were culturally important or personally relevant to the girls.

Case 2: A STEAM summer camp focused on sustainability in a local context

In 2021, a team (including, but not limited to, author 2) ran a six-day summer school in Scotland focused on environmental sustainability for 25 school pupils aged between 13 and 17 with Additional Support Needs (ASN). Specifically, participants had learning difficulties and came from areas of socioeconomic deprivation. Each day, university researchers delivered two 90-minute workshops that illustrated how their research was contributing to sustainability through science, technology and engineering. Each session began with a story that was written and presented by a storyteller who devised stories to illustrate different aspects of environmental sustainability. Activities were run in the grounds of the

activity centre and on the nearby beach. On the final day of the summer school, a suite of activities was run that sought to establish what the young people had understood of the concept of sustainability. Recognising that many participants had difficulties with literacy, these activities were designed to enable them to represent their ideas through materials found at the site, through drawing, or by having an adult transcribe their words. One of the activities asked them to contribute items to a time capsule that was to be opened by young people attending a sustainability summer school in one hundred years' time. Participants donated either physical objects or postcards on which they had written or drawn. These items (postcards and objects) were subjected to thematic coding (Braun and Clarke, 2006). After several rounds of analysis, three consistent themes emerged: 1) theoretical knowledge, or written/drawn references to ideas and objects that had been discussed but not seen; 2) affective, or written/drawn responses expressing an affective component; and 3) material, consisting of either written/drawn references to materials that had been encountered during the week, or actual physical materials. Four items fell into the "theoretical" category, six fell into the "affective" category, and seven fell into the material category.

Items that fell into the material category consisted of several physical objects as well as writings or drawings on postcards that reflected material items related to the content of the workshop, such as shells, rocks, and water worms. The objects that were contributed illustrated ways in which participants embodied their understanding about sustainability-related issues through material representation. For instance, one participant contributed a painted stone with a beach scene on one side and a picture of pollution clouds and skeletons on the other, illustrating the tensions between connection to current day environments and worry about their future degradation. Another object contributed was a plastic chocolate bar wrapper. When asked about the reason for including the wrapper in the time capsule, the contributing participant said: "I don't think in a hundred years' time that people will be allowed to use plastic to wrap food in and I think that they will be shocked that we ever were." A third participant contributed a smooth pebble and two limpet shells which they had carried around all day. When asked whether they were sure that they wanted to donate these objects, which they seemed to like so much, they answered that they were sure "because they're beautiful and I think people may not have beautiful things then." With respect to the affective category, one card referred explicitly to the participant's response to location and the sensation of being there: "The beach is nice and relaxing and peaceful. You hear the sea and feel the wind."

Overall, the contributed materials suggest that the participants gained a clear sense of concern about the environmental degradation currently taking place. For instance, one postcard read, "Hi, is cap still cool[?]" with a drawing of blue crystals in a blue circle surrounded by two more concentric red circles. This was taken to be a reference to the disappearance of the polar ice caps. Likewise, the donor of the stone and shells expressed their concern that there would not be beautiful natural objects left in the future, similar to the "before" and "after" scenes on the painted stone. There were also indications that the participants had understood the long time scale over which the environmental degradation might continue, for instance in the explanation about the chocolate wrapper.

Two aspects of the responses are notable with respect specifically to the materiality of place. The first is that seven of the participants focused on materials related to their location, whether they were naturally occurring or had been introduced for the activities. The second is that the materials provided a mechanism for at least two participants (the donors of the shells and stone plus the donor of the chocolate wrapper) to respond to the problem posed. This exercise confirms that participants' sense of place is, unsurprisingly, mediated by the materials in the environment. However, it also raises the possibility that the selection of materials provided a means of embodying their ideas, which they were then able to articulate. The implication of this is that materiality that relates learning to place can facilitate a *growth* in understanding of content and its significance in the locale. At the same time, it simultaneously provided a mechanism by which participants were enabled to *represent* their understanding.

Case 3: Learning about Scottish and South Asian plants and plant scientists

Three activities were designed to highlight the interconnections between Scottish plant scientists and South Asian plant scientists in the setting of botanic gardens in Scotland. The aim of the project was to enhance social inclusion in science, for which we used the United Nations (2016, p.17) definition: "Social inclusion is defined as the process of improving the terms of participation in society, particularly for people who are disadvantaged, through enhancing opportunities, access to resources, voice and respect for rights."

Pro-active attempts to enhance involvement in science are judged to be necessary to offset historic tendencies to make it a discipline to which only a privileged few could have access (Tobin, 2012). The activities focused on sensory engagement with plants and were informed by ideas of "decolonising the curriculum," in that they considered the historic power imbalances that made it possible for colonising travellers to exploit the resources of others (Begum and Saini, 2019). They were also written to show the cultural diversity of the scientific community, with particular reference to the sizable south Asian community in Glasgow. The activities were run in two Scottish cities and were open to anyone who wished to participate. Descriptions of the three activities follow:

1. A "sniff and match" activity, in which visitors were asked to match samples of whole spices to processed spice using their sense of smell. As visitors matched the samples, the presenters answered questions and talked about which parts of the plants were used as spices, the evolutionary basis of the fragrances and tastes of the spices, and their biological activity in deterring insects from eating them.
2. An activity in which visitors used discarded materials to build a case suitable for carrying live plant specimens that were provided (a piece of ginger rhizome, coriander seeds and a saffron crocus bulb). The case was to be designed such that specimens could survive a six-month ship voyage as they would have done in the eighteenth century. The activity was accompanied by a conversation about the lives of both current and historical Scottish and South Asian plant scientists.

3. A cyanotyping (blue printing) activity in which visitors were asked to use letters, images of plant scientists from both Scotland and South Asia, and pressed South Asian plant specimens to create an image showing what they had learned from the first two activities.

Participants chose how long they wished to spend on the activities and the time spent varied from a few minutes to half an hour, resulting in a personalised experience according to their individual interests. Evaluation postcards were used to evaluate the impact of the activities on participants. This activity evoked especially strong responses in individuals of South Asian heritage, whose culture provided the context for the activities (e.g., traditions related to South Asian plants), but was universally well-received.

The evaluation process was approved by the University of Strathclyde Ethics Committee before data gathering began. In order to be as inclusive as possible, the postcards gave participants a choice with respect to their method of response. Specifically, participants could either write or draw their ideas about plant science. Responses were solicited before doing the activities and again afterwards. The question at the top of the postcard was: “What do you think about when you hear the words plant science?” and on the back, to be filled in after doing the activities, was the question, “What do you now think about when you hear the word plant science?”

The data processing took the form of thematic analysis of free choice text and pictorial answers on the postcards. Thematic analysis was undertaken in several stages. Firstly, terms, phrases or images with shared meaning (though not necessarily the same words) were assigned a common code (Braun and Clarke, 2006). As an example of the process, one pre-intervention postcard depicted an outline of a five-petaled flower. This was placed under the sub-theme of “characteristics of plants”, which fell under the theme of “topic-specific content”. Afterwards, the same participant provided a more elaborate sketch showing different plants, both trees and flowers, people and insects. This response was considered to fall under the sub-theme of “habitat.” The first phase of analysis led to lower order codes, such as science processes. These were subsequently grouped to give three high order themes which incorporated all the meanings conveyed by the raw data, with the lower order themes forming sub-themes. The three high order themes were general epistemology, topic-specific content and the impact of scientific knowledge. Finally, the analysis was triangulated by referring to field notes and to colleagues who had been present in order to ensure that the themes fairly represented the reactions of participants (King, 2004). Anecdotal evidence from field notes suggested that the place-based nature of the plant science activities, combined with their highly sensory qualities, made the activities highly engaging. We noted affective responses based in sensory experience. One child exclaimed, “It smells like Christmas” whilst sniffing the whole cloves, whilst many other participants talked about what dishes they associated with the different spices. The multi-sensory engagement with the materials to the point of it being immersive showed that the spices held meaning for the participants. The reactions of participants to exploratory and open-ended engagement with personally meaningful objects, here spices and herbs, helped participants to re-conceptualise science as a process done by many different people and in diverse ways. The opportunity to handle, smell and examine samples with hand lenses was very popular and the sensory engagement facilitated them to relate the science specimens to

familiar domestic activities. Through this the activities could be expected to render science more accessible to a varied audience (De Witt, Archer and Mau, 2016).

Case 4: Locally significant forensic science

A contrasting set of activities were forensic science tests devised to appeal to children in the Scots Gaelic language classrooms, which are predominantly in the rural north-west of Scotland. Gaelic is commonly presented in popular media as a language linked to a historic culture rather than a modern language of the twenty-first century (Dunmore, 2017). For this reason, the research focused on whether that stereotype could successfully be challenged by the presentation of modern analytical techniques and materials in Gaelic. All resources used by the pupils were written in Gaelic, including samples of litter and bottles of reagents. The backstory linked to the importance of eco-tourism in rural Scotland, which was intended to make the problem locally relevant. Participants were asked to carry out a series of analytical tests to identify who was responsible for the death of a rare seabird caused by eating illegally dumped litter on the beach. The evidence presented consisted of a plaster cast of footprints from the crime scene, fingerprints, and a (synthetic) blood sample recovered from items at the crime scene, plus DNA profiles from the blood and hairs found there. The activities followed on sequentially although they were not always all offered, depending on the ages of the children and the length of time they took to complete one or two activities. There were corresponding pieces of evidence from three suspects. These forensic science activities were run by the researchers in schools. The sessions lasted between 40 and 60 minutes.

The evaluation took the same form as that used for the plant science activities, using a two- sided card with space for open-ended responses to the question, “What do you think when you hear the words forensic science?” Participants filled in one side prior to carrying out the forensic activities, and completed the other side afterwards; cards were available with the question in either English or Gaelic. The sub-themes and themes that had emerged from the plant science activities were used to analyse the forensic science activities. The eight sub-themes and the three themes arising from them are given below. The sub- themes are given in brackets after each theme. These were:

- Epistemology (background science content, science processes and activities)
- Topic-specific content (knowledge about the location, knowledge about the subject, people who do science and diversity issues)
- Impact of scientific knowledge (uses of knowledge, affective responses to activities)

While the same codes were used across the plant science and the forensic activities, there was a notable difference in the pattern of distribution of responses across the codes. In contrast to the plant science activities, the cards completed after the forensic activities focused much more frequently on the scientific knowledge associated with the forensic tests and how it was generated. There were no references to any kind of affective response to the forensic activity, which was surprising given that the activity included photos of a dead sea bird. Importantly, there were also no references to the relevance of the activities to the location.

Table 1. Comparison of evaluation outcomes between plant science and forensic science activities

Theme	Number of responses after doing plant science activities (Proportion of total responses)	Number of responses after doing forensic activities (Proportion of total responses)
Epistemology	23 (0.26)	30 (0.41)
Topic-specific content	39 (0.44)	36 (0.49)
Impact of scientific knowledge	26 (0.30)	8 (0.11)

The forensic activities were distinctive in their delivery, being far more structured than the others described here, with participants following instructions rather than exploring freely. Moreover, while the backstory linked to place, the materials themselves were not specifically linked to the place they were used—rather, they were ubiquitous materials such as reagents, plaster casts, and lab equipment. While such materials can be important in various facets of learning (Perin et al., 2020), they did not generate the rich, place-based and affective connections that we saw in the other cases.

Implications for Arctic pedagogy

The four cases presented here all focus on place, but the contrast in learning outcomes that emerged from the different approaches highlight the affordances of multi-sensory, multimodal, and open-ended engagement with place-based materials. The three activities that centred around the place-based, sensory-mediated materials (Cases 1-3) resulted in outcomes that included affective responses to materials and place, disciplinary identity building, and connections to culture and nature. This approach, then, supports the goal articulated in the "Position Statement on Arctic Pedagogy" of creating "an educational experience in which [learners] can feel, hear, taste and touch their cultural values" (UArctic Thematic Network on Teacher Education, 2019, p.3). In contrast, Case 4 used a place-based narrative and local language, but used non-place-based materials that required more prescriptive management and a limited sensory experience, resulting in learning outcomes that focused on scientific content alone.

From these contrasting outcomes, we argue that deep forms of learning (such as affective connections, developing disciplinary identities, and relationship to culture and place) can best be engendered by multi-sensory engagement with local materials. We posit that the most successful approaches to achieving holistic engagement with the learners' location will involve what the authors might call "immersive material culture of place." The case studies presented indicate that activities need to be connected to sensory-based exploration that uses actual materials of the place if it is to create connections to the individual's cultural context. We therefore propose materiality as an important principle of Arctic pedagogy.

Acknowledgements and funding

This material is based in part upon work supported by the National Science Foundation under Grant No. DRL 1224020. We thank NSF for their support of this work.

This work was also supported by the Engineering and Physical Sciences Research Council [grant number EP/X525820/1]. We thank the Council for its support of this work.

This research was part of the project “DiSSI – Diversity in Science towards Social inclusion – non-formal education for students' diversity” that is co-funded by the Erasmus+ Programme of the European Union, under the grant number 612103-EPP-1_2019-1-DE-EPPKA3-IPI-SOC-IN. We would like to thank the European Union for its financial support. The European Commission’s support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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