Cultural Studies of Science Education (2022) 17:1159–1192
https://doi.org/10.1007/s11422-022-10138-z

ORIGINAL PAPER

Teaching in a natural history museum: what can we learn from Estonian elementary school teachers?

Helene Uppin[1,2] · **Inge Timoštšuk**[1]

Received: 6 July 2021 / Accepted: 29 July 2022 / Published online: 24 November 2022

Abstract
Natural history museums are great places for learning new concepts and enhancing social skills and motivation. However, it is often difficult for teachers to make full use of the museum as a learning environment. Some teachers seem to be more successful than others in crossing the boundaries—they enjoy and value field trips and advocate for them in the teaching community. Such teachers are a valuable source of information on how to overcome factors that hinder field trips and support meaning-making in the museum. This study explored the practices of eight Estonian elementary school teachers who create, conduct, and analyse learning activities at a natural history museum without the direct help of museum educators. All participants frequently and willingly teach across different learning environments. A qualitative multiple case study strategy was used. The teachers were interviewed and learning activities were observed. Field notes, interview transcripts, lesson plans, and thick descriptions of observations were analysed. The participating teachers valued learning across different learning environments and were skilful in overcoming most problems connected to field trips. Teachers demonstrated supportive relationships with their students, which seemed pivotal in facilitating engagement. Estonian elementary teachers seem to have more autonomy in their teaching practices compared with their colleagues from other countries. However, participants struggled to use hands-on and interactive exhibits. This study highlighted the need for more collaboration between museum educators and Estonian elementary school teachers, especially in order to create more individualized and problem-solving oriented learning tasks.

Keywords Learning environment · Boundary crossing · Elementary school teachers · Case study · Museum education

Lead editor: B. Cowie.

✉ Helene Uppin
helene@tlu.ee

Inge Timoštšuk
inge.timostsuk@tlu.ee

[1] School of Educational Sciences, Tallinn University, Uus-Sadama 5, 10120 Tallinn, Estonia

[2] Curator of Education, Estonian Maritime Museum, Tallinn, Estonia

Humankind faces numerous urgent and wicked problems such as climate change, global epidemics, overpopulation, and loss of biodiversity, among others. Young people need a sufficient knowledge base and the ability to take various non-judgemental perspectives (Davis, Yeager and Foster 2001) into account in order to make sense of the world. Real-life problems come with the baggage of rich context and are frequently ill-structured. They often require solutions that involve collaborations among a range of stakeholders. Hence, problem solving is heavily influenced by social, material, and cultural factors that may not even be directly related to the problem (Kirsch 2009). Solving such problems can be extremely difficult. However, meaningful learning across different learning environments in the course of formal education has the potential to prepare children for this.

According to the 2015 Programme for International Student Assessment (PISA) results, Estonia shared the 5th and 6th place with Canada in the problem-solving literacy domain (OECD 2017). This is a relative success, given that according to the Programme for the International Assessment of Adult Competencies (PIIAC) report, the problem-solving skills of Estonian grownups in technologically rich environments are lower than the average when compared with other participating countries (Estonian Ministry of Education and Research 2015). Almost every fifth Estonian young man from a rural area will drop out of or end schooling after acquiring basic education because of complex reasons that include; the lack of personal relevance, the school not supporting the individual needs of students, low cognitive engagement, and low social cohesion (Kallip and Heidmets 2017). This may indicate that generally high PISA results for Estonia do not always translate into successful participation in society and raise the question of whether the Estonian education system offers enough meaningful learning experiences to its students.

It is important to consider what is meaningful learning. At the core of learning lies the construction of new meanings through the conscious integration of new information with relevant existing conceptions (Novak 2002). Meaningful learning contradicts rote learning (Mayer 2002), makes the learner reconsider previously held conceptions and leads the way to conceptual change (ibid.). As a result of meaningful learning, students gain knowledge and skills necessary to solve problems autonomously (Mayer 2002). From a sociocultural perspective, meaning-making is not seen as reproducing or connecting meanings from 'outside' to 'inside', but rather as cultural coding with the help of language and/or other mediating tools (Säljö 2003). As Roger Säljö (2003) stated, the ability to give meaning enables people to be flexible while communicating with the world and enables us to gain knowledge and perspectives that we can use in practical contexts. Thus, learners are seen as active meaning-makers with their previous knowledge, feelings, and sense of self (ibid.).

The sociocultural understanding of learning is disclosed in general terms in the Estonian National Curriculum (ENC). Problem solving, as an objective and a strategy for learning, manifests in different explicit ways (Basic Schools and Upper Secondary Schools Act 2010). For example, ENC states that students should be able to use whatever they have learned in different situations in the future and obtain an entrepreneurial approach to problem solving (i.e. actively seek problems to be solved). The European Commission's report distinctly stresses the importance of meaningful learning engagement with out-of-school partners and refers to the importance of focusing on the ability to use knowledge in different situations in science education (Hazelkorn, Ryan, Beernaert, Constantinou, Deca, Grangeat, Karikorpi, Lazoudis, Casulleras and Welzel-Breuer 2015).

The value of learning in and across different learning environments stems from the contextual nature of learning (cf. Collins and Greeno 2011). The situated view of learning introduced by Jean Lave and Etienne Wenger (1991) defines learning not through transferring obtained abstract knowledge into different contexts, but as partially engaging in

authentic activities. Thus, students should work collaboratively in different real-life settings and with meaningful (problem-solving oriented) tasks (Tuomi-Gröhn and Engeström 2003). Ideally, learning in natural history museums can provide these conditions and can be both a good method to learn something and an aim in itself because it enables students to practice learning across settings.

It is possible to discover the diversity, evolution, importance, and fragility of different natural communities in natural history museums. Natural history museums are teeming with collections that represent authentic real-life problems, and thus offer an opportunity to learn in an environment that is deeply thematic and more closely tied to real-life settings than classrooms (Mujtaba, Lawrence, Oliver and Reiss 2018). Learning in natural history and science museums and similar institutions of science and culture can support the development of scientific concepts (Krange, Silseth and Pierroux 2020), especially when meaning-making is supported by sufficient scaffolding, supporting dialogue by on-site educators, etc. (Krange, Silseth, and Pierroux 2020). Students can be inspired by the process of science and people who research natural sciences. Besides gains in knowledge, learning in museums and science centres can support the development of literacy and inquiry skills (Gutwill and Allen 2012), enhance social skills (DeWitt and Storksdieck 2008), integrate different subjects (Lawson, Cook, Dorn and Pariso 2018), expand students' awareness of their community (Nabors, Edwards and Murray 2009), and increase motivation (Paris, Yambor and Packard 1998).

Elementary school teachers who frequently and willingly organise learning activities in out-of-classroom learning environments are recognised as valuable sources of information with regards to effective field trip practices (Kisiel 2014). Yet, little emphasis has been placed so far on understanding the practice of such teachers in depth, particularly how such elementary school teachers support meaning-making in out-of-classroom learning environments, and more specifically in natural history museums. Understanding how elementary school teachers support learning at the museum is especially important while considering persistent problems in the practice of museum educators: they often rely on jargon-rich lecturing and rhetorical questioning, and do not cooperate much with school teachers (Tal and Morag 2007). Elementary school teachers have been reported to rely on museum staff while visiting a science museum and prepare students less for the visit than secondary school teachers (Tal and Steiner 2006).

Thus, the aim of this multiple case study is to explore the practice of elementary school teachers who willingly and frequently organise learning across different environments. Frequent and willing users of different learning environments are expected to provide deep insights into the reality of field trips (Kisiel 2014). Such teachers are also probably less influenced by popular myths and excuses (i.e. 'it is too difficult to organise transportation' or 'it is just a waste of time'). We focus on how such teachers (a) overcome problems they face while planning and implementing field trips, and (b) support learning during field trips.

Field trips in the context of elementary education

A somewhat shared educational space of curriculum-related field trips, outreach programmes, and other forms of collaboration between schools and museums have been present and evolving ever since the nineteenth century (Hein 1998). Contemporary museums aim to encourage visitor discussion and seek active dialogue with visitors' personal experiences (Leinhardt and Knutson 2004). This dialogical approach does not always reflect

in the learning activities designed for school groups (Griffin 2004). Some indicators of visitors' learning engagement such as talking about exhibits, asking questions, and gazing around are occasionally even discouraged during school field trips. This is troublesome considering that students' discussions show deeper engagement with content during museum learning activities than in the classroom (DeWitt and Hohenstein 2010).

However, field trips are both common and highly regarded by Estonian elementary school teachers. Frequent learning in and across different learning environments can even be interpreted as one of the many contextual factors that shape the relatively high PISA results for Estonia. Most Estonian elementary school teachers go on field trips at least once a year (Kink 2013), but many do it monthly or even weekly. The diversity in field trip practice between teachers and schools is evident both in the frequency and motives of teachers (Uppin and Timoštšuk 2019). Elementary school teachers go on field trips for numerous reasons, for example to reinforce or expand the classroom curriculum, expose students to new experiences, foster student motivation, provide a change in setting or routine, promote lifelong learning, enable student enjoyment, and satisfy school expectations (Kisiel 2005). The vast diversity of practice between schools and classrooms in Estonia is often said to originate from the high degree of teacher autonomy (Übius, Kall, Loogma and Ümarik 2014). In Estonia, elementary school teachers must have a master's degree and are expected to be creative and autonomous in their work (Tire 2021). On the other hand, many Estonian teachers feel constrained by overly detailed and prescriptive curricular aims (Erss, Kalmus and Autio 2016) and increased external pressure (Näkk and Timoštšuk 2021). This discrepancy between perceived autonomy and autonomy legally available for teachers emphasises the role of teachers' personality in situations where they must choose whether to opt in or out of rather time-consuming forms of learning, such as field trips.

Decision-making is a core competence of teaching (Kansanen 1991). Thus, a professional teacher should be able to describe what they do and explain why they do it (ibid.). Teachers without conscious pedagogical knowledge have less autonomy and depend more on curricular frame, norms, opinions of colleagues, and other similar factors (Kansanen 1993). This most probably applies to instructing students in out-of-classroom environments, too. Elementary students usually go outside the classroom, for example, on field trips more often than older students. James F. Kisiel (2014) suggested that besides lower pressure of curricular aims and testing in elementary school, elementary school teachers have little or no need to arrive at agreements with their colleagues.

Supporting learning in the museum

While talking about learning in the museum in the context of formal education, it is useful to look through the lens of the teacher. A school teacher plans, chooses, and structures the learning activities for students with or without the museum educator's involvement. During field trips to museums, the teacher can support or inhibit learning engagement, which is the visible aspect of learning motivation. Jennifer Dewitt and Jonathan Osborne (2007) concluded in their framework for museum practice that meaningful and engaging science learning in museums should encourage joint productive activities, provide supportive structures, and support learning skills (for example reading, writing, note-taking, organising information, and making presentations). The framework of Dewitt and Osborne (2007) also coincides well with the definition of inquiry-based education (Pedaste, Mäeots, Siiman, de Jong, van Riesen, Kamp, Manoli, Zacharia, and Tsourlidaki 2015). Well-implemented

inquiry-based education can support knowledge development, reasoning skills, motivation, and self-regulated learning (Hmelo-Silver, Duncan, and Chinn 2007).

Cognitively engaging learning where students are working together towards a shared goal can also be interpreted as collaborative problem solving. This kind of learning encourages content related discussions, supports curiosity and interest, enables choice, challenge and personal relevance (DeWitt and Osborne 2007). Whereas individual problem solving is not easy to measure or observe, collaboration can make problem solving visible (Hesse, Care, Buder, Sassenberg and Griffin 2015). For example, differentiation in roles, interdependency, and a shared agreement over an accomplished goal can be signs of collaboration in problem solving (Graesser, Fiore, Greiff, Andrews-Todd, Foltz and Hesse 2018). The concept of 'collaborative problem solving literacy' is defined in PISA as 'the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution' (Schleicher 2019). Hesse, Care, Buder, Sassenberg and Griffin (2015) defined problem solving as: 'a joint activity between dyads or small groups who seek to transform a current problem state into a desired goal state'.

However, it is important to note that the interdependency among students while learning collaboratively requires functional peer-relationships (Graesser, Fiore, Greiff, Andrews-Todd, Foltz and Hesse 2018). Moreover, without supportive peer or student–teacher relationships, it is unlikely that meaningful learning occurs. Students' learning gains are higher in classrooms where there are supportive peer and student–teacher relationships; engagement mediates a good classroom climate into learning gains (Reyes, Brackett, Rivers, White and Salovey 2012).

Structuring learning to support student autonomy boosts learning engagement (Jang, Reeve and Deci 2010). A supportive structure also helps connect learning at school with learning at the museum, reduces the novelty effect, and reinforces the learning experience (Behrendt and Franklin 2014). Shared goals and goal-setting by students, in particular, makes learning relevant and meaningful for them. It is especially important that students indicate beforehand what they ought to acquire in order to accomplish a set task (Lompscher 1999). Although sustained contact between the museum and the school through pre- and post-visit activities is preferable (Behrendt and Franklin 2014) there is evidence that well-structured and collaborative learning activities enhance visitors' inquiry behaviours even after a single visit (Gutwill and Allen 2012).

Difficulties with learning in the museum

The factors that support learning in the classroom support learning in the museum too. Yet, school teachers often struggle to achieve the educational potential of field trips (Kisiel 2014). Even if teachers know that it is, for example, important to connect learning at the museum with the classroom curriculum or minimise the novelty effect, they have been observed in some cases to abandon even their regular effective classroom teaching practices (i.e. setting clear goals, contextualising, etc.) in the course of guiding students in the museum (Griffin 1994). In worst-case scenarios, field trips can become an entirely unstructured 'day-off' (DeWitt and Storksdieck 2008), docent directed and lecture-oriented (Cox-Petersen, Marsh, Kisiel and Melber 2003), or overly structured by eclectic written assignments (Kisiel 2007). Learning activities offered by museums tend to lack sensitivity

towards students' lives, previous knowledge, and cultural and individual differences (Cox-Petersen, Marsh, Kisiel, and Melber 2003). Even though poorly structured but 'fun' learning activities can be enjoyable for students and schoolteachers, such learning activities are not effective science instruction (ibid.).

Numerous procedural and capacity-related problems drain the limited time resources of schoolteachers (Anderson, Kisiel and Storksdieck 2006), keep them from going on field trips, and probably influence the quality of learning activities at museums. For example, teachers face an overcrowded curriculum (Anderson, Kisiel and Storksdieck 2006), have to find funding, solve logistical problems (Anderson, Kisiel and Storksdieck 2006), find chaperones (Kisiel 2014), overcome procedural issues, and make agreements with the school management and their colleagues (Kisiel 2014) as well as the parents (Anderson, Kisiel and Storksdieck 2006). The quality of the experience in an out-of-classroom learning environment is heavily influenced by the preplanning, reflection, and general structure provided by the school teacher (Behrendt and Franklin 2014) and culture (Kisiel 2009), and teachers' beliefs around learning on field trips and what they value in the learning process (Davidson, Passmore and Anderson 2010).

The ambiguous nature of Learning across different learning environments

The boundary-crossing communication of school teachers and on-site educators seems to be one of the overarching reasons for the fluctuating quality of learning activities in out-of-classroom environments (Kisiel 2014). Ineffective communication can lead to an opaque understanding of expected responsibilities of school teachers and museum educators (Gupta, Adams, Kisiel and Dewitt 2010). For example, some elements of teaching such as behaviour management, supporting the development of learning skills and creating contextual knowledge, are sometimes considered the sole responsibility of the school teacher (Nabors, Edwards, and Murray 2009). Some museum educators may feel that their only job is to transfer knowledge or create enjoyable experiences (Kisiel 2009). Thus, learning in the museum in the context of formal education is ambiguous (Akkerman and Bakker 2011)—some aspects of teaching and learning are shared, and they are neither the sole responsibility of the museum nor that of the school.

Museum education is often described as boundary crossing (Griffin 2004), because school teachers must accommodate their regular practices in a new territory both physically and intellectually. A boundary is a 'sociocultural difference leading to discontinuity in action or interaction' (Akkerman and Bakker 2011) and such discontinuity is the source of both disruption and learning (Wenger 1998). It is not surprising then that even experienced teachers make pedagogical choices characteristic to novices while teaching at the museum (Kisiel 2007). Yet, boundary crossing can be beneficial both as a method and as an aim for both students and teachers (Ruus and Timoštšuk 2014).

Boundaries can also be seen as a source of connection between communities (Wenger 1998). Meaningful learning in the museum in the context of formal education assumes some form of collaboration between the museum and school teachers while planning and conducting learning activities (Kisiel 2014). While supporting meaning-making during a boundary practice such as a field trip, both reification and participation are exposed to foreign competences (Wenger 1998). Negotiation meaning involves two complementary processes—participation and reification ('making into a thing', creating, and using objects or tools that carry the meaning) (ibid.). Participation during a field trip is influenced by interactions with people such as guides, cashiers, and other visitors. Reifications manifest

through boundary objects like exhibition design, worksheets, museums' learning apps, and other tools. Considering that the physical context is a core component of an interactive museum learning experience (Dierking and Falk 1992), being able to use the physical environment as a learning tool is crucial for meaningful learning in the museum.

Moreover, the boundary practices between school teachers and museum educators cannot be standardized or implemented through top-town directives. Teachers' goals are not homogenous in out-of-classroom learning environments (DeWitt and Storksdieck 2008). Personality traits (e.g., beliefs and values), and teaching style of teachers become increasingly important, considering that pedagogical knowledge connected to learning in out-of-classroom environments is insufficiently covered in initial teacher training (Seligmann 2014), and sporadic (but promisingly effective) during in-service teacher training (Bevan, Dillon, Hein, Macdonald, Michalchik, Miller, Root, Rudder, Xanthoudaki, and Yoon 2010). Similar or even greater diversity of instructional approaches applies to on-site educators of museums and other similar institutions, who tend to have eclectic backgrounds, diverse career paths, are often experts in content knowledge, seldom have a degree in pedagogy (Allen and Crowley 2014), and whose professional development is generally less supported than that of teachers (Bevan, Dillon, Hein, Macdonald, Michalchik, Miller, Root, Rudder, Xanthoudaki and Yoon2010).

Even though both museum educators and school teachers aim to educate and inspire children, they still form separate communities of practice (Kisiel 2009). A community of practice is a group of people who share an interest in something they do and interact regularly, and also share repertoire, mutual engagement, and a joint enterprise (Wenger 1998). On the one hand, the repertoire (e.g. methods and didactic approaches to subject matter) of schoolteachers and museum educators is becoming more and more congruent. The past century has changed the educational ideals of both schools and museums. Rote learning is often publicly rejected in the face of more constructive, social and learner-centred ways of learning and a far more dialogical and engaging perspective towards learners has been adopted by educators across settings. On the other hand, school teachers have a sustained connection with students, and deal more with social cohesion and relationships among students, whereas museum educators usually meet the students once and concentrate on subject-based learning goals. Moreover, teachers and museum educators tend not to interact regularly to share expertise and there are notable differences in the levels of accountability, understanding of the curriculum, and modes of defining a successful field trip, among other areas (Kisiel 2014).

Nevertheless, some teachers seem more successful than others in crossing the boundaries between schools and museums; they are frequent and willing users of different learning environments, and act as brokers by advocating field trips to their colleagues (Kisiel 2014). Wenger (1998) used the term 'broker' to describe people who 'are able to make new connections across communities of practice, enable coordination, and if they are good brokers—open new possibilities for meaning'. Using Wenger's (1998) ideas on boundary practices, learning activities at the museum from the perspective of a schoolteacher can be considered a) peripheries (the schoolteacher gives full responsibility to the museum educator and does not connect the activities with learning at school); or b) boundary practices (both the schoolteacher and the museum educator take responsibility for student learning, but coordinate their efforts in a complimentary manner (the teacher acts as a broker); or c) overlaps, as described by Kisiel (2009)—although the latter seems rare in school-museum partnerships. This means that some teachers are actively involved in museum learning activities even if they are led by museum educators, whereas others either stay passive or leave while another educator is working with their students. Most encounters of teachers

and on-site educators fall somewhere in between (Tal and Steiner 2006). However, it is uncertain if even enthusiastic brokers, for whom the museum environment is relatively unknown, can use the full potential of the physical environment (e.g. hands-on exhibits, exhibits for groups) as an effective tool to mediate learning.

Aim of the current study

This study aims to explore the practice of elementary school teachers who have willingly and frequently organised learning across different learning environments in their previous experience, and in the course of planning, implementing, and reflecting on learning activities at a natural history museum during this study. Such brokers probably consider field trips as part of their core practice or 'business as usual', and thus demonstrate effective boundary practices (in other words—the best practice there is), such as understanding the need to learn across different environments, tackling problems that teachers commonly face in implementing field trips, and supporting meaning-making during learning activities. The research questions in this study focus on how teachers who willingly and frequently teach across different learning environments

(a) overcome problems they face while planning and implementing field trips, and
(b) support learning during field trips.

Research design and methods

Embedded multiple case study

An embedded multiple case-study design was used (Yin 2009) to thoroughly explore the multiple perspectives of experienced teachers. In this study, eight elementary school teachers were observed while creating and conducting learning activities in a natural history museum. Case studies are useful in investigating phenomena in real-life contexts, especially when the boundaries between the phenomena and the context are not clear (ibid.) —as is the case regarding field trips. The teachers were interviewed to understand their previous experience and to draw upon their reflections on their experiences in this study. The current case study examined teachers in a complex and novel situation (Timmons and Cairns 2012) because they generally book the learning activities offered by the museum and have little to no opportunity to customise it to suit the needs of their students. In this study, however, the teachers created and conducted learning activities on their own. The study comprised four steps:

1. The teachers participated in pre-interviews. Two semi-structured focus group interviews were conducted in November 2018.
2. The teachers participated in a joint seminar in January 2019 with museum educators. The seminar was on supporting learning during field trips to museums. The joint seminar helped teachers get acquainted with the museum environment and staff. Teachers were encouraged to act as co-researchers, collect notes, and reflect on their past and

current experiences of field trips. Preliminary results from the analysed interviews were discussed with teachers during the seminar.

3. The teachers planned, created lesson plans, and conducted learning activities in Spring 2019. They were free to choose the topic and methods for the learning activities. The only requirement was that both pre- and post-activities at the museum had to be described in the lesson plans. Teachers were given free access to the museum expositions in the planning phase. They were also encouraged to communicate with the researchers and on-site educators if they needed any help.
4. The teachers participated in post-interviews. Two semi-structured group interviews with the teachers were held in June 2019. Teachers had the opportunity to reflect on their experiences in the study. The preliminary findings were shared with them in autumn that year.

Participants

Eight elementary school teachers were invited to participate in the study (Table 1). They taught students from grades 1–6 (students aged 7–12 years, which is the age range for elementary school teachers in Estonia). A targeted sampling strategy was used to collect rich and specific data (Timmons and Cairns 2012). All teachers were known to be active and enthusiastic users of different learning environments. Whereas 5 teachers had been teaching in elementary school for 10–20 years (Mary, Jane, Zoe, Kelly, Ursula), 3 had been working as school teachers for less than 3 years (Sally, Amy, and Doris). All teachers were female, which is representative of elementary school teachers in Estonia. All participating teachers were from the capital city or its immediate suburban vicinity (Kelly and Mary) and worked in schools with Estonian as the medium of instruction. One teacher from a small industrial town participated in pre-interviews and gave valuable insights on the obstacles that teachers face in socio-economically unprivileged areas (Kate) but she had to leave the study after the pre-interview stage. As a result, another teacher joined in spring 2019 (Zoe). A more thorough description of the cases is given in the appendix.

Table 1 Participants' years of experience of teaching ranged from 2 years to over 25 years, they were currently teaching from 1st grade (7–8 yrs. old) up to 6th grade (12–13 yrs. old), which is the age range for Estonian primary teachers to work with

Teacher	Teaching experience	Grade observed	Teaching area
AMY	< 3 years	2nd grade	Urban
JANE	10+ years	3rd grade	Urban
ZOE	10+ years	2nd grade	Urban
KATE	10+ years	3rd grade	Rural/industrial
KELLY	10+ years	3rd grade	Suburban
DORIS	< 3 years	3rd grade	Urban
MARY	10+ years	6th grade	Suburban
SALLY	< 3 years	3rd grade	Urban
URSULA	10+ years	1st grade	Urban

Data collection

Data were collected at every stage in the study (Table 2). Pre-interviews were audio-recorded and transcribed. They probed previous experiences with field trips, methods of instructions in out-of-classroom learning environments, and problems and possibilities connected to field trips. Researcher notes were collected during the joint seminar.

Learning activities before, during, and after the museum visit were observed, photographed, and documented, and video-recorded when possible, in line with prescribed observation protocols. When it was not possible to observe pre- or post-activities, teachers' descriptions of their planned and implemented activities were analysed. In the course of the activities, the teachers' instructions on learning and the extent of autonomy given to students were observed. Examples of visible learning engagement (e.g. content-related student discussions) were given special attention. Researchers' field notes were collected.

It is important to highlight that participating teachers were encouraged to act as co-researchers. This meant that even though the observations were non-intrusive, the researchers always introduced themselves to students, students and teachers sometimes involved them in their learning (asked questions, talked with them, etc.), the teachers occasionally relied on researchers support during moving from the school to the museum and when students were actively engaged in their learning tasks (or in few occasions—via email after the lesson) explained their thinking behind chosen learning activities, behaviour management techniques or other contextual details they felt important to share. This made our field notes and observation protocols rich with data that would not have been possible to obtain only through passive observation. This also gave valuable insight to follow-up interviews and made it easier to distinguish the cases (teachers) from one-another.

Follow-up interviews were audio-recorded and transcribed. In the follow-up interviews, the teachers reflected on their experience in planning and implementing the learning activities—specifically to help see whether or not it differed from their regular practice and they felt they had achieved their set goals, and what hindered or supported students' learning. The collected data included transcripts of interviews, detailed descriptions of observed learning activities, teachers' lesson plans, email correspondence with teachers, and researchers' field notes. A case study file was organised to merge all relevant information on every case (teacher). Thick descriptions of teacher activities were put together by drawing from the video recordings, observation protocols, interview transcripts, and field notes.

Data analysis

Qualitative content analysis was used to systematically explore the large amount of textual data within theoretically anchored categories (Vaismoradi, Turunen and Bondas 2013). NVivo12 software was used for data analysis. Every teacher formed a unit of analysis (case) but the results were analysed across cases (Yin 2009). The theoretical framework was enhanced throughout the process of data collection and analysis (ibid.). Trustworthiness was assured through triangulation: observations were conducted by researcher-pairs and notes were compared on the day of the observation. All interviews were transcribed and analysed by two people.

Two broad categories were created ('problems and strategies' and 'supporting meaning-making during field trips') with three subcategories each (Table 3). Subcategories divided previous experience, evidence observed in the current study, and teachers'

Table 2 Data collection

Step of the study	Timeline	Data collected
I Pre-interviews with teachers	November 2018	Transcripts of interviews
II Joint seminar for teachers and museum educators	January 2019	Field notes and recordings of the seminar
III Planning and implementing the learning activities	February–May 2019	Lesson observation protocols derived from observation sheets, lesson plans, videos, photos & field notes (individual discussions before, during and after observations, e-mail correspondence with teachers)
IV Post interviews with teachers	June 2019	Transcripts of interviews

reflections on the process after they had carried out their learning activities. Thus, every meaning unit was coded either as 'problems and strategies' or 'supporting meaning-making…' and according to the timeframe (before, during, after). Possible overlaps were discussed to find suitable categories. More specific codes emerged inductively from the subsequent analysis of the coded data (Table 3).

The problems that hindered participants from going on field trips and strategies they used to overcome them were explored in the category titled 'problems and strategies'. Sentiments were attached to every meaning unit that represented problematic aspects (−) and their solutions (+) in order to understand whether descriptions of the problems and their solutions were proportional. The category titled 'supporting meaning-making during field trips' described how teachers justify learning in and across different learning environments and the kind of learning activities they use and find effective during field trips. Some excerpts for every category and subcategory are given in the appendix (Table 5).

Ethics

All teachers, students, and parents or caretakers of the students gave their informed written consent before their inclusion in the study. All the participants were granted anonymity and their real names are undisclosed. Participating teachers got written reports after the pre- and final interviews and had the opportunity to reflect on the preliminary results. We wanted the teachers to have as much autonomy in the process as possible, thus a participatory, change-oriented, and emancipatory approach was chosen (Reilly 2012). We enabled the teachers to play a proactive role in analysing their daily practice around field trips, and thus provide deeper insights on their decision-making regarding field trips.

Table 3 Categories and sub-categories in the coding process of the data

Categories and sub-categories	Previous experience	Evidence observed during this study	Teachers' reflections
Problems and Strategies	Examples of problems regarding field trips (−) and their possible solutions (+) Common problems were: • School culture • Parental support • Students with special needs and/or behavioural problems • Funding and transportation • Problems at the boundary		
Supporting meaning-making	Examples of how teachers justify learning out-side the classroom and pedagogical reasoning regarding learning during field trips. Emerging codes: • Justification of field trips • Participation through choice of methods • Reification through the museum environment • Reification through other learning resources		

Findings

Problems that teachers face while organising field trips and strategies to overcome them

Participating teachers mentioned facing numerous hindering factors in their previous experience with learning in different environments. We identified that the most prevalent themes were the influence of school culture, collegial relationships, parental support, finding and managing chaperones, supporting students with learning difficulties and behavioural problems, finding funding, organising transport, pressure to ensure good academic results, low-quality or poorly personalised learning activities offered by on-site educators, and the overall time consuming and stressful nature of planning field trips. Participants were able to share strategies to overcome most of the problems they encountered. However, fewer solutions per problems were mentioned in categories that required collaboration. For example, problems with learning activities led by other educators and supporting children with special needs during field trips had proportionally far more negative sentiments attached than possible solutions. In contrast, logistical and economic problems with funding or transportation were discussed at length and several different possible solutions were presented.

School culture and collegial relationships

There were very few support mechanisms at the school-level towards organising field trips. Teachers were expected to find replacements, apply for or organise funding, buy tickets, order buses, plan learning activities, etc. Schools do not provide systematic support for organising field trips even if they support teachers in principle. There were differences in school culture, especially in terms of the attitudes of the school management. Five teachers said that their headmasters strongly recommended learning outside

the classroom as often as possible, and the contract of one teacher even mandated weekly field trips. In contrast, one headmaster had questioned the value of field trips altogether by asking 'Do you even learn anything if you go away so often?'

Most solutions in this aspect were connected to the teachers' mindsets and planning. Participants found that they needed to develop and maintain good collegial relationships in order to organise replacements and chaperones. Mary explicitly stated that it is important to share the benefits of learning outside the classroom with one's colleagues in order to persuade them to follow their lead. The pressure of delivering high academic results was raised by two teachers, who felt that learning on field trips is not as efficient as learning in the classroom. Other teachers felt it is important to demonstrate students' high academic results to be trusted in unusual pedagogical decision-making (like going on field trips more often than other teachers) by their headmasters.

Parental support

Parents are expected to prepare students for field trips by choosing suitable clothing and packing lunch for them. They are often invited to finance these trips and accompany the students as chaperones. Problems with parental involvement were one of the most discussed topics during the interviews. The participants said that it is difficult to get parents to join in as chaperones and when they do come, they are often either disruptive (pose their own rules, pamper their own children) or too relaxed (chat with other parents, stare at their smart phones in inappropriate situations, are late for the bus, etc.). Therefore, teachers often go on shorter field trips without any extra chaperones—even though this is discouraged by schools. However, teachers seemed to have rather effective strategies to work with parents: they share detailed information on field trips with parents to prepare students and arrive at mutual agreements with the chaperones in advance. Some teachers consciously trained parents throughout elementary school to become useful partners on field trips. As Mary noted:

> 'When I begin with a new class, I choose a parent who can become my assistant in the coming years. It is usually someone who stands out in the parent-teacher meeting. I try to approach them and start testing them to find who fits me and the class the best'.

It seems plausible that elementary school teachers have more support from parents than subject teachers who do not regularly interact with parents and this contributes to the fact that elementary teachers go on field trips more often.

Supporting students with learning difficulties and behavioural problems

The challenges encountered while working with large multi-ability classes constituted one of the most emotional issues for teachers because the support system in schools varied substantially. Teachers found it difficult to support students with special needs and/or behavioural problems even in classrooms, let alone during field trips. Estonian teachers rarely have assistant teachers or other specialists present with them during their lessons. They also reported that museum staff are generally unprepared to work with 'difficult' children and felt that they are expected to take full responsibility for student behaviour. The teachers reported spending most of their time serving as assistant teachers when other educators led

the instruction. They handled a few students with special needs, and were forced to largely ignore the activities of the rest of the class. As Ursula noted:

> 'I want to experience field trips more as a teacher—to give extra value for the entire class. But then there are some children who need this kind of nanny-attention and I feel sorry for my time and the entire enterprise… I wonder why we need to go out of the classroom if I am spending all my time interacting with just two or three children… But nevertheless, I have always gone again…'

The teachers mentioned many collaborative solutions. For example, making agreements with parents, asking particular parents to join on field trips, demanding assistant teachers for class (although they rarely receive such help), or inform the place beforehand about students who had disabilities. Communication with on-site educators was mentioned by two teachers but no teacher in the group had encountered a situation where on-site educators had proactively asked for such information. The participants did not accept the possibility of leaving some students behind while going on field trips—it is unclear whether this was because they did not have a safe place to leave struggling students or whether it was a matter of values. Interestingly, they did not mention individualisation of learning tasks as a possibility to support student learning. The tasks observed during this study were not individualised, either.

Economic and logistical problems

Basic education is free in Estonia under the law (there is no school fee, free school lunch is provided for all, books are given by schools, etc.) and teachers are banned from collecting money for extra activities. There are many funding schemes and opportunities for free learning activities in out-of-school settings, especially in natural sciences. However, teachers need to actively network and have a great deal of know-how in order to participate in them, as there is no central system for field trip funding. More experienced teachers seemed more skilful in navigating such opportunities and even reported successfully receiving sponsorship from private companies. Most teachers take their students to places that require parental funding too, so elementary school teachers rely on parents to provide inputs. Estonian families seem to value education highly, so no participant had experienced a family questioning the need for such activities. Instead, the parents encouraged such activities.

However, as socioeconomic backgrounds vary significantly, some parents struggled to pay these fees. Thus, the teachers had to be very sensitive towards any signs of financial struggle. Therefore, teachers limit the number of field trips that require extra financial inputs from parents, especially when many families in the class come from moderate- to low-income backgrounds. As Sally said: 'I only organise something that requires money twice a year'. For teachers who do not work in the centre of the city and cannot use public transport, field trips cost a lot even when the distances are moderate and there are no other costs involved. One prevalent strategy to tackle the lack of funding is communication with parents. Parents often organise class money, drive students to field trips, and sometimes support students from other families. As Jane noted: 'For example, in one class some parents asked—"Jane, do you have children who cannot come (to the field trip) because of money problems? We can pay for them too!" I think that is a very normal attitude!'

Teachers were also creative in finding ways to bring real-life objects and visitors into the classroom. They maximised the use of school surroundings to minimise the loss of time and money on field trips while still enabling diverse learning experiences for their students. For some teachers, the time consuming and stressful nature of planning and implementing a field trip was the main difficulty.

Problems arising from the boundary of schools and museums

Teachers want to deliver good quality learning activities. Even if organising a field trip is a shared experience with parents, students, and other stakeholders, they feel personally responsible if time (and money) is (are) not well spent. As Doris noted:

> 'The cost of one workshop was about € 5 per student. For me, that is a lot for only 45 minutes! My expectations were high because of that. But they mostly showed some slides and only at the end of the workshop did they give the students pieces of straw to make a model… What a shame—it was such an interesting topic! They were grouped in big teams of five or six children, and they couldn't do anything. Some were just watching—that was really sad! The price and the content were not consistent'.

Teachers feel that it is crucial to choose high quality programmes that are clearly connected to the curriculum. While visiting locations where on-site educators work with their students, they often find the persona of the on-site educator more important than the location or the description of a programme. As Mary said,

> 'We have come across some angry guides. I always think on these occasions, "Look, you are working with children, you knew you were working with this age group today, why are you shouting at them?" My students are behaving well, and they are being disciplined for laughing! Sometimes, it even seems that breathing is not allowed. It is pretty tricky to get children to want to go back to the museum after something like that happens'.

Teachers mostly rely on previous experience and the suggestions of colleagues while choosing such learning activities. Only one teacher suggested coordinating with on-site educators in advance to ensure better quality learning activities. Some participants also emphasised that working as elementary school teachers gave them extra autonomy, because they teach all the subjects. They felt they did not have to coordinate much with their colleagues when going on field trips, unlike subject teachers of older grades who need to find replacements.

How do teachers support meaning-making while teaching at a natural history museum?

Participating elementary school teachers had an open attitude towards learning across settings. Most of them stated that learning happens everywhere, and some topics (especially in the natural sciences) are better taught outside the classroom. They offered numerous examples of how they both invite visitors and introduce real-life objects into their classrooms. Justifications for museum visits did not differ much from those made for visits to the theatre, public library, park, science centre, local hiking trail, and the

marketplace. They were all seen as being part of a broader spectrum of cultural education for students, with the need to 'widen the students' horizons' motivating such visits. The need to strengthen the cultural capital of students was mentioned by all teachers, including those who mainly teach children from affluent families. It was especially emphasised by Kate, a teacher who works in a small industrial town. She said: 'The families of children who come from the periphery do not go anywhere with their children and this (field trip) is the only possibility for many children to see anything! If the teacher also neglects these opportunities, then the child really misses out on many things and their horizons remain limited'.

When participants described how they teach on field trips, they emphasised on the importance of avoiding lecturing and recommended giving children something to do and using group work to support learning, social cohesion, and structure, and connecting learning outcomes with the curriculum. All the participants agreed that field trips are beneficial for both teachers as they get to know their students better, and for the students, as they get to know each other and build group cohesion better. As Mary noted: 'Children say (after field trips) "Oh my god, he/she is so cool, I didn't know!" about their classmates and especially about the opposite sex'.

They stressed that field trips offer the opportunity to solve behavioural problems, rather than inducing or amplifying them. All the participants put observable efforts into reinforcing agreements on standards of behaviour before and during the museum visit and no serious behavioural problems were observed. Through group-based learning activities that were mostly explained through the practical need to ensure on-task behaviour and not from a sociocultural perspective of learning—it is simply easier to monitor the activities of 4 groups than those of 20 separate students. All participants used group-based learning activities during this study.

Some teachers who displayed especially good behaviour management and relations with students used different activities for reflection. For example, Jane conducted numerous spontaneous reflection activities, including a mindfulness exercise to deal with anxiety as a result of being in a new environment. Kelly used Good Behaviour Game-based activities and mindfulness techniques to enable time-off and reflection. These techniques were not discussed in the joint seminar before the planning period, but were used spontaneously and rather effectively during the museum visit. Doris and Ursula used longer reflection tasks before and after the activities but not in the museum. Teachers who spent more time on reflections around learning and emotions connected to learning also had relatively higher expectations for all of heir students. However, all the participants asked their students to reflect on their learning experience in the museum at least briefly.

Diverse aims for museum learning activities

All teachers followed a three-step model. They conducted learning activities before, during, and after the visit to the museum. Most teachers said that they always prepared their students for field trips and conducted a few reflection activities, but they had not conducted pre-visit activities in such a systematic manner before. The content of the pre-activities was in some cases mostly connected to reflecting the change in the learning environment (Doris, Jane), concentrated on the format of the upcoming task (Zoe, Mary), and in some cases deeply rooted in content (Kelly, Ursula, Sally, and Amy).

Teachers' planning seemed to be driven mostly by the needs of the students rather than the curriculum, although all learning activities were related to it.

The aims of the learning activities were different: presentation skills (Mary), learning new concepts (Sally), expanding on a specific topic (Amy, Ursula), revising knowledge learned in the previous semester (Jane, Doris), free exploration (Zoe), and using the museum environment rather like an illustration for learning grammar and literature (Kelly), where the museum helped enact a folk story on magical inhabitants of forests, in which the learning activity was only loosely connected with natural sciences. In most cases, the learning activities had many aims, some of which were connected to skills and others to knowledge. Teachers informed the students of the procedural aspects and broad goals of the field trips, but no teacher was observed co-creating aims with the students.

Teachers who teach subject-based classroom curriculums said that planning the museum activity took much longer than planning regular lessons, whereas teachers (Ursula and Kelly) who worked with thematic (phenomenon-based) curriculums said that the planning did not differ starkly from their regular practice. Ursula and Kelly also connected the learning outcomes of the museum visit with not just one lesson before and another after the visit, but with the entire thematic plan throughout many activities across different subjects over two weeks or more.

Some teachers emphasized students' autonomy more than others. Ursula and Jane explicitly stated and presented in their practice that their goal was to support autonomous learning. They seemed to enable more unsupervised content-related student talk and exploration, even if the learning activities were structured and were among the most cognitively demanding ones observed in this study. The others structured the learning activities in a manner that gave the central role in organising (Kelly) or both organising and reflecting on the learning process (Mary and Sally) to the teacher.

Most of the time, students focused on the task and engaged in the learning activities behaviourally, cognitively, and affectively. Students had the opportunity to socialise, ask questions, and explore in all the lessons observed. For example, they had to fill individual worksheets during Jane's activity at the museum. However, both pre- and post-activities included reflection in groups. Throughout the process, collaboration among the students was never inhibited. A rather clever design prompted students to seek task-related collaborations and assigned the full responsibility for task completion to each student. On the other hand, Kelly did not rely on written tasks, but her students had prepared several oral assignments (reading a play and singing songs in groups) at school that they performed in the thematic museum environment. They also had several thematic discussions and observation tasks built on previously obtained knowledge about cultural heritage.

Structuring learning to support engagement

Everyone but Zoe, Kelly, and Mary used self-made printed worksheets to guide and document student learning. Kelly used books, name tags, game cards, etc., to structure learning and Mary's students made notes for their mini-presentations in groups of two or three. Zoe especially stressed the importance of working without any written material in order to concentrate and remember important things. Only Doris and Kelly introduced additional learning resources that were not worksheets during the field trip, for example, the scavenger hunt in Doris' lesson required students to use apps on their

smartphones, solve puzzles, draw, etc. Jane and Mary used GPS apps to track their route to the museum together with their students. Sally and Doris asked for some basic materials (pencils and writing pads) from the museum but no teachers used the online learning resources provided by the museum. Even though the museum staff members were informed of the study and invited to observe the learning activities, they did not do so, and all teachers reported a problematic welcoming at the museum (an excerpt from the teacher discussion illustrates this in Table 5 in the appendix).

The worksheets had diverse content. For example, students had to observe, find, describe, compare, calculate, give their opinions on, explain, group objects, and construct creative texts based on information in the museum environment. No task required a longer inquiry cycle (asking questions, collecting, and analysing data, etc.). Ursula's worksheet had observational tasks and did not require the use of exhibition texts. Some worksheets were fact-oriented (Sally), combined reflective and creative tasks with fact-search (Doris, Amy), and focused on observation and literacy skills (Jane). Written tasks were often connected to learning skills using some data from the exhibition as an illustration (for example a calculation task where students first had to find the weight of a certain bird). Literacy-related tasks often required the analysis of texts in expositions, whereas the analysis of non-textual illustrations or schemas was less frequent. For example, children had to analyse a food web and a mycorrhiza schema—the last was accompanied with such a difficult text that most students did not understand the concept without the help of their teacher. Jane and Doris incorporated numeracy in their worksheets. The teachers explained their use of fact-based questions to train the students in developing their concentration and attention—rather than expecting them to recall these facts later.

Written learning activities were not individualised according to the students' abilities, they did notinclude scaffolding or choices too. Yet, the teachers mentored some students more than others, gave oral feedback, added explanations when necessary, and actively monitored the learning of all students at the museum. For example, Ursula, who worked with a multilingual group took extra time before the visit to translate tasks with a group of students who struggled with the language of instruction. Amy, Sally, and Doris told some students to skip a few tasks or present an incomplete worksheet when they struggled to complete it, in order to lower students' anxiety. In Doris' case, tasks were very diverse and creative but also time consuming. In Sally's case, there was little variability and scaffolding, so the students began to play with interactive exhibits that were not connected with the worksheet or their tasks in general, but were very much content related. On the other hand, Sally demonstrated great flexibility towards her students' interests by investing unplanned lesson time after the visit to collectively study an interesting bug that the students found in the exhibition. In Amy's case, the worksheet had a few open-ended questions, and some struggling students either quit the task or filled it in with very superficial answers. The teacher continuously encouraged them to give more thorough answers. Most teachers urged the students to concentrate, 'dig deeper', and think or read 'once again'. Overall, the students' learning engagement seemed to be slipping when the tasks were perceived as too numerous, difficult, or ambiguous.

Students who are off-task in the classroom often cause disturbance and hinder their peers' learning. However, in the museum, this was not so. Students who got tired or were not willing to participate in the planned activities explored on their own (sometimes seeking a quiet place to be alone, such as a life-size model of wolves' cave) or, after thoroughly examining some interactive exhibit, began teaching their peers to use these exhibits. This

was most vividly observed in Sally's lesson, where a boy who got tired of filling the worksheet began playing with an interactive exhibit on bog plants, and was soon able to train about eight of his classmates to move around the interactive bog without drowning into it by stepping on plants that indicated firm ground.

Difficulties encountered in incorporating interactive and hands-on exhibits

It was somewhat surprising that interactive exhibits, especially hands-on and group-based ones, were not incorporated into learning activities, as they marked the biggest difference between the classroom and the museum. Mostly, text panels with illustrations, single objects, and in a few cases, dioramas and videos were used as part of the learning activities. Some brilliant student discussions were induced through open-ended observation tasks in Ursula's class where students had to find examples of living and non-living things. The students debated whether mounted animals should be considered living or non-living because they were presented as living in dioramas, but did not have the signs of life that the students had just learned about in class. A child explained to her friend: 'It is a living thing, but it is not alive anymore!' Students also discussed whether a tree stump is a real object (a dead tree) or a copy; whether a mounted animal depicting a corpse is more 'non-living' than figures of living animals, and whether a glass eye of a mounted animal fits into the 'non-living' category. These discussions vividly illustrate the content-related nature of student talk in a museum in the case of open-ended and collaborative tasks.

Students actively used the physical environment in the entire museum, including hands-on, interactive, and otherwise sensory exhibits even if their tasks did not require their use. Teachers did not hinder this kind of exploration. Whenever students had free time to explore, they preferred to engage with hands-on or interactive exhibits or physical objects in small groups and delved into discussions. In Zoe's lesson, students looked at a mounted lynx and stated rather emotionally, 'How could they shoot such a cute animal?' However, as the students were not supported in their exploration of interactive exhibits, they often got false impressions or did not grasp the actual meaning of these exhibits at all. For example, an exhibit in the form of a long picture roll depicting layers of peat was interpreted by a group of students as an Egyptian papyrus scroll.

Discussion

Setting out to learn from the practice of successful brokers, we discovered that even the most skilful teachers would need more support from museum educators and school management during field trips. Many of the problems reported by the participants in this study echoed the findings of previous research: procedural problems, finding funding, making agreements with parents and colleagues, etc. Participating teachers were resourceful and skilful in overcoming many problems connected to field trips. However, some aspects were less discussed in the previous research, such as for example, the teachers' choice on where to go, how often, and under what conditions. This may have been so because unlike their colleagues in other countries, Estonian elementary school teachers have the freedom to choose the aims, destinations, frequency, and timings for their field trips (Anderson, Kisiel and Storksdieck 2006). However, teachers rarely receive help from school management with organising. Lack of assistant teachers is especially troublesome as more and more

students with special needs study in large multi-ability classes and need more assistance in complex field trip situations.

Problems connected with low quality of programmes by on-site educators were discussed at length. Many suggestions were given around what the museum could do. However, there were almost no examples of meaningful collaborations with on-site educators. This could mean that museums and other similar institutions, especially where on-site educators work with students, are mostly perceived as places and activities that are largely out of their control ('black-box'), where one can just choose the venue and hope for the best. The right 'gut feeling' and skills to find the 'right' programme or on-site educator were discussed many times, whereas the possibility of communicating one's needs to the on-site educator were not mentioned at all. This indicates that the participants had not identified their role in the boundary-crossing collaboration with on-site educators (Vesterinen, Kangas, Krokfors, Kopisto and Salo 2017). On the other hand, numerous examples of meaningful collaboration with parents were made.

The participants seemed to have a deep-rooted belief that student development and achievement of curricular aims was best supported when learning in the classroom is combined with diverse 'real-life' environments and objects. They considered learning in out-of-classroom environments as their core practice and not something they do when they have extra time. They make sure that field trips connect to their classroom curriculum, but the choices on where to go seem to be driven by the needs of their students and the class as a whole. The participants' teaching styles in the classroom and in the museum were generally coherent. Teachers created learner-centred, collaborative, and engaging learning activities during the study. The participants enjoyed a sense of autonomy and creativity in their work, which probably explains why all the learning activities were unique. They knew that not all their colleagues were as active as they were with respect to field trips and felt sorry for such teachers for missing out on the field trip experience.

Teachers prepared themselves for field trips to make sure that they could support their students. They reported regular content-related reflections after their trips. This is in contrast with Tal and Steiner (2006), who reported that elementary school teachers generally relied on on-site educators and did not prepare their students for the trip. In contrast, Kansanen (1991) suggested that the pedagogical thinking of elementary school teachers differs from that of subject teachers whose initial training is obtained in one subject (i.e., chemistry, language), whereas elementary school teachers obtain content knowledge across different subjects and are expected to be experts in general didactics, psychology, etc. Thus, it may be so that highly educated Estonian elementary school teachers' broad view of children's development means that they understand preparing students for a field trip differently from both their colleagues in other countries where professional requirements for elementary teachers are lower, and subject centred on-site educators and secondary school subject teachers. However, the participants concluded that they had not prepared and reflected on field trips in such a systemic manner before this study and felt that doing so enhanced their practice.

Contrary to our expectations, teachers did not give much insight into their decision-making in out-of-classroom environments in general and during this study. Only after probing did they explain some of their choices, such as why group work is so common during field trips. Teachers mostly relied on written or text-based tasks that were not individualised nor problem-solving oriented, which can be explained by the increased time pressure from planning and the lack of familiarity with the content in the museum. However, they were quite skilful in finding suitable goals for the class as a whole and connecting learning activities at the museum with the classroom curriculum. All teachers gave continuous

and supportive individualised oral feedback and monitored the students' learning actively. However, content-related discussions between teachers and students during and after the museum visit were mostly connected to checking the right answers, and were less inclined to support wider meaning-making, problem-solving or deeper analysis of any particular topic. Without observing activities before and after museum learning, it would have been difficult to understand the intended learning outcomes. We recommend to always consider the teachers' regular teaching style and learning activities before and after the visit in order to understand their field trip practice.

There were some notable differences among the teachers. First, teachers whose classroom curriculums were thematic or phenomenon-based were more successful in connecting and integrating museum learning activities with the classroom curriculum. They also reported using less time for planning than those who taught subject-based curriculums. Second, novice teachers struggled more to match learning activities with their students' abilities and working pace than did more experienced teachers. Third, teachers who supported the reflection of emotions in the course of learning activities were more successful in keeping the students engaged at all times and gave the students more challenging tasks.

No teacher had intentionally integrated the use of group-based or hands-on exhibits into their learning tasks. Wenger's (1998) terms—participation was better supported than reification. The unique environment of the museum was used mostly spontaneously by the students. The students were often seen spontaneously playing with, observing, and discussing exhibits that were unrelated to the task at hand but deeply related to the content. However, most of the feedback from teachers to the museum was connected to the inappropriately difficult level of written texts. This resonates with DeWitt and Hohenstein (2010) who compared students' task-related discussions at school and at the museum and found that the museum environment induced deeper content-related discussions. However, it often felt as though the students saw playing with content-related interactive exhibits as breaking the rules, even though the participating teachers did not stop their spontaneous exploration and enabled content-related 'free time'. This indicates that students would probably benefit from a deeper explanation of the contextual nature of learning, too.

The schoolteachers expressed the need to collaborate more with the museum educators in the future, even in the context of 'regular' museum programmes. Teachers stated that museums' learning resources like worksheets could be more age-specific, modular (enable choices), and hands-on. Some of the things the teachers asked for were already present (e.g. online materials), but they did not know this. However, throughout this study, the participating teachers were happy to share their experiences with one another. In future research and teacher training, we recommend investing more time for all stakeholders to exchange ideas and form networks. Participating in longer training courses in collaboration with museum educators has great potential for in-service teacher training.

Finally, it is difficult to compare student behaviour in this study with classes that do not go on field trips as often. Students from affluent families who are used to visiting museums, theatres, zoos, etc., will likely feel more comfortable and 'ready to learn' during school field trips to museums. They may not need to overcome any anxiety around the novel environment or the awkwardness of not having words to describe things like 'exhibit' or 'excursion'. Thus, students who learn in classes led by teachers such as the participants in this study are given the cultural capital and vocabulary by their teachers in a step-by-step manner regardless of their socioeconomic background and after a few years, even the least privileged students can feel almost as relaxed as their peers while visiting cultural institutions like museums. This may mean that the generally high engagement of the students in this study is a result of homogeneous distribution of cultural capital across the class that

has been built up over the years by their elementary school teachers and not so much connected to good instructional techniques at a chosen time.

Implications

We have some general recommendations for supporting elementary teachers during field trips:

- Developing into a skilful teacher who feels confident to teach in and across different learning environments takes both experience and pedagogical knowledge. It is as important to support novice teachers to experiment with different learning environments as it is to provide them with quality pre-service training that includes teaching in out-of-classroom environments. After all, professional teaching is pedagogical decision making based on knowledge about human cognition rather than relying on popular opinion or current school culture.
- Elementary teachers need parents, assistant teachers, or other colleagues to join field trips. Extra help is necessary to make sure that all students can safely participate in learning and at the same time the teacher can concentrate on guiding the learning of the whole class. The school management can do a lot to nudge teachers towards using more different learning environments by assigning assistant teachers, helping with funding and logistical issues, and generally valuing teachers' efforts.
- Field trips seem to both benefit from and develop into good classroom climate, thus we recommend paying extra attention on social aspects of learning. Good practice shared by experienced teachers in our study emphasizes practicing social skills and learning in new environments parallelly in a step-by-step manner.
- Both museum educators and schoolteachers would benefit from longer joint in-service teacher training courses. Without conscious collaboration with on-site educators the out-come of a field trip can remain too much a matter of good luck.
- Supporting students' metacognition before, during and after field trips seems to help them to connect learning in different environments, support their concentration on learning activities, and boost their willingness to explore the novel learning environment. Learning on a field trip is never only about the subject matter.

Conclusion

The aim of the study was to understand the field trip practice of eight elementary school teachers who frequently and willingly teach in different learning environments. Participants were interviewed and observed in the Estonian Museum of Natural History. To our surprise, it was somewhat problematic to apply the term 'broker' or 'boundary practice' to analyse learning activities of avid museum goers. Most participants did not regularly communicate with on-site educators before field trips. When on-site educators work with their students, the learning activities are largely received as out of their control. What does distinguish avid field trip goers from those who seldom visit out-of-classroom environments is the fact that teaching in out-of-classroom environments is considered part of a core practice and is taken as seriously as any other learning activity.

Skilful behaviour management and supportive relationships seemed to be the threshold for meaningful learning. The teachers stressed that they use field trips to attain good peer and student–teacher relationships in their classes as such situations spotlighted different characteristics of their students, while also enhancing their social skills. The fact that participating teachers successfully created meaningful learning activities is probably related to professional and child-centred approach of Estonian elementary teachers with master's degrees.

The current global pandemic has delivered to the field of education yet another wicked problem. Museums are inventing new ways to meaningfully collaborate with schools with the help of digital tools. We find it extremely important that this opportunity to create more individualized and meaningful learning activities across the borders of museums and schools is not wasted. This study illustrates, that even the most experienced, educated and well-meaning elementary teachers struggle to incorporate physical features of learning environments, create individualized and problem-solving oriented learning tasks. Natural history museums can help teachers translate natural environments into learning resources, citizen science projects, and methodological materials for hybrid and distance learning sessions. It is especially important to offer personalised and modular solutions as teachers need even more flexibility during distance learning than during regular contact lessons or guided tours.

Appendix

See Appendix Tables 4 and 5.

Table 4 Description of context and content of learning activities for each case

Teacher (teaching experience) *Grade*	Exhibition room, focus of the visit, and short description of learning activities (a) before (b) during, and (c) after visit	Contextual information on the school	
AMY (less than 3 years) *2nd grade*	Exhibition: Fathers as caretakers in the animal kingdom Topic: Fathers' roles in the animal kingdom and learning to learn independently (a) Group work and discussion—roles of parents (b) Work in pairs, worksheet to guide through exhibits and exploratory group work (c) Quiz based on the museum worksheet, reflection in groups and class discussions	Public school, subject-based curriculum with high teacher autonomy to organise the timetable, and formative grading. KiVa Anti-Bullying Programme established in the school (no connected activities observed during this study)	A psychologist and a special educator were available. There was an occasional possibility for students with learning difficulties to learn in small groups in some subjects. Assistant teachers were also available to support students who had special needs
JANE (10+ years) *3rd grade*	Permanent exhibition: Estonian forests and meadows Topic: Recap of the last semester's lessons (grammar) and getting to know species that are common in Estonia (a) Class discussions on how it feels to learn in the museum, planning the route via Google maps, and reflection on previous museum visits (b) Individual worksheets on topics covered in the previous semester, mindfulness exercises and reflection in the middle and in the end of learning tasks (c) Reflection on the visit and discussion of worksheets		

Table 4 (continued)

Teacher (teaching experience) *Grade*	Exhibition room, focus of the visit, and short description of learning activities (a) before (b) during, and (c) after visit	Contextual information on the school	
ZOE (10+ years) *2nd grade*	Permanent exhibitions: Estonian forests, meadows, and wetlands Topic: free exploratory visit (a) The teacher posed two assignments: find two of your favourite animals and compare them (b) Worksheet free exploration, the teacher only reminded them of the assignments, class discussions were conducted on the spot (c) Not observed/reported	Private religious school, thematic curriculum (not subject-based)	A special educator, a speech therapist, and a psychologist are present
KATE (10+ years) *3rd grade*	*Quit project before observations, was replaced by Zoe*	Public school from an industrial small town, half the students came from Russian-speaking backgrounds. Subject-based curriculum with high teacher autonomy and formative grading. This teacher actively used the PAX Good behaviour Game	

Table 4 (continued)

Teacher (teaching experience) *Grade*	Exhibition room, focus of the visit, and short description of learning activities (a) before (b) during, and (c) after visit	Contextual information on the school	
KELLY (10+ years) *3rd grade*	Permanent exhibition: Estonian forests and meadows Topic: Cultural heritage connected with forests (a) Preparation throughout two weeks in different classes—music, language etc. (b) Joint read-a-loud of an Estonian folk story (in a play format) about forests, presentations of forest songs based on traditional melodies, games to learn proverbs around forests, observational tasks, etc. PAX games and mindfulness exercises were included (c) Weekly written wrap-up	Public school, thematic curriculum (not subject-based), and formative grading. This teacher used the PAX Good Behaviour Game actively both in class and during the observations	Assistant teachers were available. There were opportunities for students with learning difficulties to learn some subjects in small groups. There were no speech therapists
DORIS (< 3 years) *3rd grade*	Permanent exhibition: Estonian forests and meadows Topic: Recap of everything we learned last semester (forest), and practising functional reading (a) Discussion, sharing emotions connected with learning at the museum (b) Scavenger hunt, exploratory group work (c) Group reflection, checking worksheet answers, and filling the personal field trip diary	Private school, subject-based curriculum with high teacher autonomy and formative grading	A psychologist and speech therapist were present. No special educators were available. There was occasional support from assistant teachers

Table 4 (continued)

Teacher (teaching experience) *Grade*	Exhibition room, focus of the visit, and short description of learning activities (a) before (b) during, and (c) after visit	Contextual information on the school	
MARY (10+ years) *6th grade*	Exhibition: Fathers as caretakers in the animal kingdom Topic: learning to present new topics (a) Discussion + practising presentations (b) Making presentations on a novel topic, explaining new materials to others (c) Discussion and written wrap-up	Public school, subject-based curriculum, and summative grading	There were opportunities for students with learning difficulties to learn some subjects in small groups. There was an assistant teacher to support students who had behavioural problems. There was no speech therapist or psychologist
SALLY (< 3 years) *3rd grade*	Permanent exhibition: Estonian wetlands Topic: types of wetlands (a) Discussion, introduction to the topic (b) Worksheet-guided lesson in pairs (describe different types of swamps) and exploratory group work (c) Discussion on the visit and exploring a bug that the students found during the exhibition	Public school, subject-based learning, and formative grading	There was a psychologist and assistant teacher for certain subjects. There was no possibility for students with learning difficulties to learn in small groups

Table 4 (continued)

Teacher (teaching experience) *Grade*	Exhibition room, focus of the visit, and short description of learning activities (a) before (b) during, and (c) after visit	Contextual information on the school	
URSULA (10+ years) *1st grade*	Permanent exhibition: Estonian forests and meadows Topic: living andnon-living things (a) Preparation throughout two weeks in different classes. Group discussion, moving between thematic stations in pairs (b) Exploratory observation and focused group work structured with worksheets (c) Creative reflection in small groups	Public school, thematic curriculum, and formative grading	A psychologist and assistant teacher were occasionally present. There were no speech therapists and social pedagogues at theschool

Table participating teachers, their experience, school type, grading system, grade their teaching and number of students in the class. Class sizes ranged from 18 to 26, with 24 students being the most common number

Table 5 Excerpts from interviews to illustrate codes

	Examples from previous experiences	Examples from planning and implementing learning activities	Examples from reflections on the process
Coded as common problems	[Example about parental support] KELLY: It is the hardest for me to bargain with the parents so that they would come with us. I do not want to bargain like that. I would prefer if there was someone assigned by the school, like an assistant teacher to help me with this. [-]	[Example about problems with boundary crossing]	[Example about funding and transport] MARY: It was definitely a boon that we could get our children into the museum for free (during this project)! [+]
• School culture		JANE: I went there expecting them (the museum staff) to be ready for us. But then they welcomed us in a bad mood… That startled me, I thought we were expected. I felt bad and thought that maybe you (the interviewer) haven't talked with them…	
• Parental support		KELLY: I felt that too!	
• Students with special needs and/or behavioural problems		MARY: Oh, I thought it only happened to me!	
• Funding and transportation		JANE: …and so I felt we were not expected and I did not even want to continue…	
• Problems at the boundary		MARY: Well, I smiled at her and told her that I had arranged everything and just went in. I did not analyse that situation. [-]	

Table 5 (continued)

	Examples from previous experiences	Examples from planning and implementing learning activities	Examples from reflections on the process
Coded as supporting meaning-making • Justification of field trips • Participation through choice of methods • Reification through the museum environment • Reification through other learning resources	[Example of justification] MARY: You will get to know your students much better outside the classroom. Even if you go with them to the corridor, diner, or school yard, or public transport… You can see your student in a different light at the bus stop.	[Example of participation] Reflection rounds in Jane's lesson included questions like 'How are you feeling right now?' 'Why is it tiresome to learn here?' The students actively discussed the differences between learning in the classroom and at the museum.	[Example of justification] MARY: I found out that those (students) who were interested in looking around (the museum) were able to convey the topic to their classmates in an engaging manner. Those who were not interested themselves, made boring presentations for others too.

Acknowledgements This study was funded by the Research Fund of Tallinn University's Educational Department, under Project TA/2519 'Museums and research centres as part of an open and problem-based learning environment for pupils from the 1st–3rd school stage. (1.09.2019−31.08.2020)'. Open Access funded by the European Regional Development Fund through the project "TLU TEE or Tallinn University as the promoter of intelligent lifestyle" (no 2014-2020.4.01.16-0033). We would also like to thank the participating teachers, pre-service teachers who assisted during data collection and the Estonian Museum of Natural History.

References

Akkerman, S. F., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research, 81*(2), 132–169. https://doi.org/10.3102/0034654311404435

Allen, L. B., & Crowley, K. J. (2014). Challenging beliefs, practices, and content: How museum educators change. *Science Education, 98*(1), 84–105. https://doi.org/10.1002/sce.21093

Anderson, D., Kisiel, J. F., & Storksdieck, M. (2006). Understanding teachers' perspectives on field trips: Discovering common ground in three countries. *Curator: The Musem Journal, 49*(3), 365–386. https://doi.org/10.1111/j.2151-6952.2006.tb00229.x

Basic Schools and Upper Secondary Schools Act (2010). Estonian Parliament. Retrieved from https://www.riigiteataja.ee/en/eli/521062016007/consolide

Behrendt, M., & Franklin, T. (2014). A Review of Research on School Field Trips and Their Value in Education. *International Journal of Environmental and Science Education, 9*(3), 235–245. https://doi.org/10.12973/ijese.2014.213a

Bevan, B., Dillon, J., Hein, G. E., Macdonald, M., Michalchik, V., Miller, D., Root, D., Rudder, L., Xanthoudaki, M., & Yoon, S. (2010). *Making science matter: Collaborations between informal science education organizations and schools*. Washington: A CAISE Inquiry Group Report.

Collins, A., & Greeno, J. G. (2011). Situated view of learning. In V. G. Akrust (Ed.), *Learning and cognition in education* (pp. 64–68). Elsevier.

Cox-Petersen, A. M., Marsh, D. D., Kisiel, J., & Melber, L. M. (2003). Investigation of guided school tours, student learning, and science reform recommendations at a museum of natural history. *Journal of Research in Science Teaching, 40*(2), 200–218. https://doi.org/10.1002/tea.10072

Davidson, S. K., Passmore, C., & Anderson, D. (2010). Learning on zoo field trips: The interaction of the agendas and practices of students, teachers, and zoo educators. *Science Education, 94*(1), 122–141. https://doi.org/10.1002/sce.20356

Davis, O. L., Yeager, E. A., & Foster, S. J. (2001). *Historical empathy and perspective taking in the social studies*. Rowman & Littlefield.

DeWitt, J., & Hohenstein, J. (2010). Supporting student learning: A comparison of student discussion in museums and classrooms. *Visitor Studies, 13*(1), 41–66. https://doi.org/10.1080/10645571003618758

DeWitt, J., & Osborne, J. (2007). Supporting teachers on science-focused school trips: Towards an integrated framework of theory and practice. *International Journal of Science Education, 29*(6), 685–710. https://doi.org/10.1080/09500690600802254

DeWitt, J., & Storksdieck, M. (2008). A short review of school field trips: Key findings from the past and implications for the future. *Visitor Studies, 11*(2), 181–197. https://doi.org/10.1080/10645570802355562

Dierking, L. D., & Falk, J. H. (1992). Redefining the museum experience: The interactive experience model. *Visitor Studies, 4*(1), 173–176.

Erss, M., Kalmus, V., & Autio, T. H. (2016). 'Walking a fine line': Teachers' perception of curricular autonomy in Estonia, Finland and Germany. *Journal of Curriculum Studies, 48*(5), 589–609. https://doi.org/10.1080/00220272.2016.1167960

Estonian Ministry of Education and Research. (2015). Adult skills: their use and usefulness in Estonia. Summaries of thematic reports on the PIAAC study, Tartu. Retrieved from http://www.hm.ee/piaac

Graesser, A. C., Fiore, S. M., Greiff, S., Andrews-Todd, J., Foltz, P. W., & Hesse, F. W. (2018). Advancing the science of collaborative problem solving. *Psychological Science in the Public Interest, 19*(2), 59–92. https://doi.org/10.1177/1529100618808244

Griffin, J. M. (1994). Learning to learn in informal science settings. *Research in Science Education, 24*(1), 121–128. https://doi.org/10.1007/BF02356343

Griffin, J. M. (2004). Research on students and museums: Looking more closely at the students in school groups. *Science Education*. https://doi.org/10.1002/sce.20018

Gupta, P., Adams, J., Kisiel, J., & Dewitt, J. (2010). Examining the complexities of school-museum partnerships. *Cultural Studies of Science Education, 5*(3), 685–699. https://doi.org/10.1007/s11422-010-9264-8

Gutwill, J. P., & Allen, S. (2012). Deepening students' scientific inquiry skills during a science museum field trip. *Journal of the Learning Sciences, 21*(1), 130–181. https://doi.org/10.1080/10508406.2011.555938

Hazelkorn, E., Ryan, C., Beernaert, Y., Constantinou, C. P., Deca, L., Grangeat, M., Karikorpi, M., Lazoudis, A., Casulleras, R. P., & Welzel-Breuer, M. (2015). Science education for responsible citizenship. In *Report to the European Commission of the expert group on science education, Brussels*. https://doi.org/10.2777/12626

Hein, G. E. (1998). Learning in the museum. *Routledge*. https://doi.org/10.4324/9780203028322

Hesse, F., Care, E., Buder, J., Sassenberg, K., & Griffin, P. (2015). A framework for teachable collaborative problem solving skills. In P. Griffin & E. Care (Eds.), *Assessment and teaching of 21st century skills—methods and approach* (pp. 37–56). Springer. https://doi.org/10.1007/978-94-017-9395-7

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99–107. https://doi.org/10.1080/00461520701263368

Jang, H., Reeve, J., & Deci, E. L. (2010). Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. *Journal of Educational Psychology, 102*(3), 588–600. https://doi.org/10.1037/a0019682

Kallip, K., & Heidmets, M. (2017). Varakult haridussüsteemist lahkumine: trendid, mõjurid ja meetmed Eestis [Early leaving from education and training: Trends, factors, and measures in Estonia]. *Eesti Haridusteaduste Ajakiri [The Estonian Journal of Educational Sciences]*, *5*(2), 155–182. https://doi.org/10.12697/eha.2017.5.2.07

Kansanen, P. (1991). Pedagogical thinking: The basic problem of teacher education. *European Journal of Education, 26*(3), 251–260.

Kansanen, P. (1993). An outline for a model of teachers' pedagogical thinking. Discussions on Some Educational Issues IV. Research Report 121, Helsinki. Retrieved from http://perttikansanen.fi/articles/an-outline-for-a-model-of-teachers-pedagogical-thinking/

Kink, K. (2013). *Klassiõpetajate arusaamad õppekäigu olemusest, olulisusest, efektiivsusest ning õpetaja rollist õppekäigu protsessis* (Master's thesis: How Classroom Teachers Understand the Essence of Field Trip, its Importance, Efficiency And See Their Role During the Pr. University of Tartu).

Kirsch, D. (2009). Problem solving and situated cognition. In P. Robbins & M. Aydede (Eds.), *The Cambridge handbook of situated cognition* (pp. 264–306).

Kisiel, J. F. (2005). Understanding elementary teacher motivations for science fieldtrips. *Science Education, 89*(6), 936–955. https://doi.org/10.1002/sce.20085

Kisiel, J. F. (2007). Examining teacher choices for science museum worksheets. *Journal of Science Teacher Education, 18*(1), 29–43. https://doi.org/10.1007/s10972-006-9023-6

Kisiel, J. F. (2009). Exploring a school-aquarium collaboration: An intersection of communities of practice. *Science Education, 94*(1), 95–121. https://doi.org/10.1002/sce.20350

Kisiel, J. F. (2014). Clarifying the complexities of school-museum interactions: Perspectives from two communities. *Journal of Research in Science Teaching, 51*(3), 342–367. https://doi.org/10.1002/tea.21129

Krange, I., Silseth, K., & Pierroux, P. (2020). Peers, teachers and guides: A study of three conditions for scaffolding conceptual learning in science centers. *Cultural Studies of Science Education, 15*(1), 241–263. https://doi.org/10.1007/s11422-018-9905-x

Lave, J., & Wenger, E. (1991). Situated learning. Legitimate peripheral participation. Cambridge University Press. Retrieved from http://www.cambridge.org/de/academic/subjects/psychology/developmental-psychology/situated-learning-legitimate-peripheral-participation

Lawson, C. A., Cook, M., Dorn, J., & Pariso, B. (2018). A STEAM-focused program to facilitate teacher engagement before, during, and after a fieldtrip visit to a children's museum. *Journal of Museum Education, 43*(3), 236–244. https://doi.org/10.1080/10598650.2018.1474421

Leinhardt, G., & Knutson, K. (2004). Introduction: Listening in on museum conversations. In *Listening in on museum conversations*. Rowman Altmira.

Lompscher, J. (1999). Activity formation as an alternative strategy of instruction. In Y. Engeström, R. Miettinen, & R.-L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 264–281). Cambridge University Press.

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into Practice, 41*(4), 219–225. https://doi.org/10.1207/s15430421tip4104

Mujtaba, T., Lawrence, M., Oliver, M., & Reiss, M. J. (2018). Learning and engagement through natural history museums*. *Studies in Science Education, 54*(1), 41–67. https://doi.org/10.1080/03057267.2018.1442820

Nabors, M. L., Edwards, L. C., & Murray, R. K. (2009). Making the case for field trips: What research tells us and what site coordinators have to say. *Education*, *129*(4), 661–668. Retrieved from http://web.a.ebscohost.com.ezproxy.tlu.ee/ehost/pdfviewer/pdfv

Näkk, A.-M., & Timoštšuk, I. (2021). In pursuit of primary teachers ' work motivation amid increased external neoliberal pressure in education. *Teacher Development*. https://doi.org/10.1080/13664530.2021.1899040

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education, 86*(4), 548–571. https://doi.org/10.1002/sce.10032

OECD. (2017). PISA 2015 results (volume V): Collaborative problem solving. *Paris*. https://doi.org/10.1007/978-1-4939-7131-2_100128

Paris, S. G., Yambor, K. M., & Packard, B. W. L. (1998). Hands-on biology: A museum-school-university partnership for enhancing students' interest and learning in science. *Elementary School Journal*. https://doi.org/10.1086/461894

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47–61. https://doi.org/10.1016/J.EDUREV.2015.02.003

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology, 104*(3), 700–712. https://doi.org/10.1037/a0027268

Ruus, V.-R., & Timoštšuk, I. (2014). Searching for Constant Innovation in Teacher Education Curricula: the Case of Estonia. *Problems of Education in the 21st Century, 62*(November), 97–108.

Säljö, R. (2003). *Õppimine tegelikkuses. Sotsiokultuuriline käsitlus. [Lärande i praktiken. Ett sociokulturellt perspektiv]*. Eesti Vabaharidusliit.

Schleicher, A. (2019). *PISA 2018: Insights and interpretations*. OECD Publishing. Retrieved from https://www.oecd.org/pisa/PISA2018InsightsandInterpretationsFINALPDF.pdf

Seligmann, T. (2014). Learning museum: A meeting place for pre-service teachers and museums. *Journal of Museum Education, 39*(1), 42–53. https://doi.org/10.1080/10598650.2014.11510794

Tal, T., & Morag, O. (2007). School visits to natural history museums: Teaching or enriching? *Journal of Research in Science Teaching, 44*(5), 747–769. https://doi.org/10.1002/tea.20184

Tal, T., & Steiner, L. (2006). Patterns of teacher-museum staff relationships: School visits to the educational centre of a science museum. *Canadian Journal of Science, Mathematics and Technology Education, 6*(1), 25–46. https://doi.org/10.1080/14926150609556686

Timmons, V., & Cairns, E. (2012). Case study research in education. In A. J. Mills, G. Durepos, & E. Wiebe (Eds.), *Encyclopedia of case study research* (pp. 100–102). SAGE publications, Inc. https://doi.org/10.4135/9781412957397.n36

Tire, G. (2021). Estonia: A positive PISA experience. In N. Crato (Ed.), *Improving a country's education. PISA 2018 results in 10 countries* (pp. 101–120). Springer.

Tuomi-Gröhn, T., & Engeström, Y. (2003). Part I: Boundary-crossing as a theoretical basis for research on transfer. In T. Tuomi-Gröhn & Y. Engeström (Eds.), *Between school and work. New perspectives on transfer and boundary-crossing* (pp. 19–84). Elsevier Science ltd.

Übius, Ü., Kall, K., Loogma, K., & Ümarik, M. (2014). Rahvusvaheline vaade õpetamisele ja õppimisele. *OECD rahvusvahelise õpetamise ja õppimise uuringu TALIS 2013 tulemused, Tallinn*.

Uppin, H., & Timoštšuk, I. (2019). "We'll be back by Christmas"—Developing historical empathy during a museum activity. *Journal of Museum Education, 44*(3), 310–324. https://doi.org/10.1080/10598650.2019.1612660

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences, 15*(3), 398–405. https://doi.org/10.1111/nhs.12048

Vesterinen, O., Kangas, M., Krokfors, L., Kopisto, K., & Salo, L. (2017). Inter-professional pedagogical collaboration between teachers and their out-of-school partners. *Educational Studies, 43*(2), 231–242. https://doi.org/10.1080/03055698.2016.1277131

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press. Retrieved from https://www.carnbridge.org/9780521430173

Yin, R. K. (2009). *Case study research—Design and methods. Applied social research methods series* (4th ed.). SAGE Publications, Inc.

Helene Uppin is a doctoral student and a junior researcher at the School of Educational Sciences in Tallinn University and the Curator of Education in Estonian Maritime Museum. She has a background in environmental sciences and teaching science. Her current research concentrates on expanding learning environments in formal education and learning in out-of-classroom learning environments such as museums. She is especially interested in supporting the collaboration of schoolteachers and museum educators to provide meaningful, collaborative, and problem-solving oriented learning activities to students.

Inge Timoštšuk (Ph.D.) is the Professor at the School of Educational Sciences in Tallinn University. She is teaching science education to elementary school teachers and courses about teaching and learning in open environment. Her recent research projects focus on the same topics, concentrating on relationship between teaching activities, students' learning engagement and learning outcomes.