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Developing museum-school partnerships: art-based exploration of science issues in a *third space*

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ABSTRACT

A third space can be unlocked through collaborative efforts between out-of-school organisations (like museums) and schools. By bridging museum and school contexts, blurring boundaries between disciplines and shifting between multiple perspectives on a subject, a *third space,* can contribute to meaningful science education. However, resources that support collaboration between museum educators and teachers are required. The educational design of a *third space* between museums and schools can enable *an experience* informed by context-based, interdisciplinary, and value-centred teaching strategies. This study conceptualises and validates the *Alma-Löv-Programme (ALP)*, a museum resource designed to support students' interdisciplinary, and value-centred learning in a *third space*. It applies an art-based teaching strategy that encourages student groups to address science issues depicted by contemporary art. Comparison of the *Alma-Löv-Programme* design guidelines to the design instantiations of the established *Framework for Museum Practice* showed that they are largely consistent. However, noted distinctions indicate several factors that may be important for preparation and exploration of a *third space*. The findings can inform the design of activities and programmes by educators in the out-of-school sector.

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Introduction

The common perception amongst secondary school students in developed countries that science education lacks relevance is a major reason for weak interest and motivation in compulsory science subjects (Gilbert, 2006; Murray & Reiss, 2005; Osborne et al., 2003; Sjøberg & Schreiner, 2010). Thus, to enable experiences where students perceive science education as meaningful should be a key goal in secondary school science education. In 'Art as experience', Dewey argues for '*an experience*' as an enriching event that

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transforms a person's relationship with some aspect of the world (Dewey, 1934/1958). By having '*an experience*', a person finds new meaning in that aspect of the world and values this new way of seeing (Pugh & Girod, 2007).

Stuckey et al. (2013) recognised an individual, societal and vocational dimension to relevance and showed that different educational frameworks have varying contributions to each dimension (Gilbert, 2006). However, context-based, interdisciplinary, and value-centred education strongly bolsters all three (Stuckey et al., 2013). The alternative positioning and different contexts, concepts and discourses within these frameworks can together be conceptualised as a *third space* and can become rich zones of collaboration and learning (Gutiérrez et al., 1999). Congruent with Gutiérrez, we view a *third space* as re-organised extended activities (Engeström, 1999) and as zones of proximal development that results in new opportunities for learning.

A *third space* can facilitate 'an experience' that requires a transaction involving educators, content, environment and students (Dewey, 1934/1958). Collaborative efforts between the out-of-school sector and schools can cause a *third space* (Stocklmayer et al., 2010). However, there is a need 'for resources to be made available to facilitate communication and collaborative planning between informal providers and schools in mutual respect' (Stocklmayer et al., 2010, p. 35). Consequently, the pedagogical design of such resources can draw on knowledge about context-based, interdisciplinary and value-centred education.

This study conceptualises and validates the design of one such resource; an educational programme developed by the Alma Löv museum of contemporary art in Sweden. This programme (hereinafter the *Alma-Löv-Programme*, *ALP*) intends to guide museum educators' and teachers' efforts to support students' art-based learning about science issues in a *third space*.

The Alma-Löv-Programme

The *ALP* aims to create a *third space* by providing structure and resources to museum educators and schoolteachers to cooperatively create learning situations in both school and museum contexts. During the programme's three phases, students participate in group activities focused on contemporary artworks that relate to a (by the school selected) science theme, such as *gene modification*, *climate change*, *evolution and creation*, or *animal exploitation*.

The art-based teaching strategy in the *ALP* is an adaptation of the established *Visual Thinking Strategies* (VTS) that encourage dialogue about artworks' motifs and techniques (Yenawine, 2013). Together, students explore how the view and values of artists on a certain science theme (aspect) are expressed and visualised. After the museum visit, students acquire information about the science theme, and they are encouraged to discuss how that relates to their own lives, other people and the environment. Their findings are collected on mind-maps from which students use concepts and views on the science theme (aspect) they want to express and visualise in their own sculpture or painting. After construction, their artworks are exhibited with descriptive labels in a public exhibition for the school and its community. The study setting section further describes the *ALP*.

The ALP in relation to the Framework for Museum Practice (FMP)

Educational resources that support school trips should principally be designed by museums or other out-of-school sectors (Fallik et al., 2013; Noam, 2003). Like many other educational museum practices (Matterson & Holman, 2012), the *ALP* was initially based on experiential rather than theoretical grounds. However, museum educators responsible for designing and developing educational resources must become 'more reflective and evidence-based' (Falk & Dierking, 2012) because the current application of theory and research in the out-of-school sector is reportedly too limited (Matterson & Holman, 2012). From earlier research on museum visits by schools, a series of recommendations can inform the design of museum programmes, as will be presented in the theoretical framework section. These recommendations appear (with various adaptations) in several established frameworks, with varying contexts and goals, but all intend to guide students' and educators' activities in out-of-school contexts. To conceptualise and validate any new educational museum programme, its design should be analysed in relation to such a framework.

> The Framework for Museum Practice (FMP) has the potential to inform and improve the development of resources that may, when used by teachers, enhance the potential value for learning, motivation, and pedagogy of school trips. (DeWitt & Osborne, 2007, p. 707)

It offers a comprehensive set of principles to guide educational practice in museum contexts. According to the FMP, learning in museums and other out-of-school contexts most likely occurs when museum educators act as teachers, provide structure, encourage joint productive activities and support dialogue, literacy and/or research skills (DeWitt & Osborne, 2007). All principles in the FMP are supported by empirical findings from a social constructivist perspective, as described further in the theoretical background section.

The *ALP* design requires theoretical conceptualisation and validation to facilitate appropriate implementation and provide guidance for educators seeking to develop similar resources. For this, we describe and analyse its design in relation to the FMP, as it contains apparent similarities to *ALP*. Both the *ALP* and FMP are intended to guide museum educators' development of resources that can improve teachers' use of out-of-school contexts. Moreover, observations of students' and teachers' behaviour during practical application of FMP are reportedly consistent with the framework's intentions (DeWitt & Osborne, 2007).

Aim and research questions

This study aimed to conceptualise and validate the *ALP*-design and explore its potential as a *third space*. Results may enhance applicable knowledge on design aspects of educational experiences that encourage a *third space* between school and museum contexts. The following questions guided the study:

- To what extent is the *ALP*-design consistent with the FMP?
- How can the *ALP*-design contribute to a *third space*?

Theoretical background

Our study is framed by the theoretical construct of a *third space*, as presented below. Thereafter, we present key elements that can support a potential *third space* from context-based, interdisciplinary and value-centred science education. Associated with these frameworks, two applicable educational strategies, the FMP and Visual Thinking Strategies (VTS), are elaborated.

A third space

'Students take up knowledges, resources, and identities in novel ways that often go unsanctioned by school science' (Calabrese Barton & Tan, 2008). A *third space* brings together knowledges, discourses, and students' lives, allowing them to work together to build their social identities while they gain epistemic authority (Calabrese Barton & Tan, 2008; Moje et al., 2004). In a *third space*, social interactions between participants within multiple physical and conceptual contexts are key.

Besides the classroom as a physical context for a *third space* (Moje et al., 2001), Stocklmayer et al. (2010) advocate a 'real space into which the informal sector can move, bridging the gap between school and community hence blurring the boundaries between them' (Stocklmayer et al., 2010, p. 30). The concept of *third space* can therefore partly be informed by the framework of context-based (science) education.

As for the conceptual contexts, Moje et al. (2004) argue that a *third space* must cross different discourse communities, especially between academic and traditionally marginalised ones (Gutiérrez et al., 1999). Schools compared to out-of-school organisations are part of different discourse communities, arguing again for a context-based approach. Furthermore, different school subjects require different discourses. The concept can also partly be informed by the framework of interdisciplinary education. Moreover, within the current dominant school system, traditional curriculum hierarchy allocates a certain status to school subjects. The pervasive idea maintains that abstract school subjects, like mathematics and physics, are more valuable than subjects associated with concrete experience, practicality, and the body, such as physical education and art (Bleazby, 2015). Marginalisation of certain school subjects gives rise to approach *third space* from an interdisciplinary perspective.

Additionally, a *third space* also encompasses conceptual contexts like social, cultural and epistemological change (Moje et al., 2001). Academic and everyday knowledge should be challenged and reshaped by opposing values, knowledges and discourses (Calabrese Barton & Tan, 2008). Human values are foundational for societies, their cultures and their knowledge. Science education should afford students to explore, discuss, accept, reject and change values more often (Murray & Reiss, 2005). Therefore, the concept of *third space* can also partly be informed by the framework of value-centred science education.

Thus, to establish a *third space*, schools must acknowledge beneficial out-of-school involvement. Educators from the informal sector must re-evaluate their institutions' practice concerning school visits (Stocklmayer et al., 2010). This requires active collaborative planning for inclusive modes of delivery: open to multiple discourses from the perspective of students themselves, school subjects, society and the environment. Stocklmayer et al. (2010) advocate a holistic approach considering both in- and out-of-school contexts. They conclude that there is a need for resources that facilitate cooperation between the two sectors, driven by the school system, but in mutual respect. Such *third space* resources might benefit from being informed by context-based, interdisciplinary, and value-centred science education.

Context-based science education

Since the 1980s, context-based education has been used as a teaching approach to address major challenges in science education, such as lack of clear purpose, incoherent learning by students and lack of relevance to students (Gilbert et al., 2011). The general idea of context-based science education is to provide relevant real-life or fictitious learning environments that frame scientific concepts in ways that illustrate their connections and applications to everyday life, societal issues and/or technological innovations (Stuckey et al., 2013). Contexts can be crucial for illuminating scientific concepts' relevance, and 'Out-of-school contexts provide new connections with science and stimulate people to dig deeper and think more about science and its relationship with society' (Braund & Reiss, 2006, p. 1379). Theoretical nuances of the term *context* in science educational research vary widely, lacking a generally accepted definition (Bennett et al., 2007). However, the notion of context presented by (Gilbert, 2006), as the social circumstances, is consistent with key elements of *ALP*. According to Gilbert, the social dimension (the group composition and interaction) of a context should be the starting point of activities on topics with clear societal importance (e.g. social implications of genetic modification). Gilbert's model includes joint exploration of an issue by teachers and students in a *community of practice*, with productive interaction between participants through student activities that frame discussion about scientific concepts, connect to prior knowledge and develop coherent use of scientific language (Gilbert, 2006). Gilberts' *community of practice* resonates with Calabrese Barton's argument on how *third space* 'offers a way of understanding how learning science is as much about learning to negotiate the multiple texts, discourses and knowledges available within a community as it is about learning particular concepts and processes' (Calabrese Barton & Tan, 2008, p. 74). The educational context for participants in the *ALP* is defined by its design which encompasses: the objects of inquiry (professional artworks), student generated objects (student artworks), interactions amongst students and educators and, the museum spaces and classrooms where the interactions take place.

Museums as out-of-school contexts

The role of museums has over the last two centuries shifted from being interpretive authorities towards becoming participants in the world of the visitor. Where exhibited objects previously were presumed to speak for themselves, museum professionals now realise that visitors bring their own experiences to an active encounter with an object (Achiam, 2016). Museums are of out-of-school contexts that are common school trip destinations and can provide educational experiences that enhance students' interest, motivation, and both conceptual and cognitive understanding (Braund & Reiss, 2004; Storksdieck, 2001). However, teachers find it difficult to adapt their practices to museum settings due to the contextual differences between classrooms and museums (DeWitt & Osborne, 2007), but support from museums increases the likelihood of teachers integrating visits into their teaching practice (Xanthoudaki, 1998). Therefore, developing and improving learning situations in school trips to museums is necessary. Previous findings regarding out-of-school learning and their potential contributions to educational museum programme design can be distilled into the following recommendations:

- Establish equal partnerships between schools and museums, based on mutual understanding of each other's practices (Fallik et al., 2013; Noam & Tillinger, 2004).
- Align school trips to museums with the school curriculum (DeWitt & Osborne, 2007).
- Encourage teachers and museum educators to become familiar with each other's workspaces, which are students' learning contexts (Fallik et al., 2013).
- Examine and connect to students' prior knowledge, experiences and interests (Falk & Dierking, 2012).
- Plan pre-visit activities to prepare students for the setting, agenda and objectives of each museum visit (Falk & Dierking, 2012; Griffin, 2004).
- Allow free exploration of a museum, but offer limited choices of activities to provide structure, scaffold learning and encourage relevant interaction (Griffin, 2004).
- Exploit the uniqueness of the museum setting (DeWitt & Storksdieck, 2008).
- Encourage student discourse through open-ended questioning to promote inquiry-based discussions (Reiss & Tunnicliffe, 2011).
- Plan and conduct post-visit classroom activities to reinforce the experience (Falk & Dierking, 2012).

The FMP

Several established frameworks that inform educational out-of-school programmes reflect the design recommendations in the previous section. Our analysis of the *ALP* focuses specifically on the (in)consistencies with the FMP. The FMP has a social constructivist perspective and was derived from elements of Cultural Historical Activity Theory, concerning cognition and behaviour embedded in collectively organised, artefact-mediated activity systems (Engeström, 1999), theories of intrinsic motivation and conceptual learning research. Its principles are based on collective understanding, theoretical insights and experiences that aim to contribute to 'a theory of pedagogy in informal contexts' (DeWitt & Osborne, 2007, p. 689). The FMP principles subdivide design intentions that support museum and school educators' practice into distinct categories.

Principle I: Adapting the teacher perspective. Fundamental considerations regarding the development of resources and respective roles of museum and school educators when executing a programme design.

Principle II: Providing structure. Emphasises methods of providing general structure to a museum programme through planning, resources and activities.

- IIa: Reduction of the novelty effect.
- IIb: Reinforcement of the learning experience.

Principle III: Encouraging joint productive activity. Promotes the overall design of activities, where students collaborate with each other and the educators to create a final product. Specifically, such activities should consider the following.

- Principle IIIa: Discussion amongst peers and with adults.
- Principle IIIb: Curiosity and interest.
- Principle IIIc: Choice and control.
- Principle IIId: Cognitive engagement and challenge.

– Principle IIIe: Personal relevance.

Principle IV: Supporting dialogue, literacy and/or research skills. Skills beyond those obviously related to science topics should be considered in resource development. This can include reading, note-taking, organising, consolidating and communicating information in various subject areas.

Interdisciplinary science education

Like context, there is no common understanding of the term interdisciplinary due to a variety of approaches (Czerniak & Johnson, 2014), except that it is an integration of multiple disciplines, and a generally accepted definition would be helpful Rennie et al. (2012). Interdisciplinary teaching in science education is often presented as STEM (Science, Technology, Engineering and Mathematics), a concept that was coined by The National Science Foundation in the early 2000s. The idea was that teaching should be based on all these parts integrated and not as isolated content (Maslyk, 2016). Czerniak and Johnson (2014) advocate connection of school subjects because experiences of relationships among ideas and identification of patterns, instead of fragments of knowledge, can enhance students' meaningful learning. Integration of school subjects often focuses on real-world concepts tied to students' personal interests and experiences (Rennie et al., 2012). Merging science practices with other school subjects can create a *third space* that allows students to draw from a wider range of funds of knowledge. This results in student-empowerment and fosters interest and engagement (Calabrese Barton & Tan, 2009).

Interdisciplinary science education and arts

The STEM concept was added with A (arts), and some argue that integration of A into STEAM stimulates development of creativity, imagination and collaboration. Combining arts with STEM allows for students to express themselves in more variations and may allow them to envision artistic representations of ideas and solutions (Sousa & Pilecki, 2013). Despite various challenges, art-based pedagogies can foster inclusive, participatory and interdisciplinary learning of science (Colucci-Gray et al., 2017); promote engagement in and talk about science (Simon et al., 2012); and enable learning of affective, cognitive and procedural knowledge (Dorion, 2012). Furthermore, art museums can facilitate interdisciplinary educational activities that develop student participation and encourage inquiry (Wyman et al., 2016). Making visualisations is integral to scientific and artistic thinking; however, students are rarely systematically encouraged to create their own visual forms to develop and show understanding (Ainsworth et al., 2011). Drawing on the work of Dewey, Pugh and Girod (2007) argue for a pedagogical model that fosters transformative, aesthetic experiences. A part of such experience is *re-seeing* an object from new perspectives that go beyond mere looking and recognising. Inquiry-oriented science classrooms often teach disciplined perception, and look for concrete, factual accounts and patterns while passing an aesthetic perception. The expansion of perception (Dewey, 1934/1958) can be taught by encouraging students to share their experiences of *re-seeing* (Pugh & Girod, 2007). This method clearly resonates with the systematic scaffolding questions in the VTS-approach, explicated below.

Visual thinking strategies

The main teaching strategy in the *ALP* is an adaptation of VTS, a pedagogical approach for analysing artworks with groups based on psychological research on aesthetic development stages (Housen, 1980). VTS is intended to promote the ability to find meaning in images, by developing skills ranging from simple identification (naming what one sees) to complex contextual, metaphorical and philosophical interpretation. Many aspects of cognition are invoked, such as personal connection, questioning, speculation, analysis, memories and categorisation. Objective observation and understanding are prerequisites for much of these skills, but subjective and affective aspects of knowledge are equally important. Briefly, VTS is operationalised by a teacher or museum educator facilitating a group discovery process based on carefully selected images, artworks or artefacts. 'The teacher is central to the process but not the authoritative source; instead, the students drive the discussions, aided by the teacher' (Yenawine, 2013, p. 25). The teacher asks the following questions intended to set the students into a discovery mode when confronted with an image, by providing a structure for examining and reasoning about any unfamiliar object:

– What's going on in this picture?
– What do you see that makes you say that?
– What more can we find?

The wording of the questions encourages discovery of a narrative in the depiction, a meaning-making system supported by the chosen artwork. Housen (1980) observed that an inexperienced art spectator initially makes a few random observations, and then attempts to incorporate these observations in short narratives to make sense of them. The teacher helps students to look carefully at the image, artwork or artefact and talk about what they observe, backing up their ideas with evidence and both listening to and considering views of others. Finally, various interpretations are discussed. The VTS line of questioning is extended in the art-based teaching strategy of the *ALP* to scaffold students in both their perception and creation of science-related artworks. This new instructional design in *ALP* is described in the study setting section.

Value-centred science education

During the last two decennia, value-centred learning and a humanistic perspective in science education has increasingly been advocated by educational researchers (Marks & Eilks, 2010; Sadler & Donnelly, 2006). Authentic and controversial debates on scientific issues from within society can help students understand possible relationships between science and society. Moreover, students can develop debating skills by exploring values and backing up opinions with evidence in decision-making processes (Hofstein et al., 2011). Value-centred science education can 'encourage personal connections between students and the issues discussed, explicitly address the value of justifying claims and expose the importance of attending to contradictory opinions' (Sadler, 2004, p. 523). However, many science curricula in different countries focus mainly on scientific facts and concepts where the societal dimension is neglected (Hofstein et al., 2011). 'There is such a push to cover content and achieve understanding that it is easy to forget to talk about why the content is interesting and valuable' (Pugh & Girod, 2007, p. 23). Students themselves commonly express desires to include 'more ethical and controversial issues' and 'more discussions' (Murray & Reiss, 2005). Out-of-school contexts, like museums, can provide value-centred learning experiences that personalise subject matter, evoke emotion, stimulate dialogue and debate, and promote reflexivity (Pedretti, 2004). However, in-school and out-of-school educators must scaffold students' action, perception and valuing by encouraging them to systematically share perceptions on objects and related content that explore multiple values and perspectives on the world (Pugh & Girod, 2007). The art-based teaching strategy in the *ALP* is designed to scaffold students in their perception and creation of science-related art objects. On one hand, students analyse existing artworks that express the artist's values relating to scientific issues; on the other hand, students create their own artwork in which they express their own values.

Value-centred science education and arts

Science centres and museums often portray 'science as factual, uncontroversial, and without ethical dimensions rather as a means of building understanding through a fallible, distinctly human process' (Rennie, 2014). In contrast, art museums often show idiosyncratic perceptions of the world through creative human expressions that, at times, can be very controversial. A telling example of a painting from 1768 with a science-related motif that still evokes ethical considerations and emotional reactions with students to this day, is 'an experiment on a bird in the air pump' by Joseph Wright of Derby (Figure 1). The painting shows a forerunner of the modern scientist who conducts an air pump experiment with a bird that is deprived of air. Curiosity, anxiety and even distraction are distinctive reactions of the experiment's spectators revealed by a compositional claire-obscure. Shapiro et al. (2006) showed that observation of figurative paintings enhanced medical students' observational skills, showing development of students' skills in emotional recognition, cultivation of empathy, identification of story and narrative, and awareness of multiple perspectives. Thus, engagement with art can expand student's perception and values, making it a transformative aesthetic experience (Pugh & Girod, 2007). The *ALP* includes artworks (see Figures 1 and 3) that express artists' views and opinions on science issues and are chosen to inspire students not only to acquire facts about their science-related motif but also to share, debate and visualise their own values.

The study setting

The ALP implementation and design

The *ALP* was developed, revised and implemented by the first author from 2017 to 2019 with support from the Swedish National Cultural Council. Until today (June 2021), the *ALP* was executed in cooperation with six different municipalities, 16 different schools, and 56 classes with about 1,400 students. The *ALP* became a subject of research two years after its initial implementation. Within this frame of research, four upper-secondary school classes, with a total of 92 students, participated in the *ALP* in September 2019 exploring the science theme *gene modification*. Throughout their participation, students were supported by a museum educator and eight teachers (science, art, humanities and physical education),

Figure 1. *An experiment on a bird in the air pump* [Painting], by J. Wright of Derby, 1768, National Gallery, London. http://www.nationalgallery.org.uk/paintings/joseph-wright-of-derby-an-experiment-on-a-bird-in-the-air-pump.

occasionally joined by more teachers in the last phase of the *ALP* (Figure 2). Student participation was documented through audio-recordings, interviews conducted by the first author, and observations made by the first and second author. This collected data comprised all subsequent phases in the *ALP*-design and will be analysed in a subsequent study about the impact of *ALP* on students. The *ALP*-design is comprehensively described by 44 design guidelines (Appendix 1, see supplemental data). A summary of its design is presented in Figure 2, showing the roles of the different partakers and their series of actions.

In accordance with Falk and Dierking (2012), the *ALP* is divided into pre-visit, visit and post-visit structure, with three consecutive phases ('prepare', 'explore' and 'create'), which stress the importance of introducing and reflecting on a museum visit. Every phase includes several student activities that are carried out on separate occasions with specific timeframes; responsibility for guidance alternates between museum-educators and teachers, in designated locations. All activities are comprehensively described in a teacher-guide that provides instructions and resources. The *ALP's* educational content and its values are aligned with the Swedish national curriculum goals.

The ALP art-based teaching strategy

The *ALP* utilises the VTS theoretical framework as a template for the instructional design of activities in museum and school contexts. In phase 1 (prepare), students are

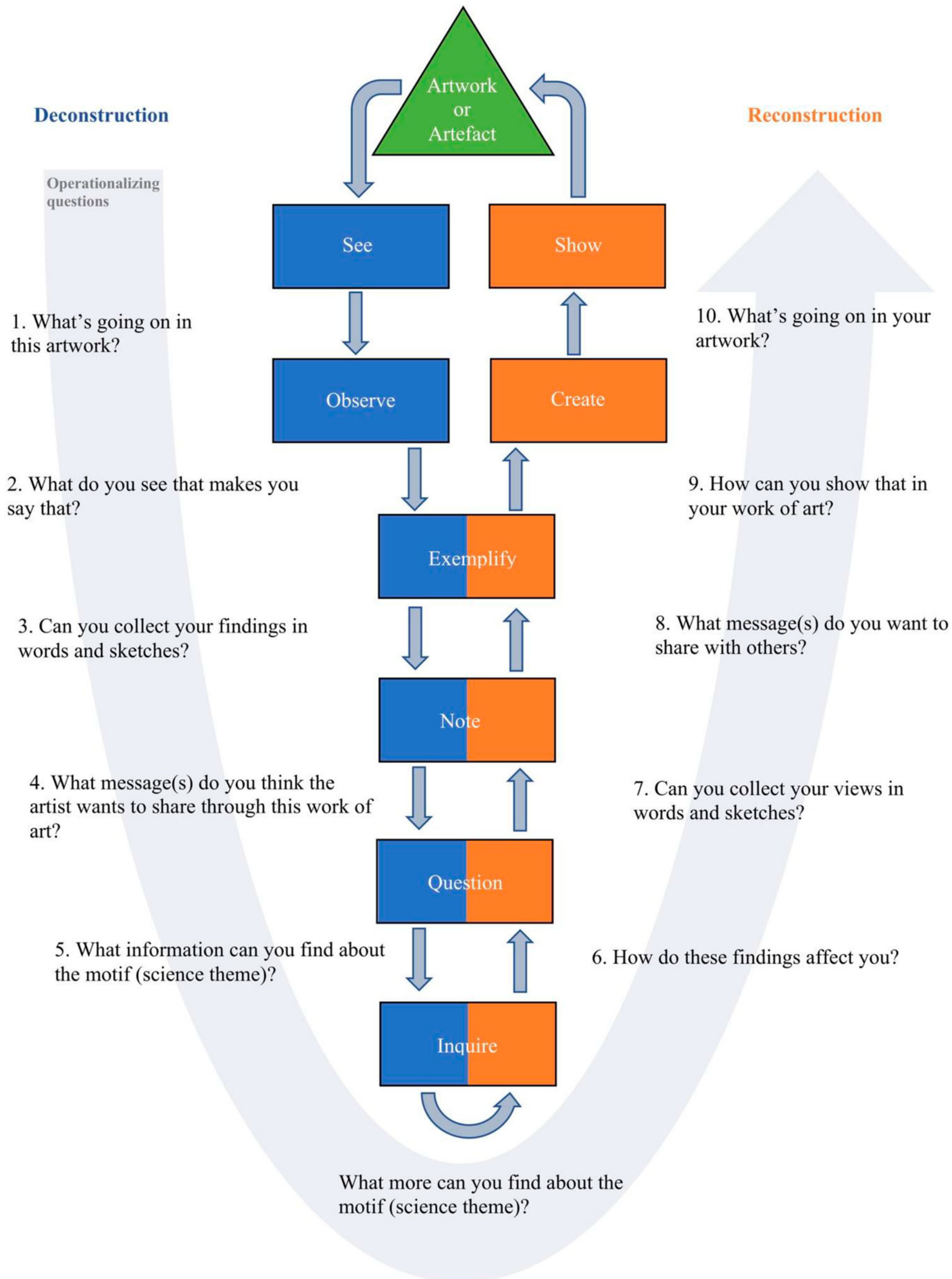

Figure 3. Model of actions and operationalising questions for systematic analysis and synthesis of artworks in the *ALP* based on VTS.

encouraged to deconstruct images of two artworks related to a selected science theme in the classroom, by helping them to systematically study, analyse and discuss the artworks' details together with peers. The teacher addresses the first three operationalising VTS-questions, as illustrated in Figure 3, with the whole class. The second image is treated

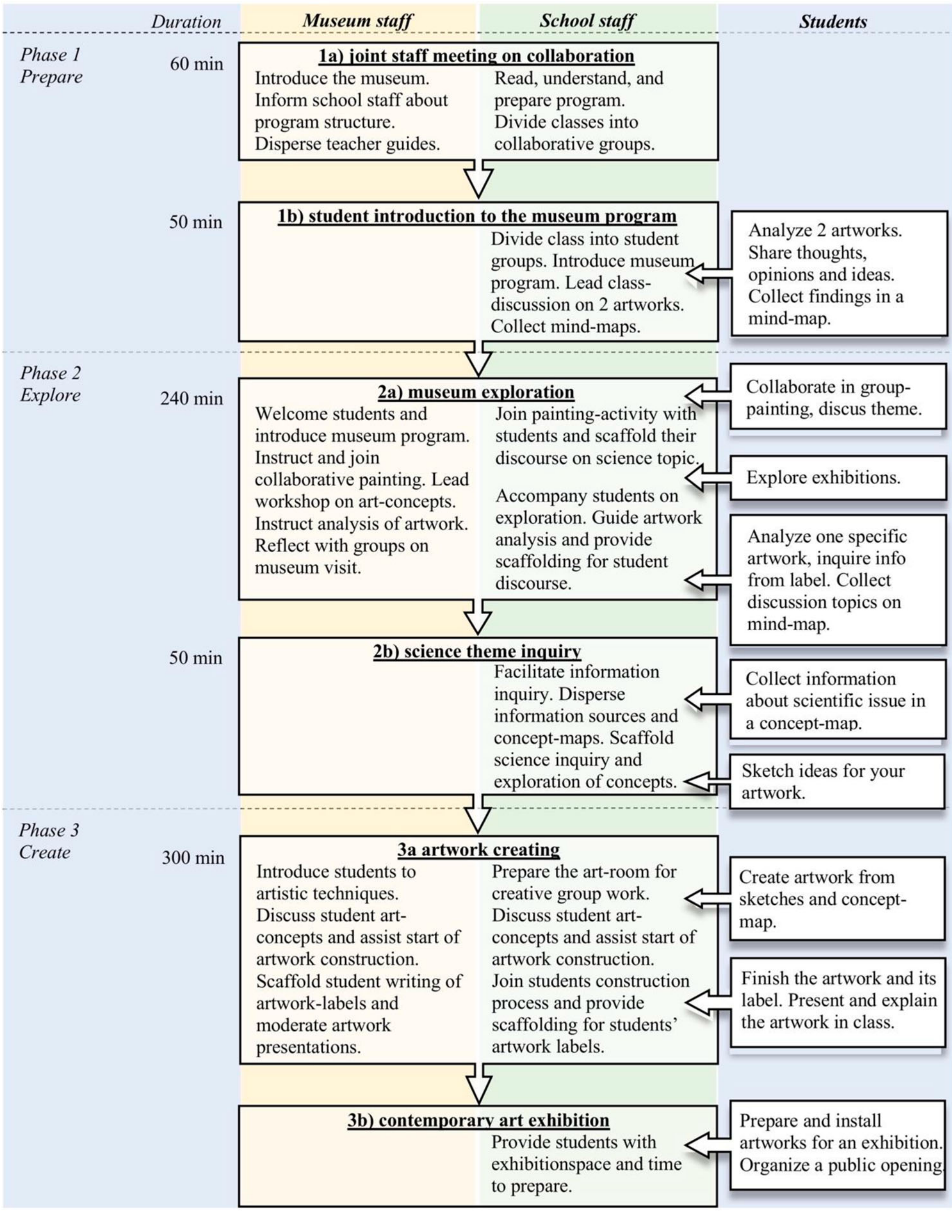

Figure 2. Summary of the *ALP* structure, including museum and school staff instructions and student activities.

similarly but with 3–4 students. During the group conversations, students are encouraged to write and sketch their findings about the artwork on a mind-map template.

During the start of phase 2 (explore), the museum educator leads similar VTS conversations as in the previous phase on images of artworks at the museum. The conversations are concluded with an outline of the key concepts substantiating the science theme. Students also receive information about the final phase in the programme concerning creation

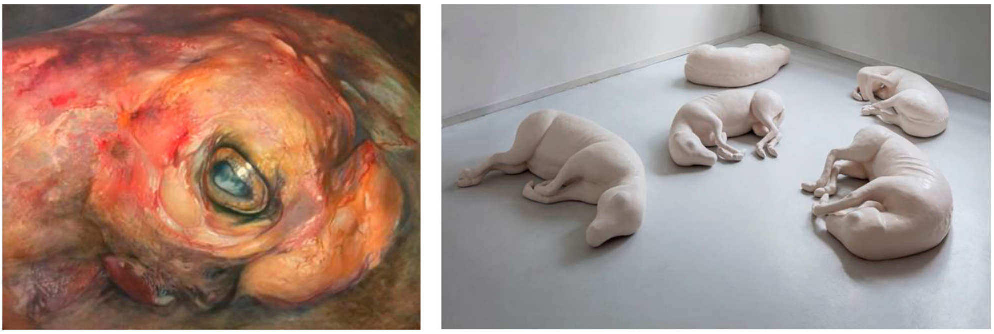

Figure 4. Two examples of artworks included in the *ALP* relating to the themes *animal exploitation*, *evolution and creation*, respectively. Left: Sheep eye [Painting], by K. Broos, 2019, Alma Löv Museum of Unexp. Art, Östra Ämtervik, Sweden. Copyright 2019 by Karin Broos. Right: Sleepers [Sculpture], by Lovisa Ringborg, 2020, Stockholm, Sweden. Copyright 2019 by Lovisa Ringborg.

of their prospective artwork in collaboration with museum educators and teachers. Phase 2 continues at the museum with encouragement of students to repeat the same analytical procedure as in the previous parts but with a real artwork in an exhibition room. Figure 4 shows two examples of such artworks. Besides the previous VTS questions, students are asked to actively consider the artwork in relation to the science theme and what they know or would like to know about the theme. The students can consult the artwork's description, a printed outline of key concepts of the science theme, their mobile phones, and both the museum educators and teachers present. The museum visit ends with a group reflection on students' experiences of the exhibition. Back at school, phase 2 continues by supporting student groups to further inquire about, reflect on and discuss information regarding the science theme, depicted by the discussed artworks at the museum. The inquiry process is led by a teacher who follows the reconstruction line of questioning (See Figure 3) and provides students with appropriate sources of information and feedback to scaffold their inquiry process. During this activity, students are encouraged to write and sketch conceptual ideas for their own artworks on a concept-map template.

In phase 3 (create), museum educators visit the school to collaborate with students and teachers in the artwork reconstruction process. The activity begins with a brief reflection on the student-groups' artwork concepts and how they relate to the science theme. After possible alterations, a decision is made on a construction plan for their visualisations, together with the museum educators and teachers. Thereafter, students engage in the creative process of constructing an artwork that visualises their views on issues with the science theme. During the construction, they repeatedly express and clarify their intentions in conversations with peers and adults, providing multiple opportunities for students, museum educators, and different subject teachers to reflect on the science issue behind their artwork. Moreover, students are encouraged to write a descriptive label (based on a template) to place beside their artwork in the joint exhibition. When the artworks are finished, every group briefly presents their artwork and explains their intentions concerning the visualisation of the science issue.

Method

The next two sections describe our dataset, comprising 44 *ALP* design guidelines (hereinafter guidelines) and 38 FMP design instantiations (hereinafter instantiations). The last section describes the nature of the comparative analysis to evaluate the *ALP*'s consistency with the FMP.

The ALP guidelines

The *ALP* guidelines concisely describe applications of resources, structural characteristics, and instructions to prepare and direct museum-educators, teachers and students throughout the programme. They are intended to be general enough to apply in multiple out-of-school contexts, but sufficiently detailed to support participants in each specific context. Details can be tailored for specific contexts. Thus, the guidelines describe broader pedagogical intentions as well as the directions and responsibilities for detailed applications. The guidelines were divided for the comparative analysis according to the FMP principles, which summarise the intended contribution of each guideline to the programme's overall design. Three example guidelines are presented in Table 1, and all 44 guidelines are shown in the data analysis matrix in Appendix 1, see supplemental data.

The FMP instantiations

In accordance with the FMP design principles, as described in the theoretical framework section, DeWitt and Osborne (2007) collaborated with museum educators to formulate 38 design instantiations to develop an 'activity unit' for students visiting a space gallery in London. The instantiations describe general rules for structure, activities and resources to implement and operationalise the FMP design principles in the space-gallery context. Three examples of the instantiations are presented in Table 1 and all 38 in the data analysis matrix in Appendix 1, see supplemental data.

The comparative data analysis

Each of the four authors was given a copy of 44 *ALP* guidelines and 38 FMP instantiations. Following an approach applied in a comparison of hypothetical and actual learning trajectories by Dierdorp et al. (2011), each *ALP* guideline was compared to a related FMP instantiation by each individual author separately. Subsequently, + symbols were assigned to guidelines that were clearly consistent with instantiations and – symbols to guidelines that were clearly inconsistent. Furthermore, a ± symbol was assigned if a guideline partly matched an instantiation (e.g. if they had the same outcome, but the method to achieve the goal differed fundamentally). This three-point (consistent, +; partly consistent, ±; and inconsistent, −) scale was deemed appropriate for the assessment, given the nature of evaluation. Where a wider scale would involve distinctions on a detail level that is barely justifiable, a two-point scale would restrict the analysis to an unnuanced comparison. The assigned scale points by individual authors were entered separately in a comparative data analysis matrix, with space to include comments. The results of the four comparisons were checked, and similarities and differences

Table 1. Section of the comparative data analysis matrix, exemplifying *ALP* design guidelines deemed to be consistent (+), partially consistent (±) and inconsistent (−) with FMP design instantiations.

FMP principle		*ALP* design guideline	FMP design instantiation	Result
(II) Providing structure	11	Programme structure: the programme comprises a prepare- (pre-visit), explore- (visit) and create phase (post -visit) during three separate occasions.	The pre-visit and post-visit activities linked directly to the content of the visit.	+
(IIIc) Choice and control	32	Artistic freedom: students choose an artform that fits to express their thoughts, feelings, and knowledge about a topic.	Pupils had to decide what photographs to take in the gallery, how much information to write, and what information to note.	±
(I) Adopting the teacher perspective	5	Staffs meeting: the museum staff presents and discusses the programme structure and content with school staff during an 'ordinary' school meeting to initiate and plan their collaboration.	Attempts were made to keep the implementation time (of resources) reasonably short.	−

were discussed between the four authors until consensus was reached on all 44 comparisons. This resulted in a final scale point assignment, which was compiled into a final comparative data analysis matrix. A small section of that matrix is shown in Table 1 and the complete matrix in Appendix 1, see supplemental data. A composition of the results is presented in Table 2.

Results

Table 2 summarises results from the comparative analysis of the *ALP* and FMP. Of the 44 guidelines, 28 were found to be consistent (+), nine partly consistent (±) and seven inconsistent (−) with the FMP. For five guidelines, no FMP counterparts were found. A complete overview of results of the comparison of *ALP* guidelines and their FMP counterparts is presented in Appendix 1, see supplemental data.

Discussion

Here, we discuss aspects of the guidelines that are consistent (+), partly consistent (±) and inconsistent (−) with each of the FMPs' main principles, in the order listed in Table 2. Implications of the findings are also addressed, particularly the potential importance for development of a *third space*.

Table 2. Consistency of the *ALP* design guidelines (nos. 1–44) with the FMP design instantiations.

	Consistency of comparisons								
FMP-principle	+				±			−	
(I) Adopting the teacher perspective	1	2	4	5	3			6	7
(II) Providing structure	8	10	11		9			12	
(IIa) Reduction of the novelty effect	13	14							
(IIb) Reinforcement of the learning experience	15	16						17	18
(III) Encouraging joint productive activity	19	20	21	22	23				
(IIIa) Discussion among peers and with adults	26				24	25			
(IIIb) Curiosity and interest	27	28	29					30	
(IIIc) Choice and control	31	33			32				
(IIId) Cognitive engagement and challenge	37				34	35	36		
(IIIe) Personal relevance	38	39						40	
(IV) Supporting dialogue, literacy and/or research skills	41	42	43	44					

(I) Adopting the teacher perspective: prepare for a third space

Consistent guidelines

Collaborations between museums and schools are more likely to be successful when they are coordinated by museum educators (Kisiel, 2010). However, without adopting a teacher's perspective, teachers often refrain from engaging in out-of-school activities (Braund & Reiss, 2004; Czerniak & Johnson, 2014; DeWitt & Osborne, 2007; Stocklmayer et al., 2010). Both the *ALP* and FMP acknowledge the importance of alleviating teachers' workloads and providing resources according to national curricular standards (guidelines 1, 2, 4, 5). Consequently, the development and use of such resources encourage educators from both sectors to initially get involved with each other's community discourses, hence preparing for a *third space* (Moje et al., 2004). Since its implementation in 2018, the *ALP* meets the requirement of adopting a teachers' perspective and continues to adjust its content and instructions with the feedback from participating teachers.

Partly consistent guidelines

The *ALP* used familiar educational formats like mind-maps, which are consistent with the FMP's use of spider-diagrams. However, the *ALP* introduced an art-based teaching strategy (guideline 3), unfamiliar to most science teachers. In conversations with the first author, most participating secondary science teachers affirmed they never use artworks as an object of entry into a learning situation. Furthermore, few had encouraged students to create their own visual forms to develop and show understanding, which corresponds with earlier findings (Ainsworth et al., 2011). While familiar formats reduce the teachers' 'novelty space', introducing an unfamiliar teaching strategy can foster *a third space*. The *ALP* implementation of an art-based science teaching strategy promoted active collaboration between teachers and museum educators but also crossed boundaries between art, science and humanities. This ties in with Fallik et al. (2013) recommendation for museum educators to adapt the design of their programme, so it can be fruitfully used in multiple learning contexts to blur the boundaries between them.

Inconsistent guidelines

The *ALP* implemented two physical meetings between staff members from both contexts prior to student participation (guidelines 6 and 7). The FMP showed no counterparts with these *ALP* guidelines. The meetings encouraged mutual recognition and acquaintance with each other's work environment, thereby contributing to bridge between in-school and out-of-school contexts and preparing to explore *a third space*. Initial questions, concerns and choices about student activities, artworks and resources were collectively discussed. Although implementing the teaching strategy saves time, it is arguably more important that the staff meetings fostered a reciprocal interaction between the museum educator and teachers. *ALP* guidelines 6 and 7, therefore, address the observation of Falk and Dierking (2012) that teachers often have a poor understanding of museum educators' roles and capabilities (and vice versa). During the meetings, school staff could experience student activities, thus reducing the 'novelty space' for teachers (Fallik et al., 2013) and receiving guidance to use museum resources (Rennie, 2014).

(II) Providing structure: exploration in a third space

Consistent guidelines

> If learning outside of school is to complement the science curriculum in school, students need sufficient structure to prepare for an active but enjoyable participation in the out-of-school experience and consolidating activities back in the classroom. (Rennie, 2014, p. 138)

Teachers also reportedly consider a well-planned educational programme focusing on a specific area of knowledge as the most important element of their classes' museum visits (Riksutställningar, 2017). Like the FMP, the *ALP* meets the need for structure in museum experiences by providing focused activities on a science theme during the pre-visit, visit and post-visit phases (guidelines 8 and 11).

Partly consistent guidelines

Despite the *ALP*'s consistency with the FMP in providing a structure through pre- and post-visit activities, there was a crucial difference in implementation of the latter. During the create phase (post-visit) in the *ALP*, the museum educator travelled to the participating school and supported student's art-concept development and artwork construction in a school context. During four sessions, comprising 6-hour exercises, continuous interaction between students, the museum educator and teachers from different disciplines was realised. All participating students and educators shared their knowledge and skills. Observed conversations covered possible views on gene technology, associated values, and ways to visualise them in a personal artwork. The reciprocal visits and the museum-school-staff collaboration in the *ALP* invigorated exploration of *a third space* and blurred the lines between contexts, school subjects and educators.

Inconsistent guidelines

We found inconsistencies between the *ALP* and FMP concerning the unfamiliar art-based teaching strategy (guidelines 12 and 18). The VTS approach to analyse images was systematically used and repeated during the *ALP*. The repetition in different phases and contexts provided structure and reinforced the learning experience from earlier occasions. As students at first analysed images with support of an educator, they subsequently were encouraged to apply VTS themselves when observing new images. The extended line of VTS questioning encouraged students to inquire more about examined artworks and their science-related motifs. The artworks catalysed discussion between students regarding science- and art-based knowledge and skills to communicate a contemporary science issue. Through this VTS-adaptation, the *ALP* empowered student groups to observe, analyse and express art- and science-concepts more independently within museum and school contexts.

Students made sketches and took photos of (parts of) artworks at the museum (guideline 17). This might have supported the development of students' ability to visualise a science theme in their own art-concepts during the following phase, thus reinforcing learning experiences at the museum in a school context. This guideline contradicted the FMP counterpart: 'encouraging students to take photos to entice teachers to follow through with the post-visit activity' (DeWitt & Osborne, 2007).

(III) Encouraging joint productive activity: creation in a third space

Consistent guidelines

We found that the guidelines describing parts of the create phase of the *ALP* matched FMP principle III. Students collaborated in groups (2-3 individuals), creating and presenting open-ended, discussion-provoking objects showing personal interests, knowledges and values connected to gene technology. During the *ALP*, art teachers supported students with their knowledge of artworks, image analysis, artistic materials and techniques. Science teachers supported students with their knowledge of gene technology and the views depicted in professional and student art. Language teachers provided guidance in writing descriptive art-labels, and civics teachers contributed with skills and knowledge on ethics, argumentation and societal norms. The support of this varied collection of subject-teachers was focused on the production of the same object for every student-group. Different teachers' perspectives on the same object made students aware of its connection to more than one school subject and more than one view. In contrast, 'Compulsory schooling tends to give rise to pupils who have been inducted into a range of disciplinary forms, though not necessarily into ways of seeing the connections between these different disciplines' (Colucci-Gray et al., 2017, p. 35). Thus, the alternating mix of different discourses and competencies in one classroom supported student's 6-hour art-construction process, crossed the boundaries between their subjects and, side by side, created a *third space*.

Partly consistent guidelines

The *ALP* contexts and instructions engaged students in others' and their own views and values related to a science theme (guideline 32). We found this to be only partly consistent with the FMP, which aims to promote inquiry-based learning, but not necessarily students' exploration of communication on science-related values. The *ALP*'s art-based teaching strategy scaffolded student's reflections by encouraging closer observation and further reasoning about the 'story' an artwork depicts. Subsequently, it supported conceptualisation and visualisation of their own views on a science issue. Figure 5 presents an example of a worked-out art-concept and its final form related to climate change. The *ALP* activities engaged all participating students. During the implementation, not one student dropped out, and all student-groups willingly presented their artwork in front of the class. Afterwards, several teachers reacted with surprise regarding the participation of certain students that rarely contribute in class. The presentations often raised questions and conversations that encouraged *re-seeing* the artworks (Pugh & Girod, 2007). We observed that the focus on the artwork draws away attention from the presenters, possibly resulting in a less nervous situation for some students to be in front of the group.

Inconsistent guidelines

Two *ALP* guidelines (30 and 40) that encourage joint productive activity differed clearly from the FMP. One is utilisation of a museum's 'odd environment', which is not included in the FMP instantiations. 'Visitors are drawn to museums because they contain objects and experiences outside their normal experience. Visitors appreciate the authentic, 'real' thing and come to museums to experience this uniqueness' (Falk & Dierking, 2012,

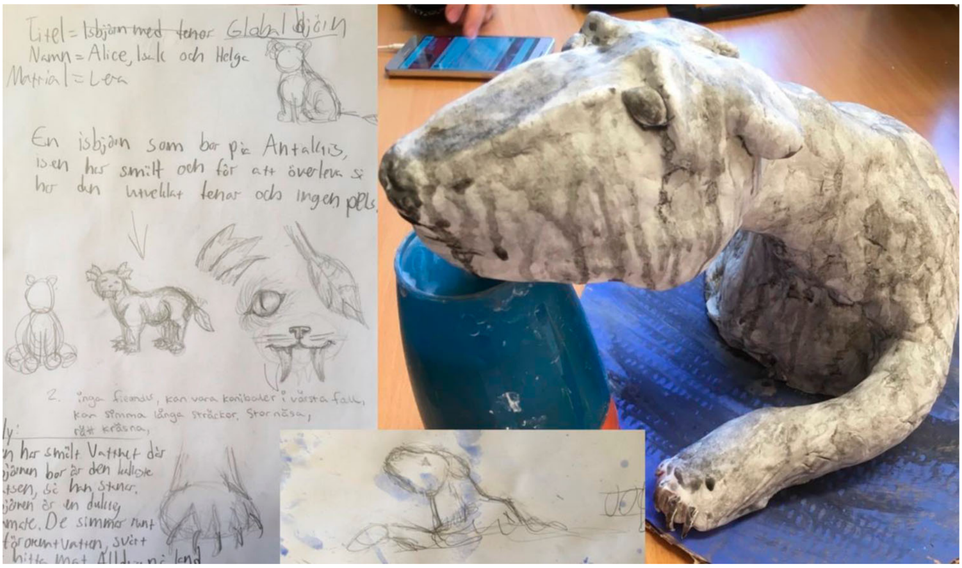

Figure 5. An example of a student generated sculpture and its antecedent concept map with notes and sketches relating to climate change [Photographs], by H. Raaijmakers, 2019.

p. 25). A museum environment can strongly differ from conventional school classrooms and thus trigger students' curiosity. The Alma Löv museum aims to offer visitors a deviating, seemingly unorganised and creative environment that emphasises the power of imagination. Secondly, no FMP counterpart was found for the *ALP* guideline regarding the public sharing of participant generated objects. Inviting family, friends, schoolmates, school staff and local press to the opening of a contemporary art exhibition can serve several goals. It can contribute to students' personal relevance through the opportunity to share a personal work with important people in their lives. It also provides a new occasion for dialogue with peers and adults about the science issue depicted, where they must engage and can be challenged cognitively. Moreover, it can empower student's own choices, and arouse curiosity and interest in science issues depicted by other students' artworks.

(IV) Supporting dialogue, literacy and/or research skills

We detected no deviation or inconsistency between the design guidelines associated with this principle and the FMP's design instantiation.

Limitations

The *ALP* was designed and tailored for schools by the first author in the capacity of museum educator. Therefore, objective evaluation of the programme, with theoretically robust conceptualisation and validation of its design, was crucial. To avoid conflicts of interest, research on the programme was conducted and peer-monitored equally by all four authors. Furthermore, the programme's design guidelines were compared with design principles of an established framework for museum programmes (the FMP). The systematic and rigorous comparative analysis resulted in a rich transparent comparative description of the two designs, as found in Appendix 1, see supplemental data. Nevertheless, the validity of our conclusions inevitably rests on the validity of assumptions underlying the applied theories and the quality of our interpretations. Applications of the programme, with appropriate adjustments, in various cultural settings and with various focal scientific issues, would be valuable for assessing the generality of our conclusions.

Conclusions and implications

Of the 44 *ALP* guidelines, 28 are consistent (+) and nine are partly consistent (±) with the FMP design instantiations. The predominant consistency of the *ALP*-concept with the FMP principles validates the *ALP*'s potential to guide museum educators, teachers, and students in- and out-of-school. Moreover, there are several consistencies and distinctions between the *ALP* and FMP, with potentially important implications for a *third space*:

– The initial establishment of a *third space* in a context-based cooperative between schools and out-of-school organisations can benefit from mutual acquaintance and recognition through physical meetings between the respective staffs prior to student participation.
– Inclusion of a pre- and post-visit structure, alternating between in-school and out-of-school contexts, where educators from both contexts are present to scaffold student conversations side by side, can facilitate a *third space* where students can encounter reciprocal support.
– An art-based science teaching strategy can encourage a *third space* through interdisciplinary interaction, with an input of knowledge and skills from students and adults that are rooted in scientific, artistic and humanistic discourses.
– An art-based science teaching strategy can also enhance value-centred teaching that offers empowering contexts and instructions for students to explore possible views and values associated with contemporary science issues.

The authentic and engaging design of the *ALP* has the potential to enable 'an experience' for students and foster learning about science. Grounded in context-based, interdisciplinary and value-centred teaching, it pushes on the FMP and opens a *third space* where environments, knowledges and feelings can merge. Museum educators can engage schools in reciprocal support for a creative exploration of their (science) exhibitions, informed by the *ALP* design. The additional design guidelines, compared with the FMP, could inform new research on the implementation and nature of a *third space* in other out-of-school contexts. The potential benefits of deploying art-based teaching strategies in a *third space* can contribute to further development and conceptualisation of STEAM and the nature of aesthetics in science education. To develop and improve support of students in holistic educational practices, empirical evidence concerning the impact on student's personal development, learning and engagement is required.

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