

The Art of Co-Creating Arts-Based Possibility Spaces for Fostering STE(A)M Practices in Primary Education

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Abstract

This multi-method project asks what the arts, in transdisciplinary learning spaces, can contribute to primary education. We position our work at the interstices of: (i) the rising wave of interest in, and imperative for, building sustainable creative futures; (ii) the concept of the Anthropocene which pulls together ideas of environmental change and the relevance of education for society; and (iii) allowing pedagogical experimentation across subject boundaries to broaden learning opportunities for empowering children. Methodologically, we use the dimensions of an arts-based perceptual ecology, where direct experience, the magical (a special and exciting quality that makes something seem different from ordinary things), intuition, imagination, art-making and the language of pattern become part of an interconnected learning system, to explore how children and their teachers co-create possibility spaces for fostering transdisciplinary learning. Using a sculpture installation as stimulus, we analyse three sets of transdisciplinary practices enabled by the co-creation of possibility spaces. The first set of practices featured an artist-led workshop for teachers to engage with an art piece, to think with their hands and to work with clay as a generative event for planning curriculum spaces for transdisciplinary activities for their children. In the second set,

children were invited to respond creatively to the art piece and consider the world as something we make rather than as something we inherit. The third set featured use of the language of patterns, connecting mathematics and art, or mathematics and music. We analyze and interpret the practices using an arts-based perceptual ecology (ABPE) framework from which to see how the arts, along with science, technology, engineering and mathematics (STEM), as a ‘bracketed’ concept (STE(A)M), is included, located and functions. We conclude and offer recommendations for the innovative work of primary schools as a whole – that is to say, the curriculum, pedagogy and the wider life of the school – to co-create the spaces for this kind of arts-based perceptual ecology in enhancing science, technology, engineering, arts and mathematics (STE(A)M). We argue for the ongoing and necessary theorizing of possibility spaces for arts positioning within STE(A)M education.

11.1 Creating Possibility Spaces for STE(A)M in Primary Education

The urgency for charting new sustainable development goals (SDGs) for the Earth’s resources, on which human life depends, is irrefutable, and is being played out across local and global scales (Leach et al., 2012). Similarly, there has been a great deal written about the need for pushing out the boundaries of how we learn at all levels, from K-12 to college and graduate levels, but, particularly, starting with the possibilities in primary education. Meeting the challenges of the 21st century needs to begin in primary education. In the UK, the Warwick Commission Report (2015) reminds us that, globally, our education systems should be creative learning landscapes, infused with possibility spaces. In this scenario, important challenges arise for curriculum design and enabling pedagogical experimentation across subject boundaries to broaden learning opportunities for children. The addition of the ‘A’ to STEM subject teaching comes as a means of humanising science and technology-enhanced learning: for it to be informed by the arts (Ge, Ifenthaler & Spector, 2015) as well as a site for developing technological expertise (see Chung, 2007); and for it to involve active learning strategies (Fenyvesi & Lähdesmäki, 2017). Defining STE(A)M reflects an articulation of what is absent from, or problematic with, any particular author’s conception of STEM education rather than a positive ascription of a subject domain or pedagogical approach.

Much of the STE(A)M literature echoes a view of the arts as valuable both intrinsically and instrumentally; the arts are deemed to be social,

inclusive, humanising and thereby significant for human development in society (Belfiore & Bennett, 2007; Canatella, 2015). Arts education literature proposes that engagement with the arts in education matters in children's education (Wade-Leeuwen, 2016; Korn-Bursztyn, 2012). Specifically, in STE(A)M education, the arts intrinsically bring a roundedness to the educational experience of pupils in which they can connect different aspects of their own and other human experience and practice (Trowsdale, 2016). As such, it is argued that the arts retain their legitimacy as specific and equally valuable perspectives on the world. The addition of the 'A' also signals more creative pedagogies (Sefton-Green *et al.*, 2011) thereby giving children a more positive view of and engagement with the STEM subjects. Whilst we strongly advocate for this position, by including the (A) in brackets, we continue to problematize how the arts are configured alongside other subject disciplines in STEM education. We want to continue to ask questions to strengthen the position that arts-based practices generally, and art-making specifically, is integral to ways of being, becoming, knowing and not knowing that are experienced as radically different; all of which may be enacted in transdisciplinary forms of inquiry and learning (Marshall, 2014). Studies often characterise the use of the arts *as a way of knowing* in STEM education. There still remains, however, much debate about the integration and infusion of the arts across the primary school curriculum. How curriculum subjects can work together in primary education, rather than as separate subjects (Russell-Bowie, 2009), remains under-theorised.

Some 20 years ago a path-breaking UK creativity researcher, Anna Craft (2015), coined the term 'possibility thinking' (PT). Co-researching with teachers and practitioners in early years and primary classrooms, Craft, along with her collaborators, sought to identify the nature of PT together with pedagogical strategies that seem to foster 'what if' and 'as if' thinking in children aged 3–11. Classroom and policy strategies were devised to foster the development of PT which generates novelty operationalized by question-posing, play, immersion, innovation, being imaginative, taking risks, and self-determination within the enabling contexts of time and space which foster it (see Burnard *et al.*, 2006). Beyond the seminal studies led by Anna Craft and her team (Burnard *et al.*, 2006), numerous subsequent studies were undertaken, fuelled by the potential of PT, the generative practices of artists working in collaboration with primary educators, and the importance of co-creating education futures to consider 'how' children 'might' learn creatively for the 21st century (Craft, 2015).

It could be considered that we are living in the age of the Anthropocene, a period in history where the planet has been irretrievably changed and altered by human activity and practices. Within an apocalyptic context, there is growing movement for reconciling art and science for sustainability (Stirling, 2012); that is, integrating art and science for transformative understanding and building social ecological resilience (Westley, Scheffer & Folke, 2012). There is also significant interest in transdisciplinarity: that studying Science, Technology, Engineering and Mathematics (STEM) as separate subjects is increasingly seen as an anachronistic task even for those going on the path to become scientists and mathematicians. It is concerning that children in primary education think that STEM subjects lack creativity and often do not relate to the aspirations they have for themselves (Mendick, Berge & Danielsson, 2017). The rise of the term STE(A)M, to denote the inclusion of the Arts (the (A) in STE(A)M), has the capacity to embrace and transform the landscape of 21st century learning in primary education. In this chapter we attempt to capture the essence of the potentials of subjects for synergy. Studies often characterise the impact of exposure to arts-based representation of scientific knowledge in terms of the participants' ecological awareness or the role of arts in the creation process of scientific knowledge and the scientific value of seeing everyone as an artist and experiencing aesthetic qualities that arise from perceptual appreciation in the experience of art-making (van Boeckel, 2013). We now turn to the practice of arts-based perceptual ecology as a heuristic method for learning about the language of place.

11.1.1 Introducing Art-Based Perceptual Ecology (ABPE) Methodology

American artist and scholar Lee Ann Woolery (2006) introduced the concept of *Art-Based Perceptual Ecology (ABPE)* as a way of knowing the language of place. Woolery identified six core dimensions of ABPE-methodology. (Perception is understood here as the process of making meaning out of sensation.)

The six core dimensions that comprise the art-based perceptual ecology (ABPE) framework which we applied as tools to conduct thematic analysis, with multiple readings of each practice, are:

- i. **Direct experience** which relates to recognition of the role of the body as the connection between self and world; forming a dialogue with images

and landscapes; moving back and forth between image making and the dialogue with objects or landscapes; and reflecting and writing.

- ii. **Magic** which refers to a special and exciting quality that makes something seem different from ordinary things; a parallel world next to the world of ordinary experience; the supramundane world of extraordinary experience where, like entering and exploring unique landscapes, languages and cultures, the domain of magic may be understood by observing young children at play or making art through deep attention and contemplation; this magical dimension involves a mindful shifting of one's perspective towards art. Indeed, art-making, in its highest form of expression, is a kind of magic. And in the magic of creation, the child becomes immersed in various art-making modalities.
- iii. **Intuition** that explores the language of what one feels ... "a way of seeing through sensing", "an internal knowing of that which is invisible" (Woolery, 2006, p. 8); one draws on clues; one senses a pattern or underlying condition that enables one to imagine and then characterize reality; sensory understanding; intuitional and visceral ways of knowing; the bridge between explicit and tacit knowledge.
- iv. **(Using) Imagination** becomes a modelling device through which we can test possibilities.
- v. **Art-making** refers to the act of making art as a tactile event, a complete body experience where you feel the shapes inside your body and your body wields the tools that capture the shapes and, as a consequence, an artistic way of knowing can come about.
- vi. **Language of pattern** addresses the dimensions of structure and pattern, focusing attention on shape, form, color, line, light and dark, value and pattern; shifting from macro to micro and foreground to background.

Methodologically, we purposively selected Art-Based Perceptual Ecology (ABPE) as our analytical framework and all six core dimensions (listed above) are clearly signposted throughout the chapter. ABPE gives a major role to key dimensions which are essential in understanding how to create the possibility spaces for STE(A)M education. The image that the teacher as artist, and the child as artist, produce can be seen as a symbol or transitional object that represents "the language of what one feels (*intuition*), with what one can touch (*direct experience*) with what one cannot see (*magic*) and *imagination* becomes a modelling device through which we can create possibility spaces" (Woolery, 2006, p. 13) (see Figure 11.1 where the ABPE methodology can be seen as framing the analysis and operationalising the process innovation in primary education).



Figure 11.1 UCPS, where releasing imagination and possibility thinking are central dimensions of the learning landscape.

Building on Hammersley, Gomm & Foster (2009), we utilise a comparative method of analytical deduction in relation to Woolery’s dimensions or tools, looking, firstly, at what theory highlights about practice and, secondly, for similarities and dissimilarities in application. Comparative analytic analysis is open-ended; it goes beyond testing a hypothesis or identifying causal relationships. The purpose of the analysis of each practice was to elucidate the ways in which ABPE dimensions shed light on data that represents the language of what one feels (intuition), what one can touch (direct experience), what one cannot see (magic), what one intuitively knows and what is held as memory in human cognition, which the learning space enables through the experience of art-making.

With its mission – “releasing the imagination: celebrating the art of the possible” (which pays homage to Maxine Greene’s social imagination work (Greene, 1998)) – the University of Cambridge Primary School (UCPS) (www.universityprimaryschool.org.uk), the UK’s first University Training School for primary education, seemed to be the most obvious site for our multi-method project. UCPS features a circular design with a central courtyard which suggests the democratic notion of education. The school provides education for children aged four to eleven. It is an inclusive school.

Displaying works of art and artistic work and engaging artists in participatory approaches who work at the boundaries of formal and less formal learning, are common practices in this school, a site where possibility 'space', an enabling context for possibility thinking, is embedded in the school's design. As Maxine Greene (1978) argues, "landscapes of our interior worlds flow and merge into the landscapes of the exterior world" and "can stimulate much needed educational change" (p. 37).

Glass panels form a canopy around the circular design, featuring the work of Ruth Proctor¹. Each glass panel is imprinted with an image of the sky taken from locations across the globe and stamped with time zone and geographical location. The art work itself is called 'We are all under the same sky'. Children at the school have engaged with these panels with both their teachers and artists. Dewey made clear the value of fostering and encouraging learners to value their own artistic cultures when he said "works of art are the most intimate and energetic means of aiding individuals to share in the art of living" (Dewey, 1934, p. 336).

11.1.2 Introducing the Installation 'With the Heart of a Child'

Commissioned by Anna Craft for the purpose of inspiring a vision of possible educational futures, 'With the heart of a child' is a sculpture installation described by its author, eco-artist/activist/sculptor Nicola Ravenscroft, as bringing together "all nations on Earth in the creation of a significant and innovative sculpture installation: it raises intellectual and emotional awareness of the urgent need to educate children and adults alike in the art of sustainable water management and conservation, and seeks peacefully to effect change, both to public policy and human behaviour"².

'With the heart of a child' embodies a powerful set of values and a message that lies at the heart of solving the pressing planetary problems shared by the global community. This powerful installation depicts six life-size bronze portraits of four-year old children (Figure 11.2) representing six continents and a rockhopper penguin-child representing Antarctica. It embodies two fundamentals of life on Earth – *water*, our most precious natural resource, and *children*, our source of continuity. The way in which the installation generates a new way of responding to these issues across the world remains under-theorised.

¹Ruth Proctor is an artist. Her work responds to the spaces and time she lives and works within. See <http://www.artspace.com/ruth-proctor>

²See www.withtheheartofachild.com for more information about the artist, and the purpose and significance of this installation.



Figure 11.2 ‘With the heart of a child’ installation.

The installation provided the basis from which to explore the significance and potential role of arts in developing new forms of STE(A)M education. From here, we articulated the research questions as follows:

1. What can the arts contribute to STE(A)M education in primary education?
2. How can the ABPE analytical framework provide a reference for understanding the enabling condition of ‘possibility spaces’ as a context for connecting STE(A)M in primary education?

The process of collecting, analysing and interpreting empirical data occurred between October 2016 and April 2017. Data were generated through collaborative discussions, classroom observations, and analysis of learning artefacts. This chapter is focused on the perspectives of teachers and children. These conversations fostered what Chappell and Craft (2011) described as a ‘living dialogic space’ where each of the researcher partners (co-authors of this paper) engaged in reflective enquiry practices to attain a deeper understanding of the meaning and point of the direct learning experience of art-making and thematic role of the arts in STE(A)M education. As Max van Manen (1990) explains, a theme is the experience of focus, of meaning, of point; it is a form of capturing the phenomenon one tries to understand: “Themes are the stars that make up the universes of meaning we live through” (p. 90).

As insider researchers, the translation of intuitively grasped meaning or tacit knowledge is not always possible through conventional and discursive renderings of language. Here we adopted an art-based research approach using ABPE methodology to interpret the role of art and art practice. The unit of analysis – the situated practices – and the data reduction involved the researchers narrowing in on three sets of data. Three data sets, covering both teachers’ and children’s perspectives, were collected and then subjected to extensive and focused analysis by all six researchers using the six core dimensions of the ABPE thematic analysis: **(i) direct experience, (ii) magic, (iii) intuition, (iv) imagination, (v) art-making and (vi) the language of pattern.**

These data sets were collected during the study over two school terms across 2016 and 2017. The six researchers, including an artist, several teachers, the Headteacher, a senior teaching assistant and university research partners were directly involved. Data were collected through (teachers’, artists’ and researchers’) discussions, observations, teachers’ self-reflection accounts, photos (taken by teachers), scrapbooks, workshops, artefacts, (children’s own) audio-recordings and interviews. *Data sets 1 and 2* feature teachers’ and children’s exposure to, exploration of, and interaction with a piece of art – the sculptural installation ‘With the heart of a child’. Both teachers and children were invited to work as artists, creating possibility spaces for figurative/abstract responses to the sculptures and for little-me making activity (van Boeckel, 2013). *Data set 3* features creation of possibility spaces, in a set of formal classroom practices, for the fusion of arts and mathematics, i.e. teaching and learning mathematics through seeing and hearing patterns, discovering one’s body in a new way, thinking with one’s hands, seeing music and hearing mathematics. The descriptive overview of the three data sets is presented in a tabular form below (Table 11.1). This is followed by a detailed description and analysis in narrative and visual form.

11.2 Analysis and Findings

As mentioned in the previous sections, art, art-making and art responding have been used to both collect data and interpret the role of art and art-making. The three data sets are presented, explored and analysed through the lens of the ABPE six core dimensions (direct experience, magic, intuition, imagination, art-making and the language of pattern) and their manifestation in different but interconnected and multi-layered practices.

Table 11.1 Overview of the three data sets

Purpose	Data Sets	Participants
	Data set 1:	
To observe the teachers' exposure to and interaction with a piece of art through art-making with an aim of inspiring didactic translation of their experiences and interactions with art into STEM lessons.	a) Non-participant unstructured observations of 12 primary teachers' initial exposure to the sculpture installation followed by teachers' photos and self-reflection accounts of their impressions, questions and internal dialogue. Purposeful engagement and interaction with the installation/the art.	a) 12 primary teachers
	b) Teachers' CPD workshop with 12 primary teachers, using clay and water to produce their own pieces of art which they integrated with larger sculptures creating their own new installation, followed by teachers' self-reflection accounts of their experience. Teachers then engaged in possibility thinking about innovative lesson plans in STEM subjects.	b) 12 primary teachers
	Data set 2:	
To observe the children's exposure to and interaction with a piece of art through creative cross-curriculum activities with the aim of inspiring connections between their experiences and cross-disciplinary/STEM learning.	a) Placement of the installation in a primary school – teachers' observations of children's reactions.	a) whole school
	b) Art and Design project inspired by the presence of the installation 'With the heart of a child' sculpture at a primary school – observations of the children's interaction with the installation and the art-making process of their own little-me 'sculptures' (artefacts) documented in a scrapbook .	b) 21 children and 1 teaching assistant, 1 artist (Nicky Smith), 1 governor/artist, 1 parent/artist (wider community)
	c) Cross-curricular activities involving Art (sketching), English (planning, writing, speaking, reading, drama), Computing (using digital media purposefully), Science (experiments with building and testing shelters made of different materials) – teacher's observations, an interview with the teacher and children's artefacts and audio recordings .	c) 25 children
	Data set 3:	
To observe and experience how STE(A)M teachers engage children/learners in creating possibility spaces through art-infused mathematics teaching/learning (seeing mathematics through art; hearing mathematics through music).	Observation of a Year 3 mathematics lesson, led by a specialist Finnish STE(A)M teacher, based on engaging with and creating arts and design-infused mathematics learning and a Year 2 mathematics lesson based on engaging with and creating an arts/music infused mathematics learning environment and interviews with the teachers.	49 learners 2 teachers 4 guest STE(A)M teachers

11.2.1 Teachers' Experience of and Interaction with the Installation (First Exposure to the Installation and Artist-Led Participatory Teacher Workshop)

The installation was placed at the UCPS and, as a non-gallery space, brought art closer to both teachers and children as well as providing inspiration for creating both physical and metaphorical 'possibility spaces' within a school setting. The first data set, realized as a participatory design workshop with teachers that was led by an artist, features the use of the sculpture installation 'With the heart of a child' to *inspire a co-created set of 'possibility spaces'* for STE(A)M education in the primary curriculum. Prior to the participatory workshop, the 12 UCPS teachers were invited to engage with the installation in a purely experiential way and, using their phone or an iPad, to take photographs/film/draw a particular part of the sculpture that attracted them. They were invited to note down any inner dialogue and intuitive responses.

Teachers had an opportunity to reflect and engage with the materiality, atmosphere and presence of the sculptures and, through this, reflect on the global position of children and water scarcity/sustainability. Teachers were able to touch and interact, on this occasion, something often prohibited in galleries or museums, but depth of engagement was not dependant only on the physical touch. The invitation was to respond to the sculptures, to be amongst them, to observe them, to notice their own inner dialogue (Figure 11.3).



Figure 11.3 Teachers' first exposure to, and interaction with, the installation.




Figure 11.4 Teachers' art-making.

The second part of *Data set 1* encompassed art-making as the 12 UCPS teachers attended a 'clay workshop' where they engaged both with the installation, with the movement of the 'bronze children' around the room and with the process of art-making itself. Teachers were asked to use clay and water as essential components of the bronze sculptures (the process of making bronze sculptures often involves clay and water before metal is used), to make an image, an abstract shape, a person or an animal in relation to their initial impressions (Figure 11.4).

They were encouraged to allow the materials and their emotional responses to reveal the shapes and meanings of their creations. They placed their own sculptural responses among the 'bronze children', thus curating their own installation. Towards the end of the workshop, teachers were asked to explore how their experience of the installation and process of art-making could infuse, or be integrated in, already planned school curriculum themes. They were asked to consider the implications of using an arts-based approach with their children (e.g. in science – water and sustainability). Teachers discussed, devised and wrote ideas on paper and then placed them on the wall with links and lines connecting with school curriculum themes. After the workshop, teachers' reflective accounts of their experience were collected.

Table 11.2 First data set's presentation and analysis

ANALYSIS OF DATA SET I	
(Teachers' Initial Exposure to a Piece of Art and an Artist-Led CPD Teachers' Workshop)	
Illustrative Examples	ABPE Core Dimensions and Specific Findings
	<p>Teachers' direct experience (i), exposure to and observation of the sculptures evoked <i>emotional states</i>:</p> <ul style="list-style-type: none"> ● un-nerved ● hope/hopeful ● confident ● determination ● excited ● compassion ● joy ● powerful ● submissive ● scared ● dried out ● burnt ● sadder ● despair
<p>Figure 11.5 One of the teachers focused on facial features.</p> <p><i>Quite haunting. The lack of expression and blurred facial features make me feel a little un-nerved</i> (Teacher A)</p> <hr/> <p><i>Hope, feeling hopeful, looking to the future, places to go</i></p> <p><i>Confident children ready to take on/explore the world</i></p> <p><i>Our children can achieve anything</i></p> <p><i>Determination</i></p> <p><i>The children had a very positive impact on me. I felt excited by them and wanted to know more.</i> (Teacher G)</p> <hr/> <p><i>Upon greeting the children for the first time my immediate emotion was that of compassion</i> (Teacher C)</p> <hr/> <p><i>At first, I feel instant joy on viewing the statues. The children look powerful ... the more I look at them, the more I think about the possibility of them being submissive and scared. They look dried out and burnt. I am feeling sadder and sadder ... It looks more like them looking up in despair now.</i> (Teacher F)</p>	<p>In the written reflections on their (i) direct experience of the installation, teachers linguistically illustrated <i>connection</i> between the sculptures and their own selves by alternating between writing about the sculptures (e.g. the children, they, them) and about the impact the sculptures had on teachers' own emotional experience (e.g. makes <i>me</i> feel, <i>I</i> felt excited, a very positive impact on <i>me</i>, <i>I</i> feel instant joy). Teachers described both the sculptures' and their own <i>emotional states</i>.</p> <p>The combination of <i>experiencing</i> emotional states and the relational dynamics between themselves and sculptures led to creation of <i>experiential possibility spaces</i> for <i>making meaning</i> out of connections between the 'bronze children' (others/world) and self.</p>

(Continued)

Table 11.2 Continued
ANALYSIS OF DATA SET 1

(Teachers' Initial Exposure to a Piece of Art and an Artist-Led CPD Teachers' Workshop)

Illustrative Examples



Figure 11.6 Teacher's focus on 'bronze child's' hands.

Our tiny hands must carry the same hope.

We crumble under the same need.

Our sleep is haunted by the same dreams.

Our hands are all the same. (Teacher B)



Figure 11.7 Teacher's focus on 'bronze children's' lips.

How can we release voices and open eyes to possibilities when children have no voice?

(Teacher C)

Are you ok? Where are your parents/carers?

Do you need a hug? (Teacher A)

ABPE Core Dimensions and Specific Findings

While taking photos of parts of the sculptures, teachers focused on their body parts (e.g. faces, lips, hands) and were interpreting them through seeing, hearing and feeling what was not explicitly there:

- "Our sleep is haunted by the same dreams"
- "Our tiny hands must carry the same hope"
- "... when children have no voices?"

Teachers also used 'we' and 'our' to refer to both the sculptures ('bronze' children) and themselves clearly indicating *unity* and *care and concern*:

- "Are you ok? Where are your parents/carers? Do you need a hug?"

Using (iv) **imagination**, (iii) **intuition** and allowing themselves to feel a 'magical moment' in a (ii) **magical space**, led teachers to (iii) **intuitively** experience what was not explicitly there thus opening *intuitive possibility spaces* for the *feeling of unity, concern and care* and bringing *otherness* closer to *self*.



Figure 11.8 Teachers working with clay and adding to the installation.

*... both working with the clay and adding to the installation made me more excited about the sculptures. I **felt more a part of them** and my understanding and **relationship** with the sculptures changed. The next day, I brought my class to feel the sculptures as we were exploring bronze as a material in our history studies.*

(Teacher B) – reflective account

*Using and relying on the senses, is not something I like. I am not comfortable to enter into **oneself**.*

(Teacher F)



Figure 11.9 Teachers exploring materials used for art-making.

*Working with this clay has deepened my understanding of the art work. In particular, through working with the clay and handling this material I have reconsidered the **relationship** between clay, water and sustainability.* (Teacher A – reflective account)

(Teacher A – reflective account)



Figure 11.10 Teachers interacting with the installation.

Teachers experienced an artist-led Continuing Professional Development (CPD) programme for teachers through (v) **art-making** as a tactile, open-ended, sense-based process. While using their hands, teachers fostered the appearance of *embodying possibility spaces* for *relational inter-connectedness* (e.g. with ‘oneself’, with the children/others, with ‘the sculptures’/a piece of art, with and across disciplines and subjects).

The (v) **Art-making process** inspired teachers to ‘blur’ dualisms between others and self, between the art-making process and a piece of art, between different groups of disciplines and subjects (e.g. using the installation for history, science, mathematics lessons) and build ‘connections’ across subjects.

(Continued)

Table 11.2 Continued
ANALYSIS OF DATA SET 1

(Teachers' Initial Exposure to a Piece of Art and an Artist-Led CPD Teachers' Workshop)

Illustrative Examples	ABPE Core Dimensions and Specific Findings
<p>... <i>I hope to use the ideas stimulated from this session within my planning. Specifically, I will consider the connections that can be made across subjects more carefully and creatively, as a result of ... interacting with the artwork.</i> (Teacher F – reflective account)</p>	
<p><i>The workshop has made me consider how we could plan a series of 'what if' sessions with the children working in small groups.</i> (Teacher G – reflective account)</p>	
<p>... <i>We could also use this as an opportunity for the children to think in scientific ways to solve the challenge of not having clean water. It would also be possible to discuss distance, measuring and capacity with the children through this activity.</i> (Teacher B – reflective account)</p>	
<p><i>This could lead to map making, story writing, film making, stage directing, dreaming and imaging. A soundscape could supplement all of these ideas.</i> (Teacher C – reflective account)</p>	
<p><i>Clay</i> <i>Move</i> <i>Mould</i> <i>Drip</i> <i>Drop</i> <i>Life</i> <i>Flow</i> <i>Forever</i> <i>Never</i> (Teacher D – reflective account)</p>	<p>Teachers' exposure and interaction with art provided <i>exploratory possibility spaces</i> for the appearance of the (vi) language of pattern: <i>internal and external patterns</i> in the form of, on one hand <i>expressing internal dialogues, thoughts and feelings</i> and on the other hand, <i>discovering external patterns and procedures of art-making</i> thus exploring both foreground and background patterns, visible and invisible patterns, physical and abstract patterns.</p>
<p>... <i>Splashing colour on</i></p>	
<p><i>On</i></p>	
<p><i>On</i></p>	
<p><i>Tired faces</i></p>	
<p><i>On</i></p>	
<p><i>Breathing in silently</i></p>	
<p><i>Deeply</i></p>	
<p><i>Reflecting on what why</i></p>	
<p><i>Why here in a school</i></p>	
<p><i>Why</i></p>	
<p><i>Silent teachers ...</i></p>	
<p>(Artist's reflective account while observing teachers' initial exposure to the installation.)</p>	

In summarising teachers' direct experience of and interaction with the sculpture installation, as with findings from the teachers' clay workshop and, in this case, the role of the installation in creating possibility spaces, we see evidence that:

- a. Through **(i) direct experience** of exposure to and interacting with a piece of art, teachers engaged in a curious, emotional and reflexive exploration of *experiential possibility spaces* for *making meaning out of sensation* through attempting to understand the *connection between the 'bronze children' (others/world) and self* (e.g. through evoking different emotional states from despair to hope). Teachers used descriptive narrative to express emotionally their **(i) direct experience** of the installation, and alternated between talking about themselves and the children (by using 'I'/'me' and 'children'/'them'/'they') thus demonstrating relational dynamics between 'others and self'.
- b. While experiencing and interacting with the installation, teachers used **(iv) imagination, (iii) intuition** and found themselves in a **(ii) magical non-gallery space** where they **(iii) intuitively** used either 'we' sentences (expressing unity of themselves and the sculptures/'bronze' children) or direct speech sentences (addressing the sculptures/'bronze children directly with 'you-sentences' when expressing concern and care for them). Direct speech was used when **(iv) imagining** and **(iii) intuitively** seeing and sensing what is not explicitly there (e.g. voices or lack of them, sleep or lack of it). Thus, *intuitive possibility spaces* for the *feeling of unity, concern and care* and bringing *otherness* closer to *self* seemed to gain significance. The sense of **(ii) magic**, a special and exciting quality that makes something seem different from ordinary things, that arose in the **(iv) imaginative** and emotive responses to the sculpture, was a sense in the imaginative possibilities inherent in teaching and learning; that there was wider significance in the work of teachers, beyond practical matters or accountability frameworks, but something more akin to the social **(iv) imagination** that Maxine Greene advocates (1998). There was a sense of **(ii) the magic** in the *intuitive possibility spaces*.
- c. While changing roles from being observers of art to active engagement with art through **(v) art-making**, teachers focused on relationship and connections with oneself, with each other, with the process, with the art piece and with different subjects through contemplating how to 'translate' their experience into a cross-curriculum/trans-disciplinary learning space for children. Thus, the *embodiment of possibility spaces*

for *relational inter-connectedness* (e.g. with oneself, with others, with a piece of art, with and across disciplines and subjects), was fostered.

- d. While exploring and making art, teachers discovered *exploratory possibility spaces* for expressing and discovering the *internal and external (vi) language of pattern* through expressing internal dialogues, thoughts and feelings and through exploring external patterns and procedures of art-making.

The teachers' reactions to, exposure to, and interaction with art were aligned directly with the affective, sensuous and embodied dimensions of learning where physicality and associated feelings shape learning (Claxton, Lucas & Webster, 2010; Fuchs & Koch, 2014; Kontra et al., 2015; Stolz, 2015). They experienced art directly and actively. The teachers experienced the process of creating possibility spaces, with the point of departure being a response to the art installation, and in this process, discovering how sensory perceptions can generate STE(A)M practices.

11.2.2 Children's Exposure to and Interaction with the Installation

The second data set explores the dynamic relational and living space between the installation 'With the heart of a child' and the children at UCPS.

The initial location of the installation in the school hall/gym (the bronze statues arranged in a line looking down from their plinths) was designed to provoke an open and child-led response. Initially, the learning was about asking questions – any question, all questions.

i. Direct experience: Similarly to teachers, children's first exposures to the installation opened *exploratory possibility spaces* for evoking *emotional states* as illustrated below by teaching assistant's observation:

Some of the children found them disconcerting: 'they are dead', 'they look sad', 'they look poor'. 'Why are some people poor?' The statues seemed to have an effect on the children because parents came to talk with the Headteacher saying that we needed to do more work with the children so that they didn't feel worried about the statues ... (Senior teacher assistant's observation)

The children viewed the statues in many different arrangements/positions. The installation was later moved to a smaller space to change the dynamic and qualitative features; it was moved to a special room named the 'the Nicola

Ravenscroft room’, which had a sign on the door reading ‘Nicola Ravenscroft and The University of Cambridge invite you to enter peacefully with an open heart and mind’. Children were encouraged to open their hearts and minds, thus reinforcing, this time, positive emotional states with which to approach **(i) direct experience** of the installation. Children’s emotional states moved from being scared and worried (*‘they look poor’*) for the ‘bronze children’ to entering the installation room with open hearts and minds. Thus, *making meaning* out of connections between the ‘bronze children’ (others/world) and self contributed to the creation of *exploratory possibility spaces* through the **(i) direct experience** of art.

vi. Language of pattern: The room/place contained all the ‘bronze children’ arranged in a different constellation – this time in an arc and at ground level. Different shades of blue material to create the impression of a vast ocean were used. As well as this, books about water, water-related pictures and a water music (CD playing in the background) were added (see Figure 11.11). The UCPS team clearly set out on a journey of arts-based perceptual ecology by bringing an awareness of *patterns* in the ‘landscape’ and changes in locations, positions and effect of art and how all these yield the language of place. Children experienced *exploratory external patterns* of different physical arrangement, location and positions of the installation and reacted differently to the installation based on its location and arrangement. The new curation was a provocation to teachers and children to ask more questions. The more intimate arrangement provoked different responses to the installation. New possibilities in new possibility spaces arose.



Figure 11.11 The installation room’s floor turned into ‘water’.



Figure 11.12 Final ‘sculptures’ made by Art and Design Club members.

v. Art-making: The Art and Design Club/Project was inspired by the ‘visit’ to the ‘With the heart of a child’ installation and, through self-selection, 21 children from Years 1–3 enrolled in the club. Children spent a few weeks working on creating their own ‘little-me’ sculptures, using foil and Modroc, with an overarching theme that included ideas and plans about future and ‘All about me’.

All the activities, ranging from creating artefacts to writing about themselves, were recorded in the form of a scrapbook. Over the period of a few weeks, children learned how to make a ‘sculpture/little-me’ of themselves in relation to their hoped for/perceived future by first using their own bodies to explore different stances, then manoeuvring wire and foil to create sculptures and finally completing Modroc ‘figures’ (Figure 11.12). The use of their bodies prior to art-making enabled children to explore art through *embodiment* of their future creation as documented by the Senior Teacher Assistant (TA) below:

Firstly, they were encouraged to think about their own bodies and how they could stand in different poses. The children stood up and practised standing in different stances. Next, they were given two pieces of foil to manipulate into a foil figure. All of the children set to work to create some amazing foil figures, all of the poses were so different. (Senior TA’s observations)

Thus, again, similarly to the teachers’ experiences, through a tactile, hands-on process, the children experienced embodying *possibility spaces* for art-making. The embodied responses were in connection to the *creation* of the world of the future rather than just *inheriting it*. It was in an empowering future of possibilities rather than in an apocalyptic vision of uncontrollable certainties that the children engaged in positive explorations of their futures.

I am blown away by the level of concentration, thoughtfulness and pride these young children demonstrated during the project (Senior TA's reflective account)

Using (iv) imagination, (iii) intuition and (ii) magic: Children also explored many art-based and art-inspired activities while visiting the installation room. A spectrum of teacher-designed activities took place, ranging from observation, sketching the installation, imagining the bronze children were a travelling circus troupe that ended up on an island, taking the identity of one of the bronze children and writing a story (Figure 11.13) about what happened to them from a first-person perspective.

When children turned their stories into ‘first-person’ stories and narrated them as if they were the ‘bronze children’ their teacher noted that they gave ‘bronze children’ voices; this builds nicely on what teachers asked in their very first exposure to the installation (see Table 11.2).

How can we release voices and open eyes to possibilities when children have no voice? (Teacher C)

In order to take on an identity of one of the ‘bronze children’, children used **(iv) imagination** and described **(iii) intuitively** what might have happened to the ‘circus troupe’ that ended up on an island. Children saw what was not there and sensed what might have been there. As they became absorbed by the story that something happened to the circus troupe, they wanted to know what happened next, and this was then handed over to them. They were imagining, seeing what is invisible and hearing what is inaudible: who the children are, where they went, what happened to them – thus answering the questions that both teachers and children in their first exposure to the installation asked. Art-making (of sculptures or stories) thus became a means to reveal *embodied*

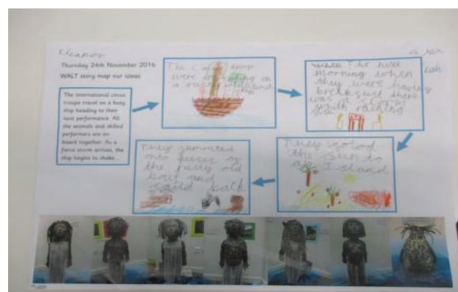


Figure 11.13 Story mapping.

intuitive knowing. The temptation to answer their questions was avoided by teaching staff, as one of them recalls:

Being confused was an important part of the process and was embraced. Staff resisted answering questions but engaged children in finding their own solutions ... or sometimes in recognising that problems could not be answered ... but required more questions ...
(Senior TA's reflective account)

Thus, teachers managed to transfer *agency* to children, who, in groups, were making decisions on their own on which direction to go with their stories and what events they wanted to include. Again, similarly to teachers, children experienced *intuitive possibility spaces* for the *feeling of empathy* (while imagining being 'bronze children' and building Lego-bricked boats and shelters for them) and bringing *otherness* closer to *self*, and adding the notion of *agency* to their use of **(iv) imagination**, **(iii) intuition** and the **(ii) magic spaces** they created.

11.2.3 Trans-Disciplinary Learning Spaces

Once children's stories were finished, they were peer assessed and, later, children used modern technology/applications to record sounds of water running, a door slamming, etc., to accompany audio recordings of their stories, which they subsequently stored in their folders in Dropbox (Figure 11.14).

During the phase of children's exposure to and interaction with the installation, teachers, researchers, teacher assistants, governors and parent volunteers were involved in the project. A Senior TA summarized the phenomenon:

I loved this element – not only had we had a governor and the university but also a parent involved – the project had a real community feel. (Senior TA's reflective account)

The final sculptures/mini-me's children made were displayed in the art room window. The collection was named 'From the heart of a child'.

Adults involved in the project shared their surprise at how well children worked on diverse trans-disciplinary activities as well as on how well they incorporated the themes of water and sustainable futures into their sculptures and stories.

It was amazing that independently the children's plans for their sculptures contained elements of water that linked so well with the installation.

Linking the statues with the environment was a direct link between art and geography, and matters of climate change. Children were involved in a number of activities that required them to continue asking questions.

(Senior TA's reflective account)

Children's trans-disciplinary (STE(A)M) learning was summarized by teachers in the following subject-related categorization, which represents the far-reaching nature of arts-infused practices on cross-curriculum learning.



Figure 11.14 Children using technology to audio record sound effects for their stories.

Table 11.3 Overview of children's learning experiences during many arts-infused and arts-based practices/cross-curriculum activities inspired by the presence of the installation

Subject/Area	What Have Children Learned?
Art	<ul style="list-style-type: none"> ● observational sketching ● personal response to a piece of art
Engineering/Design	<ul style="list-style-type: none"> ● story mapping/planning structures ● writing an account of modelling ● seeing designs in nature ● mapping the body/connecting to design
Technology/Computing	<ul style="list-style-type: none"> ● using and manipulating digital media purposefully ● using software for audio recording ● storing and organising digital data
Science	<ul style="list-style-type: none"> ● making simple observations ● making predictions ● building physical structures (with Lego) ● seeing the science in nature
Mathematics	<ul style="list-style-type: none"> ● taking mathematical roles ● storying problem solving using mathematics outdoors ● making sense of numbers (performing patterns, shapes)

Children's direct experience of, and interaction with, the sculpture yielded interesting findings similar to those of the teachers, indicating that exposure to the installation initiated the appearance of similar *possibility spaces* across the school setting. From the analysis of the children's exposure to the installation, we see evidence that the following *possibility spaces* were opened:

- a. Through **(i) direct experience** of the installation children found *exploratory possibility spaces* for evoking *emotional states* (from fear and concern to openness of heart and mind) that brought about the understanding of connections between the 'bronze children' (others/world) and self.
- b. Using **(iv) imagination, (iii) intuition** and creating **(ii) magical spaces** helped children experience *intuitive possibility spaces* for the *feeling of empathy and agency* which brought *otherness* closer to *self*.
- c. Through the tactile, hands-on process of **(v) art-making** children experienced *embodying possibility spaces* for art-making in connection to *creating* the world of the future rather than just *inheriting it*.
- d. Through being exposed to the installation in different locations, positions and arrangements children experienced first-hand *exploratory possibility spaces* for the appearance of the **(vi) language of pattern**, and learned the importance of landscape/place patterns.

What children learned during their exposure to, and interaction with, the installation reinforced what was mentioned at the beginning of the chapter – that the arts can enhance high performance teamwork, improve observational skills and adaptability. Children (similarly to the teachers) moved from the *direct experience of the emotional state of fear* and thinking that the 'bronze children' are dead to *caring* about them and building them boats and shelters, thus clearly supporting the belief that the arts are social, inclusive, humanising and thereby significant for human development in society (Belfiore & Bennett, 2007; Canatella, 2015). There seemed a movement from inertia to social activism: the children moved beyond their fear of the unvoiced 'bronze children' to providing their own voices through the 'bronze children' and for the 'bronze children'; from uncertainty in experiencing the static sculpture to actively creating new imagined journeys for the sculpture.

Through the changes of the locations and positions of the installation, children experienced it differently in a 'special room' where one entered with an open heart and mind. Arts-based perceptual ecology again proves to be valuable in understanding how places, environments and positions can be important in discovering patterns of interactions and relations between people and their environment.

11.2.4 Teacher-Led Didactic Formal Classroom Session

Part I: 'Seeing' mathematics through constructing structures

The third set of practices is divided into two parts. The first classroom session features the use of arts-infused practice to teach mathematics through constructing/building models for a Year 3 class (children 7 to 8 years old) and the second classroom session teaches Year 2 mathematics through music. In the first session, led by a group of Finnish specialist STE(A)M teachers, creative meaningful learning spaces use art-making not as an object but as a playful event to teach pentagons, hexagons and patterns and shapes one can create with them. The lesson's goal was the experience-oriented discovery of a truncated icosahedron (which is the structure of a football or the Fullerene molecule), learning about connections between 2 and 3-dimensional patterns and structural manipulations of pentagons and hexagons.

(i) Direct experience and (v) art-making: Children were exposed both to real balls (football) and photos as well as real 'building materials' and model samples and photos of them (Figure 11.15). This prompted children to construct their own 'football'. The teacher introduced the topic through questions about what children thought they could make out of the presented materials and kept the whole lesson focused on creating, building and discovering patterns, which led to children creating 'houses', sunrays, etc. Through inviting children to first explore available materials, then to see different models made of the same materials and finally to compare the physical ball with models, the teacher provided conditions for children's **(i) direct experience** of both materials and models. In a similar way to that of the children who experienced *experiential possibility spaces* for *making meaning* out of connections between the installation and self, the Year 3 children experienced *experiential possibility spaces* for *making meaning* out of connections between the models and self.

(v) The art-making process was present throughout the lesson and mathematics learning happened alongside creating possibility spaces for arts-infused practice. Children stayed excited throughout the lesson and were learning mathematics through their 'hands', while constructing/building their own 'football' models in an open-ended task. *Embodying possibility spaces* for art-making connected to *constructing* mathematics rather than just *learning it* involved some risk, as one of the teachers noted:

To me, it was left open. I had no expectations of what they needed to meet. It was not said. It was not prescribed.

We shared our worlds together for a short time. Something was and is always at stake for the participants, the teachers, the children, we all took a risk. The risk is that we all come upon a certain understanding that was not given on forehand. It's not about understanding of information being processed. It's, in essence, educating new insights. (STE(A)M Teacher)

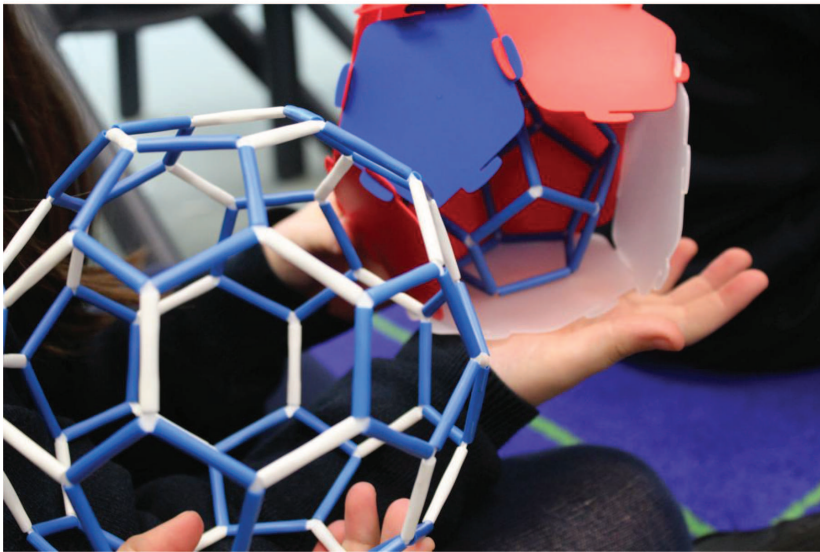


Figure 11.15 Slides of 'building materials' and model samples.

Using **(iv) imagination, (iii) intuition, (ii) magic** and **(vi) the language of pattern**: The teacher's invitation to children to transform into 'inventors' and to think differently opened the *intuitive possibility space* for **(iv) imagination, (iii) intuition** and **(ii) magic** (i.e. seeing, hearing and feeling what is not there). In no time, children took on the identities of inventors and came up with ideas as the illustrative examples below show:

I'm making a snowflake.

I'm making a house.

I'm following my own way. I have made two balls. One is inside the other.

I have made planet earth and an earth station.

I made a doghouse.

I made something for people who are blind ... it works well ... it's all about feeling it.

I made a bell. It was really hard for me to kind of get what was going on. I concentrated on my hands. I closed my eyes. Ideas came.

(Researcher's notes)

Children worked in pairs, studied thoroughly the **(vi) language of pattern** of real balls in the classroom, and each made a half of the ball. They supported each other by checking whether *patterns* in their halves were equal and could be used to form a whole ball with pentagons and hexagons. Direct experience of *pattern detection and pattern recognition* was enhanced with cooperation and team work similar to a group work of children creating a story about what happened to 'the circus troupe/bronze children'. In the children's words, they 'followed their own way', 'closed their eyes' and 'it worked well' because 'ideas came' and it was 'all about feeling'. Once again, perception was the key to *reading patterns* whether they are mathematical (arrangement of pentagons and hexagons in a truncated icosahedron) or emotional (shifts from one emotional state (e.g. despair) to another (e.g. hope)).

Compared to other data sets, which featured direct experience of art out of formal classroom settings (school hall, special room for the installation, art room), the mathematics lesson was delivered in the classroom. Before the closing discussion the children released all their energies piled up during the

highly-concentrated building process whilst also focusing on the realization of their ideas: in the school's sports hall, free ball play allowed the children to enjoy their constructions. According to ABPE, each place has its own patterns. The teacher's invitation to children to use their **(iv) imagination** and **(iii) intuition** and explore how to think and build as inventors seemed to have removed any obstacles to creativity. The children's agency and propensity to seeing, hearing and feeling what is not there were opened up through the invitation.

Part 2: Hearing mathematics through music

The 'mathematics through music' lesson featured a Year 2 class whose teacher created meaningful *possibility spaces* throughout a day of 'performative musico-mathematic knowing', bringing diverse configurations of mathematics and music into meaningful relationships through STE(A)M education.

The mathematics teacher aimed to help children develop a 'mathematical lens' through which to interpret their experiences of the world; to consider mathematics as a subject imbued with patterns, and help children to make connections between maths, music and art. Lesson sequences built on these different contexts to bring understanding and insight into structures of counting, place value and multiplication. The lesson was part of a whole-day, whole-school event where different teachers engaged in a 'Musical Mathematics Day' and performed, sang, danced, heard and composed mathematics.

During the observed lesson children engaged in different activities ranging from learning to conduct and practising multiplication through clapping to composing through the use of three-dimensional mathematics (e.g. Numicon) and digital media (online applications).

(i) Direct experience: The mathematics lesson started with learning to conduct through listening to classical music rather than with an overt focus on mathematics. Children focused on conducting the pulse of the music (Figure 11.16), which gave them a way to actively participate in joining in with the music and making some implicit and explicit links to the relationships between music and number. The teacher reported that children were captivated by the music and enjoyed conducting.

After a musician (flautist) visited the class and introduced the children to the metronome, they played 'clapping times' in pair thus practicing multiplication through coordinating. The role of body (i.e. embodying mathematical



Figure 11.16 Children conducting the pulse of music.

concepts (e.g. multiplication)) required a cooperative learning focus as both players had to focus on their own numbers at the same time as reciprocal partner work.

Some children shared their experiences:

I hear intervals

I see the intervals in sound now

*There is a different kind of surface to this sound when it's a colour
or a line you've drawn . . .*

(Researcher's notes)

(i) Direct experience of listening to both the recorded and live music performances while learning mathematics created *emotional states* (enjoyment) that lead to the creation of *experiential possibility spaces* for *making meaning* out of connections between the musical patterns and numbers.

Art-making, imagination, intuition, magic and the language of pattern

Children were also invited to **(v) make art**, i.e. to compose by using the Cuisenaire rods and Numicon shapes (i.e. by using their hands and manipulating plastic pieces). They first explored making a simple rhythm using different number pieces to represent the number of notes they would play. Each child chose a part and **(iv) imagined** what kind of piece they would like to create. Later in the day this was extended for them to try overlapping two

parts which provided an opportunity for them to see number relationships and **(vi) patterns**. Conceptual variation of differing representations appears to help strengthen the understanding of concepts (Gu et al., 2004). Pattern recognition in art, landscape, environment and mathematics may be one of the commonalities across disciplines and as such is easy to transfer to all STE(A)M areas.

The **(v) art-making** process of making music by using plastic 3D pieces combined with the **(iii) intuitive** choice of **(vi) pattern** contributed to the *embodying, exploring and intuitive possibility spaces* for a holistic experience of *hearing mathematics* rather than just *learning it*.

The lesson finished with using a simple flash music animation online application that children explored and then, through trial and improvement, created a piece (Figure 11.17). The task involved problem-solving, reasoning, collaborative learning and **(vi) pattern** recognition.

According to the ABPE framework, in both lessons teachers and children were *co-constructing* and *co-composing possibilities* for STE(A)M education through:

- a. *experiential possibility spaces* for **(i) direct experience** of models and music composing/constructing in mathematics
- b. *intuitive possibility spaces* for the use of **(iv) imagination, (iii) intuition and (ii) magic** in mathematics
- c. *embodying possibility spaces* for **(v) art-making** of composing/constructing in mathematics
- d. *exploratory possibility spaces* for the **(vi) language of pattern** in relation to its detection and recognition in mathematics

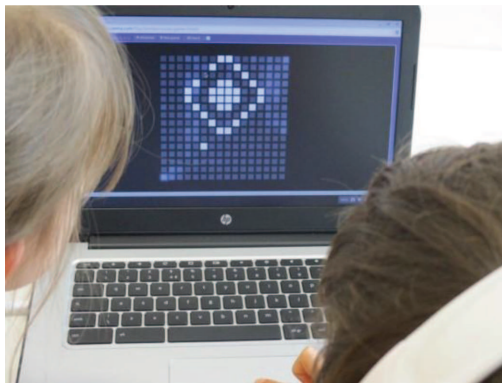


Figure 11.17 Children composing with the help of an online application.

11.3 Concluding Discussion

Along with offering leading-edge practices using STE(A)M Education (in Science, Technology, Engineering, Arts and Mathematics), this small-scale study promised several things: Firstly, we aimed to arrive at new understandings about what characterizes ‘*possibility spaces*’ within the learning engagement of young children and how such spaces enable innovative practices. Secondly, we asked what the arts can contribute to STE(A)M education in primary education. Thirdly, we reviewed how the dimensions of ABPE methodology (involving direct experience, magic, intuition, imagination, art-making and the language of pattern), can be understood in several ways. Finally, we investigated the role that using a sculpture installation as a stimulus played in implementing the ABPE methodology.

In this chapter, we have further *theorised* ‘*possibility spaces*’ as the unique enabling spaces in which innovative learning engagements emerge. What these spaces and related practices highlight, in particular, is how a multiplicity of voices in a school context, evoked through the encounter of direct experience and art-making, can spur the imagination, ignite a sense of intuition and manifest as magic, acting upon, and situated in, the sensation of learning engagement.

So, what have we learned? We have learned that the experience of art-making provides a doorway which, once passed through, can help make new and valuable innovative links and meaning in Science, Technology, Engineering and Mathematics (STEM) education for both teachers and children. John Dewey held that an art form “carries the experience, not as vehicles carry goods but as a mother carries a baby when the baby is part of her own organism” (Dewey, cited in Woolery, 2006, p. 33). We have learned that in the intuitive process, the child finds a way of seeing through sensing, as an internal knowing which is art-making. We have learned that intuition stimulates imagination, which acts as an organizing process that creates representations of our learning experiences. Thus, imagination becomes a modelling device through which we can test possibilities and co-create enabling possibility spaces. We have learned that art-making is not simply a tool, it is a process which is a tactile event, a complete body experience where children feel the shapes inside their body and their body wields the tools that capture the shapes. We learned that if teachers engage in/with/through the co-creation of possibility spaces as sites of transdisciplinary learning, together with children, they give way to and in to ‘possibility thinking’ and teaching differently.

The central contribution of the arts-based perceptual ecology framework (involving direct experience, magic, intuition, imagination, art-making and the language of pattern) is twofold. Firstly, it offers a way to avoid dualisms like mind/body, self/other, thought/feeling. Secondly, the APBE methodology enables us to contain the great complexities and contradictions of learning engagement for STE(A)M education without diminishing them. We have shown why ABPE can be approached as a ‘living system’ (away from mechanistic approaches to primary education).

What can we take away from these findings which have significant implications for developing pedagogies of possibilities in primary education practice? We have illustrated how art-making is a unique means to acquire knowledge and how an artistic way of knowing can come about in primary education as part of STEM. If a sculpture installation can embody an idea then we need to accept that art-making involves perception, emotion and action – that is, the entire process of life. The artistic process, as with the ‘little me’ clay making that evoked responses to the sculpture installation by both teachers and children, becomes transformative. This shows the extent to which participating in art-making can make a profound impression on teachers, the children and, potentially, their communities. The sculpture installation invited participants into ‘possibility spaces’ where they came to see ‘learning others’ as learning selves and the significance of *how art creates a world*. The implication for creating sustainable futures is that art-making is a unique means to acquire and absorb new knowledge; it allows us to *know* ecological elements of the landscape in which we exist, and from which we cannot separate ourselves.

What we have come to understand about the complexity and materiality of teachers’ work is captured in the concept of arts-based perceptual ecology, as pedagogies of possibility which facilitate innovation and change in co-creating transdisciplinary learning and possibility spaces for STE(A)M education. It is the dynamic *possibility spaces* which enable teachers to imagine possibilities for STE(A)M-oriented possibility thinking that provides new directions for pedagogies of possibility.

Why we consider that the study and the practice of arts-based perceptual ecology is important in our day and age is that it facilitates innovation and change, enabling possibility spaces for diverse configurations of STE(A)M education. We can conclude that STE(A)M education holds within it a new set of *possibility spaces* and opportunities for authentic, hands-on, interactive learning, allowing children, their teachers and school communities to form the vanguard of transformation now needed to co-create and realize their collective dreams for our sustained creative futures.

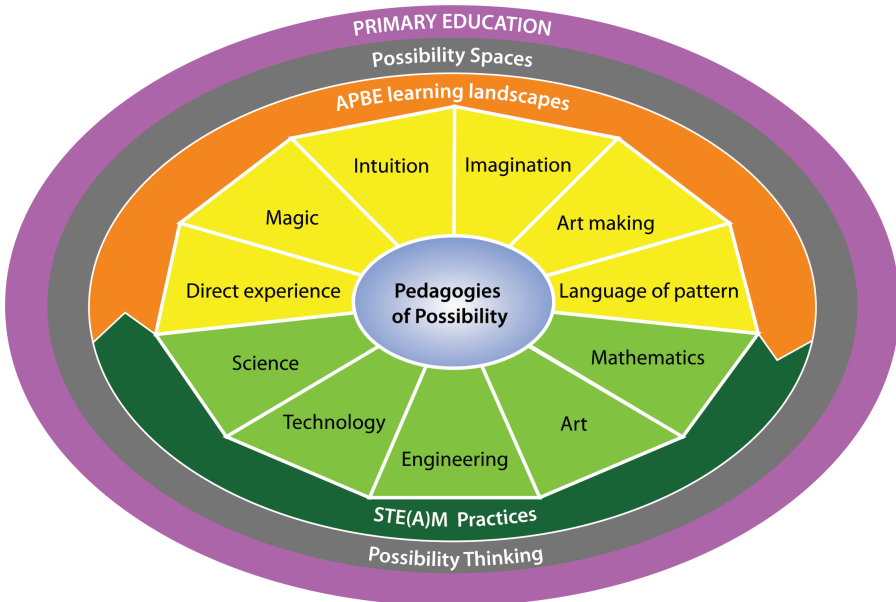


Figure 11.18 Towards a framework for innovation and change in primary education.

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