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Improving Children's Visual Literacy by Fostering Visual Design Thinking through Arts-Based Methods

Amna QURESHI[*a], Melanie SARANTOU[*b] and Satu MIETTINEN[*c]
University of Lapland, Finland

The field of visual literacy (VL) has rapidly grown, partially because of its potential to stimulate the conceptual process of visual thinking (VT). Humans have always enjoyed visual stimuli, but the new generation of children have access to a more powerful visual experience than previous generations. This paper presents the results from a summer workshop for children aged between 10 and 12 that was conducted at the University of Lapland, Finland, in 2021 Acting on the Margins: Arts as Social Sculpture (AMASS); the project was a European-wide testbed and part of a Horizon 2020-funded research project. In this paper, the significance of VL is investigated by integrating arts-based methods (ABMs). The objective is to explore learning as a function of design thinking (DT) that can tap into the voices and expressions of children to enhance their creative mindsets. The findings can help in raising children's awareness of their surroundings, making them stakeholders in formal and nonformal learning. A four-topic analysis is presented, here aiming to engage children in visual design thinking (VDT) processes; this can lead to enabling the children to express their emotions and cognitive experiences while giving them the ability to enhance their reflections in a way that can impact their creative mindsets.

Keywords: arts-based methods; children; co-creation; creative mindsets; visual design thinking; visual literacy

Corresponding author: **Amna QURESHI** | e-mail: aqureshi@ulapland.fi

Introduction

Our mental creations are the products of a variety of experiences (Folch, Pereira, & Icart, 2019), interactions (West, 2002) and connections we encounter (Hunter, Bedell, & Mumford, 2007). Memories of these experiences shape us, moulding us into whom we become over time—a montage of images and feelings that give a sense of how we have evolved, even if the details have faded away. As we grow older, we realise that we are nothing more than the experiences that have made us. Early life experiences define individuals' personalities; it is the emotional (Greenhalgh, 2002), social (Huang, Sherraden, Kim, & Clancy, 2014; Landy, 2009; Thompson & Lagattuta, 2006) and physical (Tomporowski, McCullick, & Pesce, 2015) growth of young children that determines their overall development and the adult they will eventually become. In line with this, Preedy, Duncombe and Gorely (2022, p. 292) stated, 'By creating games and providing opportunities for play, both indoors and outdoors, adults can support children to develop their core strength, stability, balance, spatial awareness-ordination and agility'. This is why investing in young children can ensure their future well-being.

A mindset informs how a person views and interacts with the world (Howard, Senova, & Melles, 2015). Looking at children's development from a creative point of view, children of all ages produce the most unique and original mental and physical creations. Additionally, children behave differently when working creatively as individuals or in groups. Cocreation among children can be practised in various formats. For instance, there are numerous ways to engage children in creativity, hence allowing them to adopt creative mindsets. These ways include (a) making them work together as team members, (b) helping them collaborate and present ideas while offering them supportive input and (c) offering them the freedom to express their views to each other without providing any critical judgement. Whichever way is chosen, the process discussed, conceived and cocreated—that is, the collaboration—provides a rich and productive experience that allows children to engage in a wide range of learning different subjects and in various contexts.

Similarly, in the current study, the children expressed their own views on the specified creative task, and then, they were placed into teams; this was followed by an inclusive and collaborative process that resulted in freedom of expression while stimulating their creative mindsets. While closely working and observing the children, the selected philosophical approach, interpretive phenomenological analysis (IPA) was used to critically evaluate the data collected. As part of an arts-based research (ABR) strategy, the methods for data collection included workshops, arts based-methods (ABMs), interviews and note taking. The collected data were analysed using four-topic analysis based on IPA.

Starting from this inclusive contextual view, the present research serves as a lens for examining youth, here by focusing on young children's cocreative processes as they use tools such as ABMs to stimulate their creative mindsets, hence harnessing their visual design thinking (VDT) abilities. The present study introduces a VDT model from the literature that can enable youth to direct their own creative learning experiences. Viewed from the premise that creativity is not just one idea but instead a set of solutions put together for a specific purpose, the primary purpose of the current study is to integrate ABMs as tools to examine children's VDT abilities, thereby expressing their visual literacy (VL).

In the current study, 16 children between the ages of 10 and 12 participated in a summer workshop conducted in collaboration with the Faculty of Art & Design and the Faculty of Education, University of Lapland, Finland. The young participants were asked to share their reflections on their experiences of making mandalas using objects found in nature. Through ABMs, the present study provides a better understanding of the need to integrate VDT with ABMs to assess children's existing VL and determine what can be done to facilitate it. This qualitative research has helped to examine and discuss a VDT model that can support young children in fostering their VL using ABMs as instruments. The study uncovers avenues for future research that can be explored to construct new ideas about young children's cocreative and reflective approaches.

Project Background and Target Group

The current paper is an enriched extension of an experiment previously piloted with university students from the University of Lapland as part of the AMASS project. The project included 35 artistic experiments used as a way to explore how the arts can help mitigate societal challenges. Finland alone contributed six artistic experiments;

however, the experiment described in the present paper was implemented in Finnish Lapland, specifically in the Arctic city of Rovaniemi. In the pilot study (Qureshi, Sarantou, & Miettinen, 2021), we investigated the importance of creative freedom and self-expression through lived experiences explored in a visual literacy workshop (VLW).

Conversely, in the current paper, a younger target group was tasked with using diverse ABMs, which allowed the participants to access their voices in the context of VL through their personal creative processes. The study has demonstrated a novel means of introducing a VDT model, enabling youth to direct their own creative learning experiences. Carrying out a study with young children provided valuable insights into how ABMs can lead to problem solving and be integrated into primary and secondary learning for the establishment of young people's creative mindsets. This study provides insights into the potential development of VL from an early age and how it can be enriched over the years.

Defining Key Themes

Definitions of the key themes are presented hereafter. The concept of VL is explained, followed by visual and design thinking (VT and DT). The proposed VDT model, and the relationship between VDT and VL, are introduced.

Visual Literacy

VL is an ever-evolving concept (Stokes, 2002) and can be simply defined as the ability to read images. Fransecky and Debes first published a pioneering definition of this relatively new term in 1972. Other definitions have followed. Each visual thinker has come up with a similar idea but supplemented it with their own perspective. Indeed, the definitions that already exist often have discipline-specific additions. Similarly, we redefine VL as follows: the ability to emotionally and cognitively interpret or apprehend visual images and give them a meaningful representation. In light of this definition, the present paper aims to extend the understanding of the role of VT and DT in VL.

VL is a significant form of literacy, often based on semiotic interpretation, but still suffers from a lack of attention and awareness (Matusiak, Heinbach, Harper, & Bovee, 2019) because it does not intuitively arise from onself, instead needing to be learned (Ausburn & Ausburn, 1978). It has a wide-ranging impact on visual learning (Messaris, 1994; Moore & Dwyer, 1994), empathy (Sinquefield-Kangas, 2019) and, most prominently, self-awareness (Jung & Franz, 1964; Jung, 1976). VL's significance has been acknowledged by many researchers, artists, designers, visual artists and professionals, but despite this wide-ranging acceptance, it is still marginalised in various disciplines (Little, Felten, & Berry, 2015), hence remaining weakly supported in the literature.

Visual Thinking

Rudolf Arnheim (1997), the pioneer of VT, first introduced the concept of educating the visual sense. He proposed that VT is everywhere and can be applied to various domains. As Arnheim (1997) pointed out, we cannot be intelligent without perception because the ideas around a concept determine our perceptions of it. We act through perception and think through thought. However, visual stimulation by an unfamiliar object is more engaging than by one that is familiar. This correspondence between stimulus and intellect is a valuable feature of our daily lives. The process of translating intangible concepts into tangible forms helps us reperceive and further elaborate on them. By visualising these concepts, we refine our thinking and can connect ideas to the real world.

VT enables information to be processed and visualised more effectively, helping us render thoughts into a tangible form (Ware, 2010). Designers such as Cross (2011) and Goldschmidt (1991, 1994, 2003) have confirmed that the ability to convey ideas in the form of charts, diagrams and quick sketches—either through conventional drawing materials or a project management tool—can help others comprehend these ideas more easily. Goldschmidt claimed that 'when it comes to conception and the reasoning that it entails, imagery is a powerful tool' (2003, p. 84).

Visualisation is paramount in DT because it facilitates collaboration and communication, creates a common understanding, speeds up the process for more rapid innovation cycles and leads to actionable insights (Shimojima, 1999). Thus, a deeper understanding of visuals is needed, as well as of how they are used within the various phases of DT, the principles they convey and how they affect the cognitive, emotional and social dimensions of DT. Without VT, some logical solutions may not be possible because VT can help identify patterns, call out problems and even allow a new perspective to emerge (Hortin, 1980).

Design Thinking

DT refers to a five-part process that can help create novel solutions for the problems that a particular group of people are experiencing, often with a product or service (Melles, Howard, & Thompson, 2012). The five stages of DT are empathise, define, ideate, prototype and test, which need not follow any particular order or time frame (Wolniak, 2017). DT is generally defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback and redesign (Razzouk, 2012). Primarily, DT is a process of attempting to understand the user and their experience before moving into ideation and design (Cross, 2011). As Bresciani (2019) explained, cocreation and collaboration should be supported by DT sessions and visualisations. When applied in this way, DT helps develop a new mindset and skills set that can develop one's abilities and knowledge. Ultimately, DT encourages creative mindsets that can build creative confidence (Rauth, Koppen, Jobst, & Meinel, 2010). Visually literate mindsets in education can have a greater impact on the education of the child (Howard, Senova, & Melles, 2015).

At the inception of DT, the design company IDEO and Stanford Hasso Plattner Institute of Design were a leading force, applying it to business and societal problems (Cross, 2011; Kernbach & Nabergoj, 2018). Brown (2009) noted that in recent years, DT has becomne a popular method that has been used by a wide range of organisations around the globe. Kernbach and Nabergoj stated the following:

> In design thinking, interdisciplinary teams work on design challenges in which they aim to identify where the problem is by empathizing with the user through observation and interviewing. Based on this understanding, they aim to define a problem statement that inspires and guides solution finding, which is also known as 'point of view' (POV). Based on this problem statement, ideas on how to find solutions to those problems are created, first by thinking divergently about possible solutions and then choosing and converging the best possible solution. Based on these ideas, prototypes are created in the form of tangible physical objects or drawings that invite users and team members to test them, give feedback and refine the solutions. (2018, p. 362)

Visual Design Thinking

VT and DT are often confused because they tend to go hand in hand, but they have very different connotations and purposes and are used in different situations. We argue that when the two are combined, they result in VDT. Although both VT and DT work to accomplish the same objective, they do so from different perspectives. The VT perspective visually perceives the concept. The DT perspective involves finding and choosing the solutions to the idea, which is followed by a process of testing the solution. By combining them, a model—one not found in the literature—that is comprised of both processes can be conceived. Considering the need to clarify this combined concept, we visualised the VDT model, as shown in Figure 1.
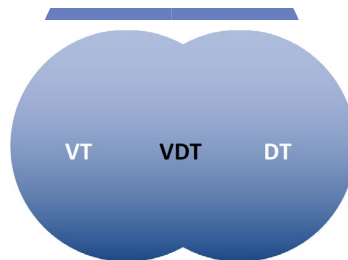

Figure 1: Visualisation of visual thinking (VT) and design thinking (DT) into a visual design thinking (VDT) model as a cognitive process, 2022.

By integrating VT and DT into VDT, the present study presents a methodology for designing and tailoring creative interventions for young learners that can stimulate their level of VL, aiding them in their creative confidence. As part of a qualitative and iterative process, we tested this methodology with the children. Thus, the current study used VT and DT to develop and present a VDT learning prototype for improving and scaling interventions that can address demanding learning reforms, such as the development of VL for enhancing shared visual languages that can describe meanings.

In summary, VDT can be viewed as a holistic cognitive process that can help children develop new skills and mindsets, thus strengthening their creative confidence in becoming visual design thinkers—all of which contribute to their VL.

Methodology

The methodological approach we adopted was phenomenology. The selected methodology aimed to address the following research questions: How can VT and DT complement one another as cognitive processes in learning environments? How can ABMs assist in stimulating children's VDT abilities?

Study Design

The current study used cocreation and a qualitative phenomenological inquiry into the reflective activity of children during a summer workshop held at the University of Lapland in 2021. The research design is illustrated in Figure 2.
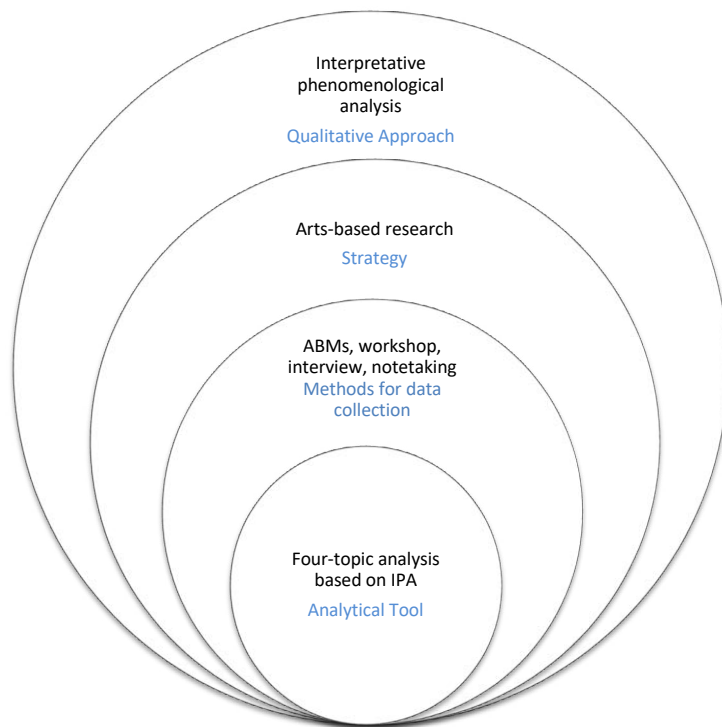
Interpretative
phenomenological
analysis
Qualitative Approach

Arts-based research
Strategy

ABMs, workshop,
interview, notetaking
Methods for data
collection

Four-topic analysis
based on IPA
Analytical Tool

Figure. 2: Study design of the research, summer workshop, 2021

As the overarching philosophical approach selected for the present research, phenomenology is the study of phenomena: the appearances of things as they appear in our experiences or the ways we experience things, thus constructing the meanings things have in our experiences (Smith, 2018). IPA uses participants' subjective experiences and perceptions of objects and events to thoroughly examine the lived experiences of a phenomenon (Smith, 2017), which is important for children to learn how to reflect on their creative processes. Therefore, in the present study, IPA was used for our analysis of the data collected during the workshop.

We have focused on understanding the participants' perceptions of meaning-making in artistic settings and later translated them to calculate meaning based on these perceptions. The goal of the IPA method is to enable the researcher to develop an analytic interpretation of the participant's account that draws upon and goes beyond the participant's sense-making and conceptualisation but that also protects it from being distorted by the researcher (Smith, Flowers, & Larkin, 2009). Taking into consideration the children's interpretation of their artwork was important, and doing so enabled us to dive into the young participants' cocreative 'art worlds' (Becker, 1982, 2008; Qureshi, 2021).

Besides the philosophical approach discussed earlier, the present study utilises the ABR strategy by using ABMs (mandala-making and installation), workshops, interviews and note taking for data collection. As an analytical approach, the research developed and tested a framework based on the attributes of visualisations identified through the four-topic analysis of the creative process, here as perceived by the participants.

According to Leavy (2020), 'arts-based practices can be employed as a means of creating critical awareness or raising awareness' (p. 24). Further, she added, 'ABR opens up avenues in many ways and demands the following from the researcher: flexibility, creativity, openness and intuition, storytelling proficiency, thinking conceptually, symbolically, metaphorically and thematically, and paying attention to ethical practice and one's values system' (p. 305). In addition, 'ABR can support artistic creativity, discussion and the generation of insights that may lead to defining, understanding and contributing to the empowerment of communities' (Miettinen, Sarantou, & Kuure, 2019, p. 8). Bearing in mind the wide range of results that can be obtained through ABMs, we explored a VDT model integrated with the ABR approach.

The qualitative data collection methods used during the current research were as follows:

1. **Workshop**
   To begin the workshop, the children were given a brief overview of the mandalas. First, they were shown a few mandalas in the classroom to provide them with a generic visual reference. After a brief introduction to this form of art, they were taken outside and encouraged to explore objects found in nature, such as pinecones, stones, flowers and leaves, and to put them together to design a mandala. It was a very specific workshop process designed by the first author of the current paper and was defined and presented to the participants in steps. The collected data from the workshop overlapped with other data collection methods to provide a rich data set for analysis.

2. **Research diary**
   Another data collection method, a research diary, was used for collecting notational data. A detailed journal was kept in which analysis of a minimum of four topics per student was recorded:

   i. The first journal entry described how the participants saw their mandalas; they were prompted to give the mandalas a title and an explanation of what they saw.
   ii. The second entry described the immediate emotions associated with their creation.
   iii. As part of the third entry, they gave their feedback on how they could improve the mandalas.
   iv. The fourth entry was more reflective and included ideas for future creation.

3. **Storytelling/Interviews**
   Short, two-to-three-minute semi-structured interviews with the children were conducted so that they could express their reflections of their processes.

4. **Visual data**
   Having phenomenology as the guiding philosophical approach, data came forth from the ABMs, such as the mandala-making and installation during the exhibition (Qureshi, 2022a). The visual data were captured by photos and analysed through semiotics and through our personal interpretations and our experiences we shared with the children.

By the end of the workshop, the children had many reflective thoughts, which were then analysed to identify four-topic analytical themes. Throughout the workshop, the children actively participated in short interviews, and their

responses were recorded and transcribed. This relates back to IPA because the four-step analysis approach reflected on an experience-based phenomenon from the participants' and our perspectives. When connected with the ABMs, it enabled us to explore the deeper meanings of the mandalas analysed by the children.

ABM—Mandala-Making

Mandalas were used as ABMs by the young participants to express their VL, here in accordance with the ABR approach of collecting, analysing and visualising data (Leavy, 2017). The assumption was that through ABMs, the young participants would be able to reflect on their experiences, express their perspectives and share their views. The students were taken into nature, allowing them to discover natural materials and create mandalas utilising their natural surroundings. A similar kind of mandala-making tool was employed in the pilot study (Qureshi et al., 2021) with older university students at the University of Lapland, who were asked to use only 2D art materials and paint their personal mandalas. The tool proved useful because it allowed the group to share their individual understandings. However, in the current study, we investigated younger children.

Using natural objects such as leaves, flowers, pinecones, acorns and stones, the children employed great imagination in constructing their mandalas. The selected mandalas shown in Photo 1 demonstrate their creativity and imagination, with the children using almost the same natural materials but associating these with a variety of stories and reflections.

The mandala-making enabled the children to process their VDT in three significant phases. The first was to use their VT abilities and represent their understanding of a visual language. The second was verbal sharing and storytelling. The third was the most significant because it included reflections on each other's mandalas from a DT perspective. The workshop lasted six hours, during which the children were free to relax, enjoy themselves and play while making their mandalas, with no pressure or judgement. Providing a carefree environment allowed the participants to listen to each other's stories, and some remade their mandalas with a new perspective. This enabled two processes: 1) making and remaking facilitated a peer-to-peer learning environment, and 2) individual self-reflective work enabled the processing of personal reflections.

Photo 1: Selected mandalas from the summer workshop, 2021

ABM—Installation

Children can create change in society. Studies such as the present one are valuable in terms of making children more aware of their surroundings and enabling them to consider themselves as stakeholders in formal and nonformal learning. As a means of dissemination, the work was exhibited at the Kopio Gallery at the University of Lapland (Qureshi, 2022a) (Photo 2), the AMASS Conference (Qureshi, 2022b) and the AMASS Symposium (Qureshi, 2022c; Qureshi 2022d). Using the participants' mandalas as the research data, the first author-researcher created a hanging mandala from recycled materials to demonstrate the process. The way the participants expressed their reflections was reimagined in this research activity to see if the concepts could be applied differently and would be effective. The method proved viable and practical by embedding observations of the children's art worlds (Becker, 1982, 2008; Qureshi, 2021), here combined with the nonbiased phenomenological expression of the researcher. The installation helped the author-researcher to reflect on her own DT and the learning prototype that had been created.
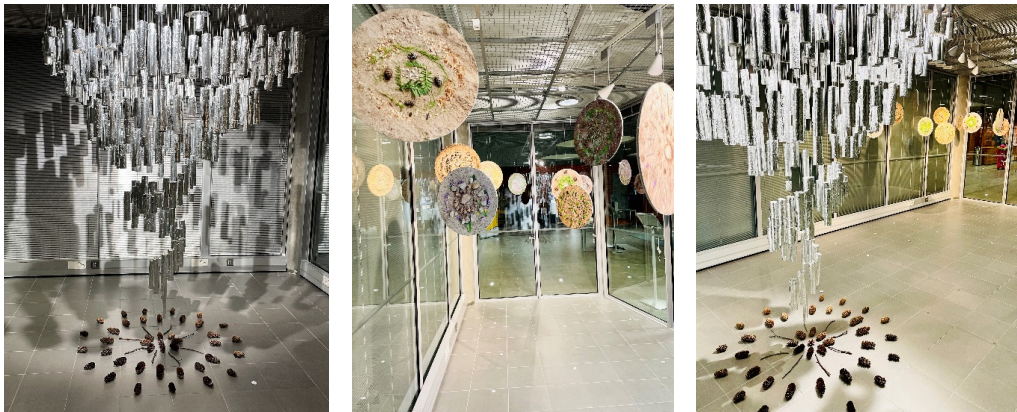

Photo 2: (Left, centre, right): Summer workshop exhibited at Kopio Gallery, University of Lapland, Finland, 2022

Findings—Four-Topic Analyses

Collaboration and a reflective approach within a dialogic setting are two of the primary conceptual constructs behind the current study. A good cocreating experience requires enough time for thoughtful discourse and narratives, which can be attained through empathy (Miettinen, Sarantou, & Akimenko, 2016). Bearing this in mind, the children were provided with a lively and enjoyable environment, enabling them to experience an empathic role in the design process, hence leading to peer-to-peer learning and enabling them to explore their self-reflective work. As discussed in the introduction, children's creativity can be enhanced when they work in teams and are given the freedom to express themselves. The current study provides noteworthy findings from the four selective topic analysis entries from each participant, which are discussed below.

Topic 1 - Titles

As reported in the first entry, the children gave the mandalas titles and explained what they first saw. Interesting titles such as snowman as friend, friendship, relaxing circle, nest, circle of hope, clock and time, deep feelings of happiness, fun and water waves all emerged. This showed that even at their age, the children had a sense of symbolic understanding and could express it in more than a literal meaning. It also showed that they were fascinated by the visualisation of the objects found in nature, prompting them to verbalise their thoughts into names and, thus, entering the cognitive stage (Bjorklund & Causey, 2017).

Topic 2 - Emotions

The second entry described and recorded the children's immediate feelings and responses. One of the young participants said, 'It gives me a happy feeling that I can play and learn at the same time'. Others said, 'I see sun in my mandala, and the yellow flowers are the sun rays'; 'I made a nest for the birds to rest'; and 'I see hope in my mandala'.

The children's entries, here as based on their feelings, suggest that they were able to interpret certain symbolic aspects and connect them to their learning experiences. They were able to make connotations and express their emotions, such as a feeling of contentment, while learning and playing, interchanging and expressing the positive connotations between yellow flower petals and yellow sun rays. Additionally, the making of a nest as a way to show care for birds illustrates the children's connections to the well-being of the natural environment and feelings of hope and optimism. All of these expressions showed that VT and DT helped the children select elements from their designed mandalas and, through a reflection on the visual appearance of their creations, interpret symbolism and express personal meanings. It was VDT that helped the children first conceptualise and then reflect and express their sense of care, ability, purpose, plan and agency.

These few examples of instant responses from the children, which carry deep meaning, show that they had entered a phase of emotional intelligence during the workshop (Hansenne & Legrand, 2012; O'Neil, 1996). This also shows that the children engaged in learning processes, expressing their feelings about their creations with positive attitudes and creative mindsets.

Topic 3 - Feedback
The third entry was based on individual feedback regarding the children's own and others' mandalas. The participants analysed and discussed what could be improved. One participant stated, 'The nest looks homey for birds, but I see it as a deep hole. If more twigs were used at the centre of the nest, then I would not think of it as a deep hole. I don't like deep things!'

Thus, using personal emotions, the participant expressed his feelings about the nest-like mandala. Because the child was fearful of being in the deep hole, he proposed an iteration—based on VT and DT—to make the nest better so that it could provide a sense of protection instead of being a deep hole, thereby expressing a positive attitude and creative mindset.

Topic 4 - Reflection
The fourth entry was more reflective and included suggestions for future creation. During the workshop, the reflections shared by the young children demonstrated the need to supplement nonformal learning settings with open dialogue and reflective practice, both inside and outside the classroom (Pflaum, 2021). Therefore, an atmosphere was constructed that contributed to the children's engagement with one another, specifically with nature and the mandala-making learning activity.

Discussion

VL involves cognitive functions such as critical viewing and thinking, imagining, visualising, inferring and constructing meaning, as well as communicating and evoking feelings and attitudes (Avgerinou, 2001). The four-topic analyses provided a structure for explicitly discussing some key advantages of visualisation and how it can shape the VTD model. We designated the VDT model as an inquiry-based process that could enhance the children's innovation skills, empowerment, collaboration and artistic intervention. It also enhanced the children's VL and constructed new knowledge. As a practical tool, ABMs enabled the children to experience VT and DT in a holistic way within the VDT model, which itself is a cognitive process. This showed that having an understanding of VDT at a young age can bring about a big difference in children's VL. Indeed, children should be encouraged to practice their VDT abilities, and such opportunities should be provided. With the addition of VT, DT becomes even more profound, and a learning process where the children can use their different senses and enhance their learning abilities, which are closely related to learning visually, should be provided. Thus, the current study established that VDT can be a stimulus for a creative mindset with a problem-solving attitude, showing that children can learn from a very young age.

In our view, the method of creating a learning prototype that incorporates play, creating and reflecting helped developing our DT processes as we viewed the process through the eyes of children, thereby also evolving our creative mindsets.

Limitations

Because this new concept is only just emerging, the model is limited in many ways. The method explored here has yet to be evaluated more throughly and extended to longitudinal experiments. Various ABMs can be used to engage different ageism as well as on a large scale to illustrate the implications of this model. Nevertheless, the current study represents only the preliminary realisation of the VDT model in the context of VL.

Conclusion

In summary, VDT can be viewed as a holistic cognitive process constituted by VT and DT that supports learning and stimulates creative mindsets. The empowering effect of sharing reflections brought the children closer to each other, which created a creative learning environment for the children, who shared, listened and reflected on each other's artwork. This has helped validate that VDT is a cognitive process.

It was also established that ABM can assist in stimulating children's VDT abilities because the creative process adapted in the workshop—the act of making a mandala in nature and requiring a search for a solution to a set of problems—stimulated their VDT abilities. Moreover, the four-topic analysis process added valuable insights to the learning prototype. DT and ABMs assisted in the reflections of the first author–researcher, and these reflections were then tested in the installation of the exhibition. All of this helped to verify the learning prototype introduced in the study.

Although more studies are required to establish the practical utility of this new model, the initial results provide empirical evidence to support the effectiveness of analysing young children's cognitive functions through the application of well-planned ABMs. The present study has demonstrated that children's VL can be improved by enabling their creativity and stimulating VDT for self-esteem and individual emancipation. It can also help young children develop their creative expression and performance and in verbalising their processes and outcomes. Going through the reflective activity with the children and looking and experiencing things from their perspective has shown that having VDT abilities can make a great difference to their VL, allowing them to direct their own creative learning experiences. Therefore, the VDT model has the potential for helping children develop their VDT abilities.

Additionally, it can be helpful for professionals to know more about the development of VL among younger children and to create better learning plans to help them be actively involved in their futures as agents of change. Such plans support social constructivist approaches to learning because these approaches tend to be experience based and can be well connected to phenomenological directions in research. Opportunities for further research include an assessment of the learning prototype presented in the current study in various environmental settings (McRobbie & Tobin, 1997). The effectiveness of using existing or different combinations of ABMs in combination with the learning prototype or development of novel ABMs for this purpose offers additional avenues for ongoing research.

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